STRUCTURAL PRESERVATION SYSTEMS

Engineering Services
14713 Jersey Shore Drive
Houston, TX 77047
Phone 713-433-2155
Fax 713-433-2558
www.structural.net

July 2002

CONDITION SURVEY AND EVALUATION OF THE CONCRETE HYPERBOLIC COOLING TOWER SUPERSTRUCTURE SHELL IN UNIT NO. 1 AT AEP'S BIG SANDY POWER PLANT

LOUISA, KENTUCKY

Prepared for:
Mr. James G. Burton
American Electric Power
P.O. Box 400
Louisa, KY 41230-0400

Prepared by:
Structural Preservation Systems, Inc.
Engineering Services
14713 Jersey Shore Drive
Houston, Texas 77047

AMERICAN ELECTRIC POWER
BIG SANDY PLANT
LOUISA, KENTUCKY

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EXECUTIVE SUMMARY

The concrete Hyperbolic Cooling Tower superstructure Shell in Unit No. 1 at American Electric Power's (AEP) Big Sandy Power Plant Louisa, Kentucky has been exposed to approximately forty (40) years of moist environmental exposure and intrusive full Shell thickness repairs. The combination of these effects have resulted in diminished durability. Reviewed concrete material characteristics exhibited marginal durability characteristics in the form of low compressive strength values and significant water-soluble chloride ion content. Currently, the prior restorative concrete repair efforts are resulting in the formation of full Shell thickness leakage conditions. These observed leakage conditions can be expected to degrade the Shell at an ever increasing rate if left unrepaired/unprotected with the prospect of continued concrete deterioration an undesirable certainty.

TECHNICAL SUMMARY

The concrete Hyperbolic Cooling Tower superstructure Shell in Unit No. 1 at AEP'S Big Sandy Power Plant has experienced approximately 40 years of process service, environmental exposures and the effects of prior attempts at restoration. The combination of these effects have resulted in creating conditions of diminished durability. The condition of the reviewed structure, based on Structural Preservation Systems, Inc.'s (SPS) experience with similar structures, should be monitored on a regular basis to address changing distress conditions, should they occur. Also without initiating a repair/protection program, AEP should be prepared for progressive deteriorating conditions eventually leading long-term to a diminished structural integrity scenario for the subject Cooling Tower Shell. Based on information developed during the course of this investigation and the results of laboratory testing of submitted concrete samples, the reviewed reinforced concrete structure can be expected to degrade at an ever-increasing rate. AEP can however, by implementing a substantial and proactive repair strategy NOW, provide a significant extension to the structure's service life. Two repair/protection scenarios have been presented that provide repair opportunities for On-line service and Off-line outage Plant conditions. Using state-of-the-art concrete repair/protection technology augmented with high performance construction materials and sophisticated installation techniques, an effective repair/protection program can be implemented either during Unit operation or during a short duration outage. A successful repair program for structures similar to those reviewed, have historically required meticulous attention to repair construction detail, requiring a high level of repair technician competence, close coordination with the repair designer and understanding of AEP's requirements.

It has been SPS's experience after performing over 9000 concrete rehabilitation projects, a well planned and implemented repair/protection program should provide a significant amount of additional service life to the subject structure.

BACKGROUND AND PROJECT UNDERSTANDING

Based on site visits, meetings and review of project specific plans, SPS understands:

1. The reviewed structure was originally designed by L. G. Mouchel and Partners Consulting Engineers of London, UK in 1960 and constructed shortly thereafter for The Kentucky Power Company.
2. The Cooling Tower structure was designed to provide cooling to Unit No. 1, a fossil-fueled (ie. coal-fired), 260-Megawatt power plant.
3. The Cooling Tower design is based on the Marley-Mouchel Natural Draught Cooling Tower Concept consisting of spread mat foundations, diagonal columns, an integral ring beam and hyperbolic configured Shell Wall. The materials of construction consists of conventionally reinforced concrete.
4. Concrete design compressive strength requirements for above-grade cast-in-place, concrete elements were as follows:

- Foundation Base Pads	3,000 PSI
- Basin Floor and Division Wall	3,750 PSI
- Column Stools and inclined Columns	3,750 PSI
- Ring Beam at Base of Shell	3,000 PSI
- Annular Conduit Floor and Wall	3,750 PSI
- Shell Concrete Walls	3,750 PSI

5. The steel reinforcing bar grade noted on the reviewed construction documents revealed Intermediate Grade (Grade 40) with deformations conforming to ASTM-A305.
6. Construction drawings indicated the protective concrete cover overtop of embedded reinforcing steel bars in cast-in-place elements to be a minimum of 1-1/2 inches. Concrete members cast in contact with the earth were to have a minimum protective cover of 3 inches.
7. Access to the elevated level entry into the Cooling Tower is via a post-construction metal frame stairway with a catwalk leading to a metal frame doorway.
8. Two prior restoration attempts were performed in 1992 (2-phases) and in 1995 (4-phases) involving full depth excavation of the concrete Shell and replacement with shotcrete (ie. pneumatically placed concrete).

OBJECTIVE AND SCOPE

The objective of SPS's work was to evaluate the existing condition of the Hyperbolic Cooling Tower superstructure Shell in Unit No. 1 at the subject facility, evaluate the causes of concrete distress and provide conceptual repair recommendations. Work was performed within the following scope:

1. Reviewed available project documents relative to the subject structure.

2. Performed a visual inspection of accessible concrete surfaces, via two 10 feet wide swingstage scaffolding "drops" noting significant concrete features. Distress was photodocumented and incorporated into this report.
3. Performed an acoustic impact survey (ie. soundings) over accessible concrete Hyperbolic Cooling Tower superstructure Shell Wall surfaces in an effort to detect subsurface voids and/or delaminations (ie. internal separations).
4. Performed Ferroscan pachometer surveys and Proceq covermeter scans in an effort to determine the presence, orientation and protective cover thickness associated with the embedded reinforcing steel. Reinforcing steel bar configurations were drawn with lumber crayon on concrete surfaces to provide "clear" areas for core drilling and powder sampling. Additionally, the information was captured via instrumented software and recorded field sketches.
5. Performed Non-Destructive Testing including Rebound Hammer Testing (ASTM C-805) to establish relative consistency of the concrete, in-situ. Results were reported and included in this report although the testing was performed to assess qualitative attributes of the subject concrete surfaces and not quantitative measurements of the surface hardness with interpretative compressive strength.
6. Collected four (4) concrete cores using wet rotary diamond core drilling techniques. Four (4) concrete powder samples were also extracted at concrete core sample locations using rotary hammer drill techniques. Concrete core and drill holes were filled with shrinkage compensating repair mortar upon sample extraction.
7. Submitted collected core and powder samples for laboratory analysis including:
    a. pH Testing and Depth of Carbonation was determined using a modified phenolphthalein indicator solution sprayed onto freshly fractured concrete surfaces. Observation of resultant spray surface color tints indicates the existing concrete environment and current susceptibility to corrosion activity.
    b. Chloride Ion Content of Hardened Concrete Test (Germann Instruments RCT-500 Test Kit) results determine the water soluble chloride ion chemical level within the concrete. The detected level is an indicator of the potential electrochemical process of embedded metal corrosion within the concrete mass.
    c. Compressive Strength Testing of Concrete Core Specimens (ASTM C-42, Terra-Mar Inc. Report No. 008). Test results provide unconfined compressive strength values and is an indicator as to the relative quality of the concrete.
8. Performed a review of available repair/protection alternatives and evaluated comparisons between cost, effect on work space and installation during process operations.
9. Assembled and submitted this written report detailing findings, analysis and recommendations.

FIELD INVESTIGATION

Field investigation work was performed by SPS personnel on May 8 & 9, 2002. Work consisted of visual inspection, acoustic impact testing of accessible areas, Rebound Hammer testing of selected concrete surfaces, a pachometer/covermeter survey and collection of concrete core and powder specimens.

Visual Inspection – Site Survey

Accessible interior and exterior areas of the Hyperbolic Cooling Tower superstructure Shell Wall in Unit No. 1 at the subject facility were visually examined to document observed deterioration. Locations of observed distress were photodocumented and attached in Appendix A. An access swingstage Drop Location Plan is presented in Appendix B.

Acoustic Impact Testing

Acoustic impact testing (ie. mechanical sounding) was performed on accessible concrete surface areas of the Shell Wall. Using hammer and sounding rod techniques, surfaces were tapped with resonant sound emissions noted. Typically, surfaces impacted exhibited either a sharp metallic ring or dull hollow sound representing "sound" and "unsound" concrete conditions, respectively. Generally, unsound (ie. delaminated) areas were in the immediate proximity of localized open spalls or faulted crack regions adjacent to open spalls or in regions of "undressed" concrete repair attempts.

Rebound Hammer Testing

A Rebound Hammer consists of a spring-loaded steel hammer which when released strikes a steel plunger in contact with the concrete surface. The spring-loaded hammer travels with a fixed and reproducible velocity. The rebound distance of the steel plunger is measured on a linear scale attached to the frame of the instrument. This method (ASTM C-805; Test Method for Rebound Number of Hardened Concrete) is used to assess the uniformity of concrete in-situ, delineate areas of poor quality or deterioration in concrete structures. However, test values are not intended as an alternative for strength determination of concrete – the scale number values provide qualitative comparisons between similar concrete materials. Typically, a series of 10 readings are performed approximately 1 inch apart with test results recorded and tabulated. The test results indicated Rebound Hammer values ranging from 32 to 50 with an average value of 40. Referring to manufacturer supplied compressive strength correlation charts an average interpreted compressive strength of 4,950 PSI could be inferred, based on supplied chart data.

Pachometer Survey

A Ferroscan pachometer and Proceq covermeter were used to ascertain the presence, orientation and depth of protective cover of the as-constructed embedded reinforcing steel bars. The devices typically operate by generating an electromagnetic field which records disturbances created in the field by the presence of ferrous based materials, such as steel reinforcing bars. A total of four (4) locations were surveyed, in the immediate proximity of each concrete core and powder sample location. Detected reinforcing was documented using integrated equipment imaging software. Information regarding protective concrete coverage overtop of the embedded reinforcing steel bars was also captured and tabulated. Both reinforcing steel bar configurations and concrete coverage information has been attached in Appendix B. Apparent embedded reinforcing steel bars were marked in the field with lumber crayon on tested concrete surfaces. This technique was employed to "clear" concrete coring locations that minimized the opportunity of contacting and/or cutting embedded reinforcing steel.

Sample Extraction

Four (4) concrete core specimens were collected using wet rotary diamond core drilling techniques. Additionally, adjacent to Shell coring locations, four (4) powder samples were extracted using rotary hammer drill collection techniques. Concrete core and powder sample locations are shown on the Concrete Sample Location Drawings in Appendix B. Concrete core samples were visually examined with data logs attached in Appendix B. Concrete core and powder extraction holes were patched with shrinkage compensating repair mortar subsequent to sample collection.

LABORATORY TESTS

Laboratory testing on selected concrete core specimens and collected concrete powder samples included Water Soluble Chloride Ion Content of Hardened Concrete and Compressive Strength of Concrete Cores (ASTM C-42, Terra-Mar Inc. Report No. 008).

pH Testing and Carbonation Depth Determination

pH color indicating solution ("Rainbow Indicator" manufactured by Germann Instruments) results indicated pH values ranging from 7 to 11 for samples tested. Generally, the pH value of 7 was recorded from 0 to 1 inch in depth below the formed concrete surface. The remaining concrete materials revealed a pH value of 11. Results are recorded on Concrete Core Logs in Appendix B.

Chloride Ion Content

Water soluble chloride ion tests were performed on four (4) concrete powder samples removed from selected support members. Results of chloride tests indicated water soluble chloride ranged from 0.019 to 0.024 percent by weight of sample. Using an assumed calculated cement content of 15%, water soluble chloride ranged from 0.127 to 0.160 percent by weight of cement. Detailed test results are provided in the report entitled "Water Soluble Chloride Ion Content of Hardened Concrete", attached in Appendix B.

Compressive Strength

Compressive strength tests were performed on core samples that were of acceptable laboratory quality. All four (4) concrete core samples, from representative reinforced concrete Shell Wall elements, met laboratory criteria. Results of the compressive strength tests on submitted cores ranged from 3,100 to 3,600 PSI. Information on sample identification and detailed test results are provided in ASTM C-42, Terra-Mar Inc. Report No. 008, entitled "Drilled Core Compression Test Report" in Appendix B.

ANALYSIS

The following analysis of the concrete Hyperbolic Cooling Tower superstructure Shell in Unit No. 1 at AEP's Big Sandy Power Plant Louisa, Kentucky is presented below.

Material Properties

Compressive strength results indicate the concrete strength ranges from 3,100 PSI to 3,600 PSI. Average laboratory compressive strength for the 4 concrete cores tested were 3,335 PSI, well below the specified design compressive strength of 3,750 PSI. Please note, the American Concrete Institute (ACI) allows extracted concrete core specimens, subjected to laboratory compression testing, to represent 85% of the design compressive strength due to the destructive nature of the core extraction process (refer to ACI Committee report 318 "Building Code Requirements for Reinforced Concrete"). Based on ACI guidelines, the average compressive strength value is approximately equivalent to 3,925 PSI.

The depth of carbonation essentially extends down to 1 inch below the formed exposed concrete surface. Carbonation is the reaction of carbon dioxide from the air with calcium hydroxide in concrete, which results in product formation of calcium carbonate. This reaction product has a lower pH (ie. more acidic) than the parent material and effectively "depassifies" the alkaline environment of concrete. An alkaline environment is necessary for a passive film to form on the steel reinforcement to inhibit the electrochemical process of corrosion. The generally accepted pH value of 9.8 has been determined as a depassification threshold below which the concrete mass can be assumed to be an "active participant" in the corrosion process. Concrete material carbonation does not appear to be a significant contributor to the observed distress.

Corrosion Survey

Concrete powder samples extracted from selected concrete support members were tested for water soluble chloride ion content. Results of chloride tests on concrete powder samples ranged from 0.127 to 0.160 percent by weight of cement. According to the ACI Report 222, "Corrosion of Metals in Concrete", under some conditions, a chloride content of as little as 0.15% by weight of cement is sufficient to initiate corrosion of embedded steel in concrete, in the presence of oxygen and moisture. All powder samples had tested values within the approximate range of the established ACI corrosion threshold amount for chloride in concrete. The chloride samples were collected from 0 to 3 inches below the exposed concrete surface. Results recorded suggest these chloride levels may have existed at the time of original construction due to the consistently elevated chloride ion contents within the structures tested. Chlorides are typically incorporated into fresh concrete either by the introduction of chloride laden mixture constituents (ie. water, cement, sand or stone) and/or incorporation of chloride chemical admixtures during batching.

Visually obvious examples of localized corrosion were not observed with any frequency throughout the reviewed structure. However, when encountered, the electrochemical corrosion process at that location culminated with the complete detachment of the concrete cover ranging in thickness from 0 to 1 inches. During embedded steel bar corrosion activities, the steel bar metallurgy changes, with corrosion products requiring and occupying more space than the parent material. As such, significant tensile stresses are exerted on the concrete in the immediate proximity of the corroding rebar. Although inherently strong in compression, concrete is relatively weak in tension. Therefore, unrestrained portions of the concrete mass (ie. protective cover overtop of embedded reinforcing bars) will crack at the corroding bar interface.

DETERIORATION

Discussions presented below are generally related to environmental process exposure of the Hyperbolic Cooling Tower superstructure Shell in Unit No. 1 at AEP's Big Sandy Power Plant Louisa, Kentucky

Cracking

Cracking observed at the subject structure typically took the form of planar fine horizontal and vertical cracks with crack width measurements ranging 0.003 to 0.005 inches. Crack patterns were determined to be planar (ie. level across crack shoulder edges) and are believed to be related to material shrinkage characteristics of the normal-weight, cast-in-place concrete members.

Leakage & Efflorescence

At many locations along the exterior of the Hyperbolic Cooling Tower superstructure Shell, white mineral deposits (i.e. efflorescence), believed to be composed of salt precipitants, were located adjacent to leaking joints in the concrete. The joints, both horizontal and vertical appear to be associated with prior restoration attempts at the structure and from original construction. Essentially, the leaking joints occur at the interface between the original concrete Shell and the edge of the existing patch repairs and at original Jump Panel formwork joints. These leaking areas are typically associated with moisture migration through concrete with efflorescence the result of leaching cement paste hydration products.

Typically, inside a Hyperbolic Cooling Tower Shell, the ambient environment includes both high temperatures and high relative humidities. On the Shell's exterior, the environmental conditions are dictated by atmospheric weather conditions. Generally, interior temperatures and relative humidities are higher within the Shell than outside the Shell. As a result of these environmental differences, water in vaporous form, will migrate or "drive" through the concrete Shell cross-section. The driving force for the water vapor diffusion from the inside to the outside surface is the temperature and humidity gradients between the interior and exterior of the Shell. Also, as water vapor migrates across the concrete Shell section, it transports in solution, mineral products that emerge and form exposed surface deposits (ie. efflorescence), upon desiccation.

Concrete anomalies such as cracks or joints facilitate water penetration through the concrete Shell. Water vapor drive from the interior to the exterior can be expected to be greatest at the location of the Shell throat (ie. smallest dimensional radius) because the velocity and density of the interior water vapor is greatest. Another potential source of moisture is the water vapor plume that exits a Hyperbolic Cooling Tower and cascades onto the exterior top elevations of the Shell.

Delamination

Areas of internal separations (ie. delaminations) were typically not detected at the structure surveyed. Generally, the only delaminated areas detected were in very localized regions adjacent to exposed corroding reinforcing steel bars or associated with "undressed" conditions along the perimeter of existing repair patches. Embedded reinforcing steel corrosion processes have been discussed above in the **Corrosion Survey** portion of this report.

Spalling

Spalling is defined as areas of concrete cross-sectional loss created by detachment and/or dislodging of the concrete mass by natural (ie. gravity, seismic, flood, etc.) or manmade forces (ie. fire, impact, corrosion, etc.). The spalling observed at the subject site appears primarily related to the failure of concrete in tension. As the tensile strength of the concrete material was exceeded by expansion forces created during embedded metal corrosion product formation, the concrete separated from the "parent" substrate along a conical failure plane. The spall always progresses along the path of least resistance whereby the failure initiates at the corroding rebar/concrete interface and extends toward the unrestrained outer surface (ie. through the unreinforced concrete cover). The spalling observed was typically associated with lack of as-specified concrete protective coverage overtop of embedded reinforcing steel bars and was very localized.

Existing Concrete Patches

Examination of the 1992 & 1995 vintage concrete restoration programs exhibited varying levels of deterioration. Review of AEP-supplied archival information, attached in Appendix C, indicates approximately 263 concrete patch repair locations exist at the subject Cooling Tower. Repairs are primarily located in a region extending down 60 feet from the top of the Cooling Tower with the highest incidence of "patch repairs" located in the Northwestern third of the Cooling Tower. Examining photographic documentation generated during the various restoration phases revealed the typical patch extends through the entire Shell section. Reinforcing steel augmentation in those regions of reinforcing steel cross-section loss were noted in photographs as well as the use of single-sided plywood formwork. Although, one photograph shows perimeter-edge sawcutting, the majority of production repairs indicate rough edge perimeters. The repair material placement method viewed from photographs indicated shotcrete application techniques at less than a 90^0 nozzle incident angle. Reportedly, the material applied was conventional shotcrete.

Finished patch repair surfaces exhibit a rough, float finished surface texture on the exterior of the concrete Shell and a somewhat smoother surface, but having significant "overpour" edges, on interior concrete Shell surfaces. It should be noted that the Jump-Panel Formwork construction process, used to construct the concrete Hyperbolic Cooling Tower superstructure Shell, provides existing Shell surfaces with numerous formwork fins and depressions. At most repair locations, the patch perimeter visually appears to be leaking water and leaching white mineral deposits (ie. efflorescence).

FINDINGS AND RECOMMENDATIONS

The information developed during the course of this evaluative effort brought to light several interesting factors relative to the subject structure. Being the "first-of-a-kind" for a structure of its' type constructed in the United States, based on an European design, the structure incorporated unique construction detailing. Construction details such as employing single layer steel bar reinforcing, having a thin Shell thickness (ie. 6 to 8 inches) and specifying low protective concrete coverages (minimum of 1-1/2 inches) were seen as innovative and optimized at the time of construction. However, in service, these details have generated concern regarding the long-term durability of the structure. Specifically, with tested marginal concrete properties outlined in the **ANALYSIS** portion of this report, the optimally designed structure is more sensitive to environmental and process service conditions than a structure designed to current standards. Currently, structures of similar service to the one reviewed, incorporate improved durability detailing in the form of:

- Dense concrete materials of construction
- Thicker concrete Shell cross-sections (12 to 32 inches in section)
- Increase in concrete protective coverage thickness with minimums in excess of 2 inches
- Steel reinforcing design redundancy in the form of double-mat steel bar systems.

It should be noted that the concrete Hyperbolic Cooling Tower Shell did not exhibit any visible features that would be interpreted to be a compromise in structural integrity. Faulted cracking, torsional crack patterns and/or racking of the structure were not visually apparent at the subject structure.

Based on the information developed during the course of this investigation and meetings with AEP personnel while on-site, several concrete repair/protection scenarios were discussed and thoroughly considered. The programs outlined below follow two paths. The first program provides a repair/protection opportunity during On-line process service and will not require any interruption of process service. The second scenario incorporates a "positive" side waterproofing membrane that will require an Off-line service outage of the Hyperbolic Cooling Tower to allow for membrane installation. Of the two programs highlighted, the Off-line Repair/Protection Option is superior due to its' positive side monolithic waterproofing membrane features.

General Project Repair/Protection Priorities

Much of the distress observed at the concrete Hyperbolic Cooling Tower Shell took the form of water/vapor leakage along joints and through cracks in the existing Shell concrete and patch repairs. As such, a repair/protection program establishing an effective waterstop/seal will be required to provide extended durability to the concrete Shell and mitigate contact of embedded reinforcing steel with external moisture. Stopping moisture contact with embedded reinforcing steel, in the presence of carbonated concrete materials and significant chloride ion contents, will provide a significant extension to the structure's service life.

On-line Repair/Protection Option

Water/vapor leakage that migrates along joint and crack interfaces can be effectively stopped employing chemical grout injection techniques performed along exterior concrete Shell surfaces. Essentially, each joint/crack location will require "port-to-port" communication to ensure a successful grouting installation. The chemical grout materials are pressure-injected into predrilled port locations where they penetrate joint cavities and crack fissures, chemically catalyze and expand to completely fill joint/crack interface areas. This action stops the ingress and egress of moisture along chemically grouted joint cavities and crack fissures. The single-side chemical grouting operation allows waterstop/seal activities to be performed from the exterior and doesn't require a Cooling Tower outage. However, should new cracking propagate overtime, additional chemical grouting of new cracks may be required at a later date.

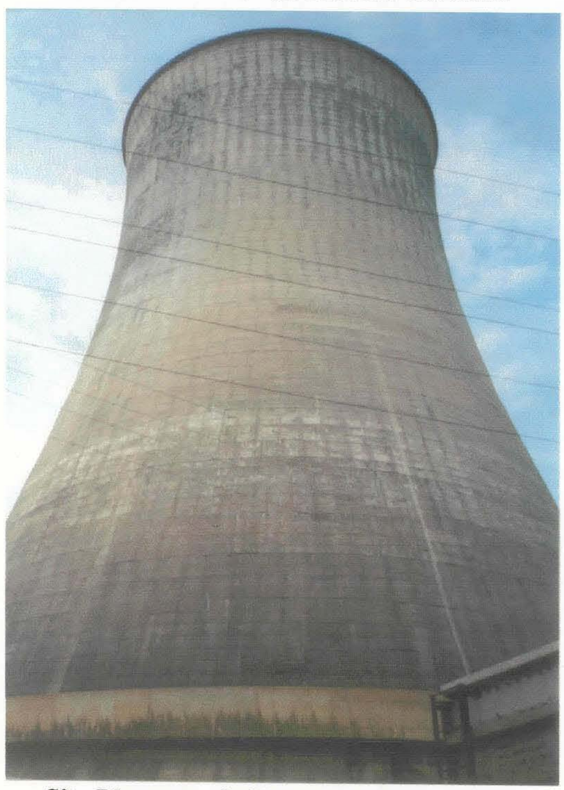
Off-line Repair/Protection Option

Providing a "positive" side waterproofing membrane to interior concrete Shell surfaces provides an excellent barrier to water/vapor migration, when designed to address the ambient service environment including airborne chemical contact. However, for a waterproofing membrane to be effective, a significant amount of surface preparation and detail work will be required due to the original Jump Formed concrete surface, irregular patch repair edges and the presence of surface algae. Membrane surface preparation requirements typically include surface grinding and abrasive grit/waterblasting. Subsequent to surface preparation, surface priming and membrane application follow strict adherence to manufacturer recommendations. Construction monitoring during membrane installation generally follows a defined Quality Assurance and Quality Control (QA/QC) Program with "Go" and "No-Go" milestones. The purpose of the QA/QC program is to capture information at the time of installation to determine, in a timely manner, the acceptability and long-term prospect for success of the subject installation. The advantage associated with the Off-line repair/protection option is the installation of a monolithic waterproofing membrane to all interior concrete superstructure surfaces at the Hyperbolic Cooling Tower. Should new cracking propagate, the cracks would be effectively "bridged" by the elastomeric properties of the membrane and maintain the Shell's water-tightness.

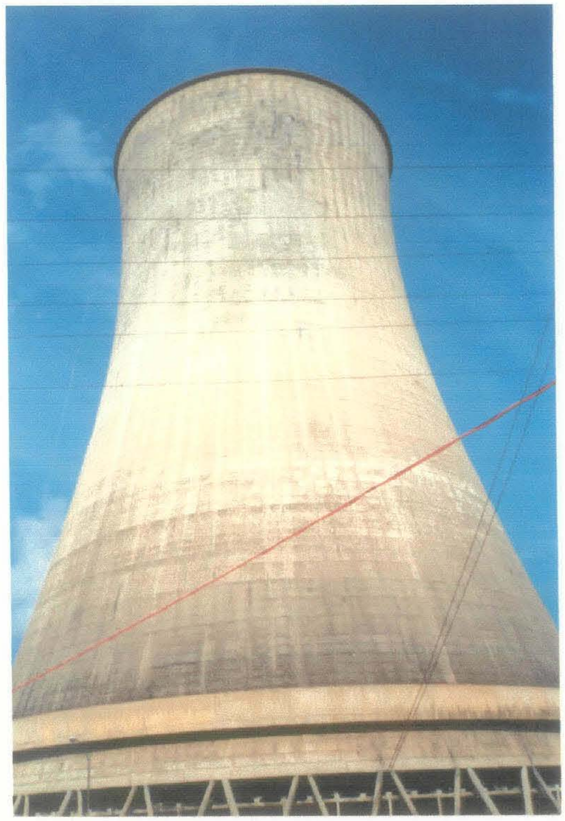
APPENDIX A

SITE PHOTOGRAPHS

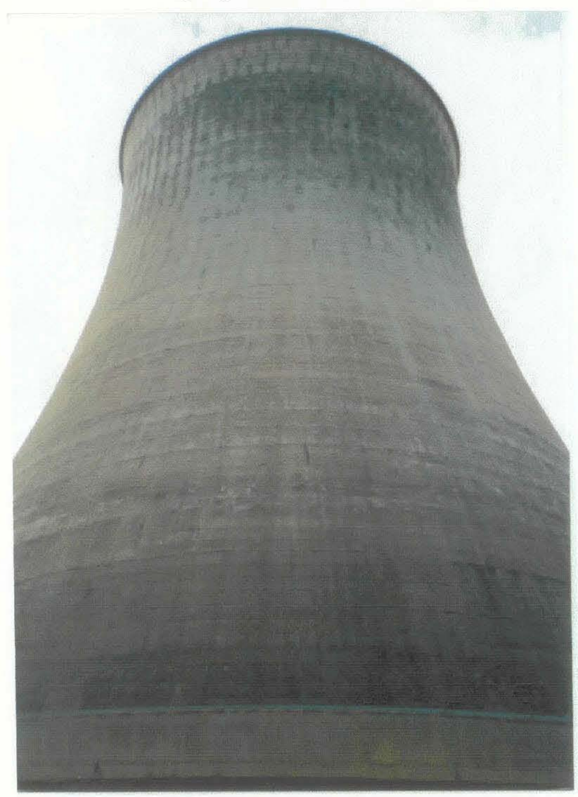
Site Photograph No. 1 Overall view of Cooling Tower Inspection Drop Location at Unit No. 1 North elevation



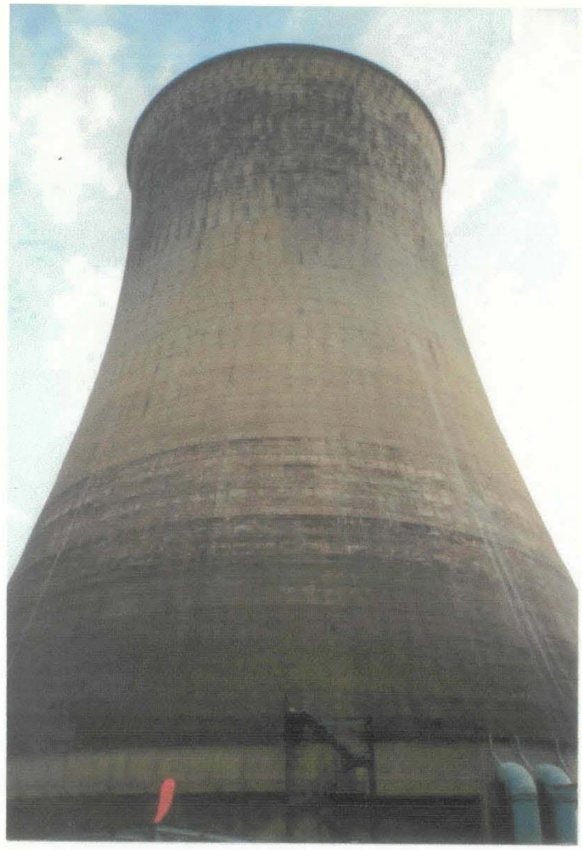
Site Photograph No. 2 South elevation



Site Photograph No. 3 West elevation



Site Photograph No. 4 Southeast elevation



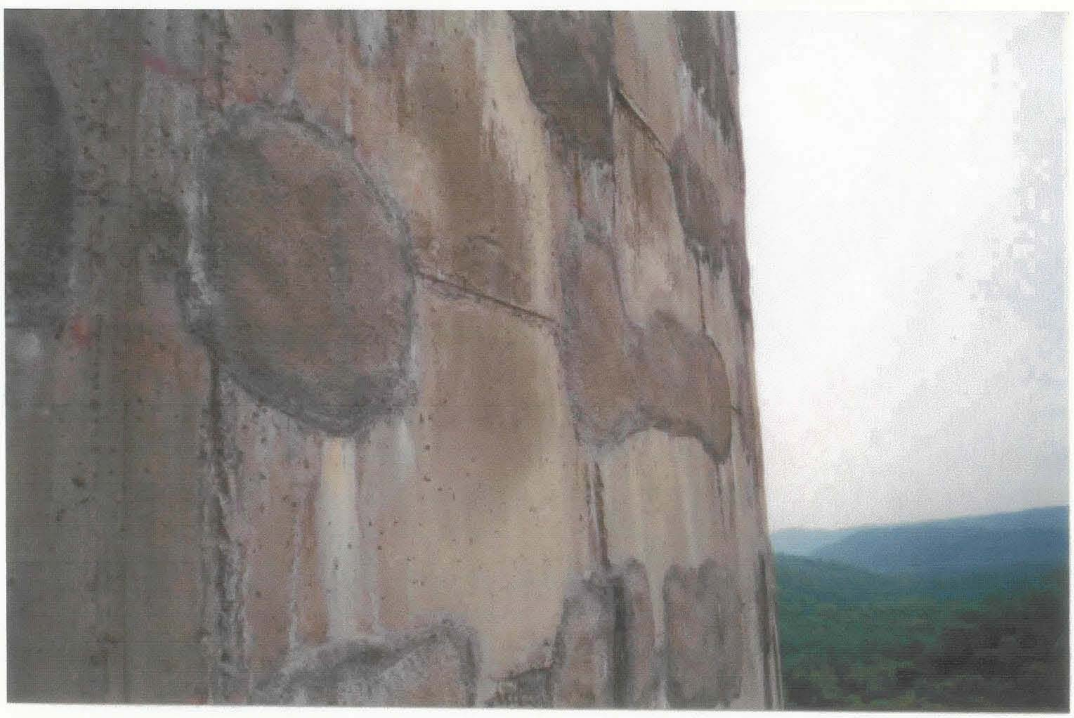
Site Photograph No. 5 Northeast elevation

Site Photograph No. 6 Patch repairs on interior face of Cooling Tower Shell

Specimen Photograph No. 7 Patch repairs on interior face on Cooling Tower Shell

Site Photograph No. 8 Patch repairs and close-up of jump panel formwork impressions on exterior face on Cooling Tower Shell

Specimen Photograph No. 9 Patch repairs on exterior face of Cooling Tower Shell. Note efflorescence and water leakage conditions along patch perimeter

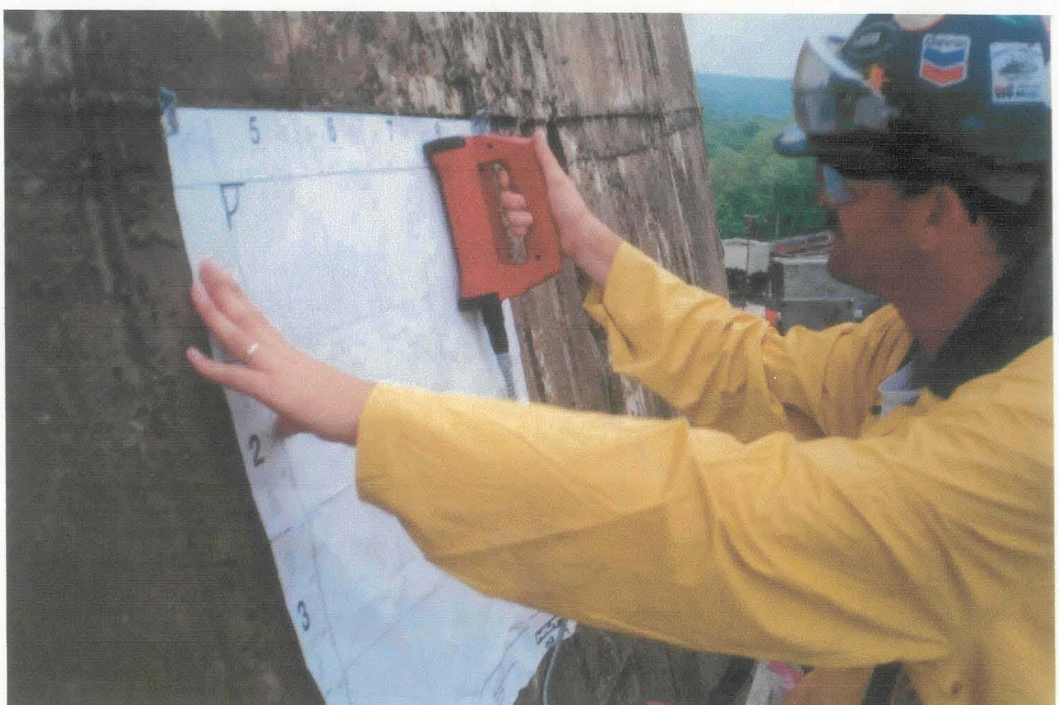


Site Photograph No. 10 Patch repairs on exterior face of Cooling Tower Shell. Note irregular patch repair configuration

Specimen Photograph No. 11   Typical honeycomb at panel joint locations

Specimen Photograph No. 12   Corroded rebar

Specimen Photograph No. 13 Rebound hammer testing



Site Photograph No. 14 Ferroscan testing

Specimen Photograph No. 15 Core extraction location and reinforcement layout markings

Specimen Photograph No. 16 Core extraction location and reinforcement layout markings

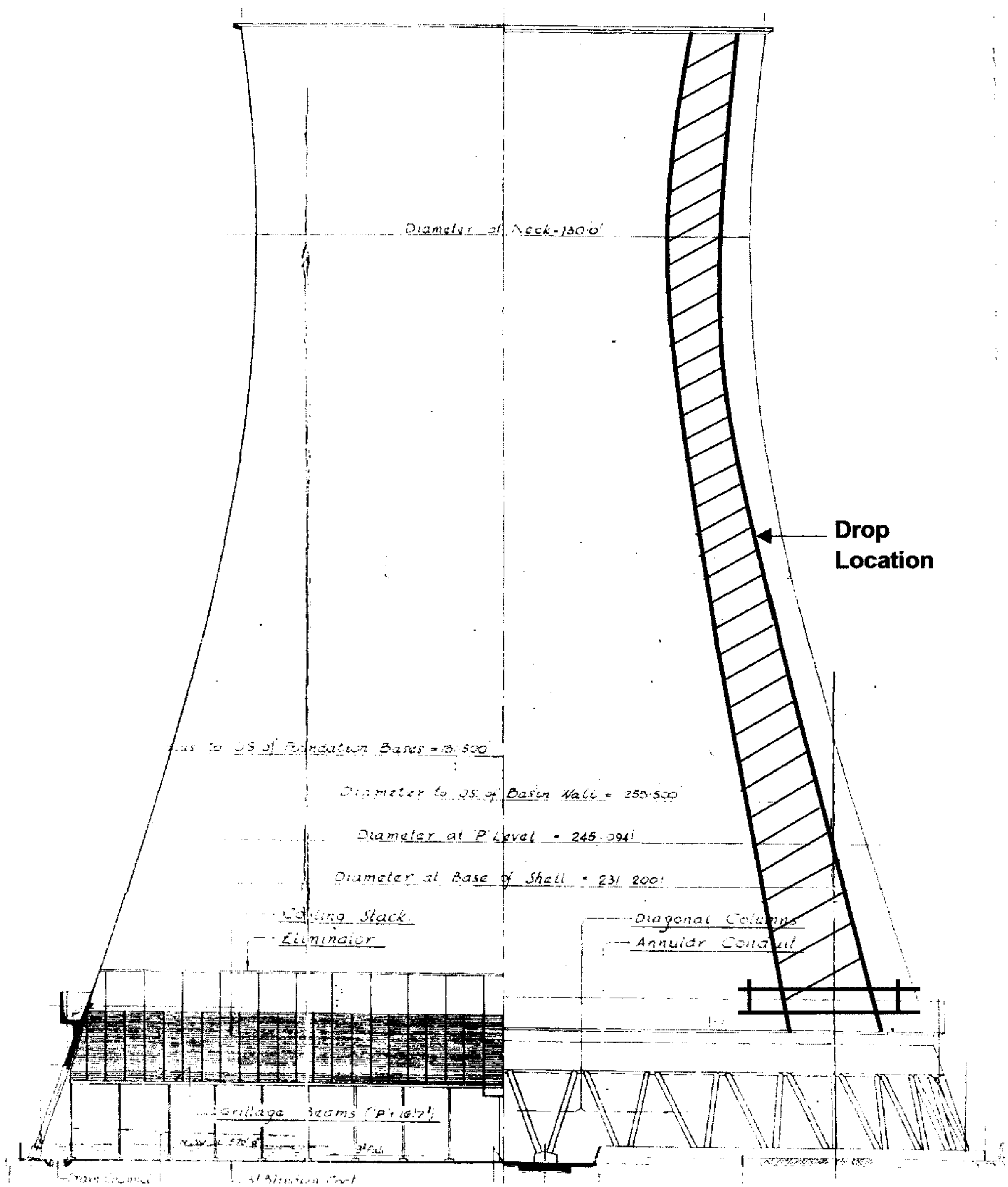
Site Photograph No. 17 Core sample extraction

Site Photograph No. 18 Core excavation

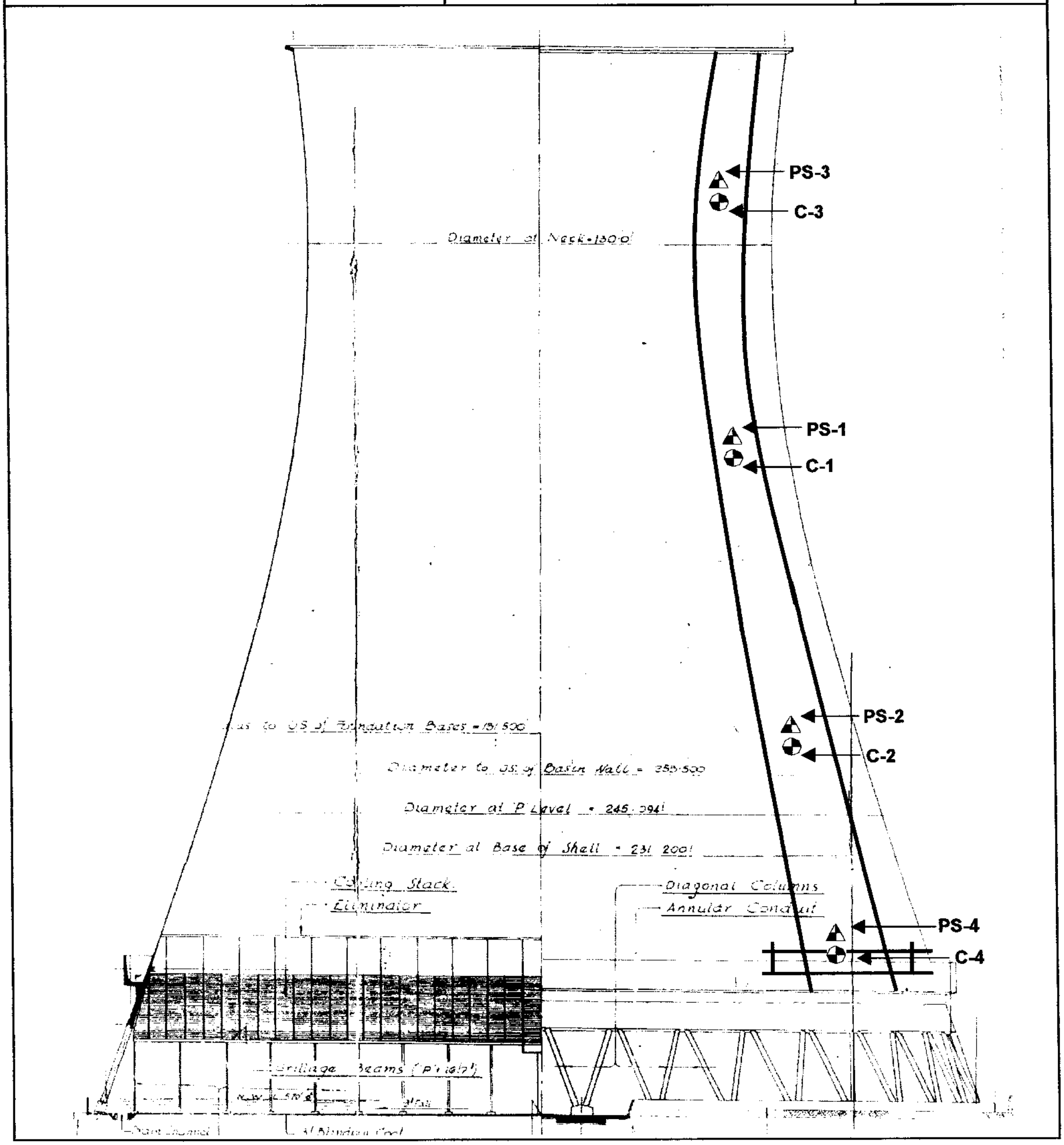
APPENDIX B

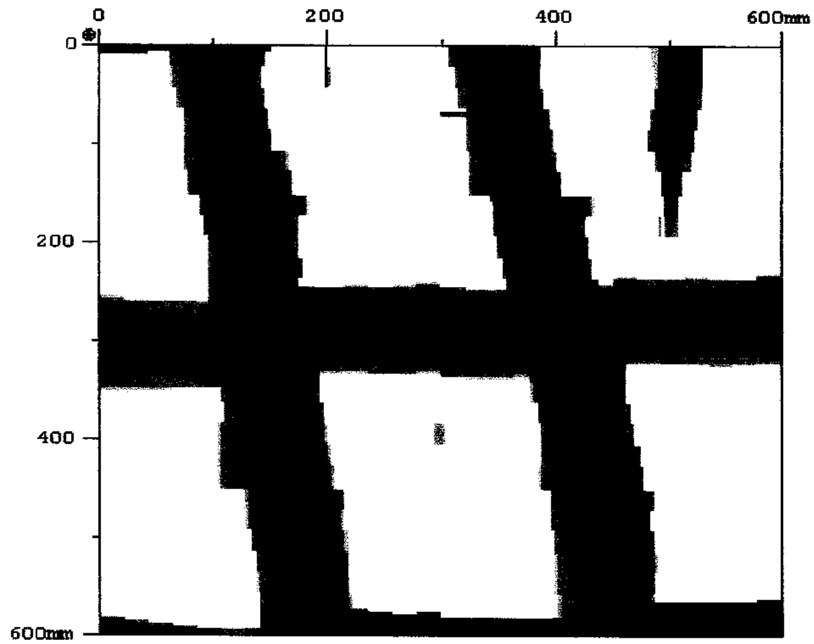
EXTERIOR/INTERIOR SHELL TESTING

STRUCTURAL PRESERVATION SYSTEMS	SUBJECT: AEP - COOLING TOWER UNIT 1 - BIG SANDY	
	JOB: 10147	PAGE: FIG. NO. 1
	DESIGNED BY: JOEL MOORE	DATE: 6/21/2002

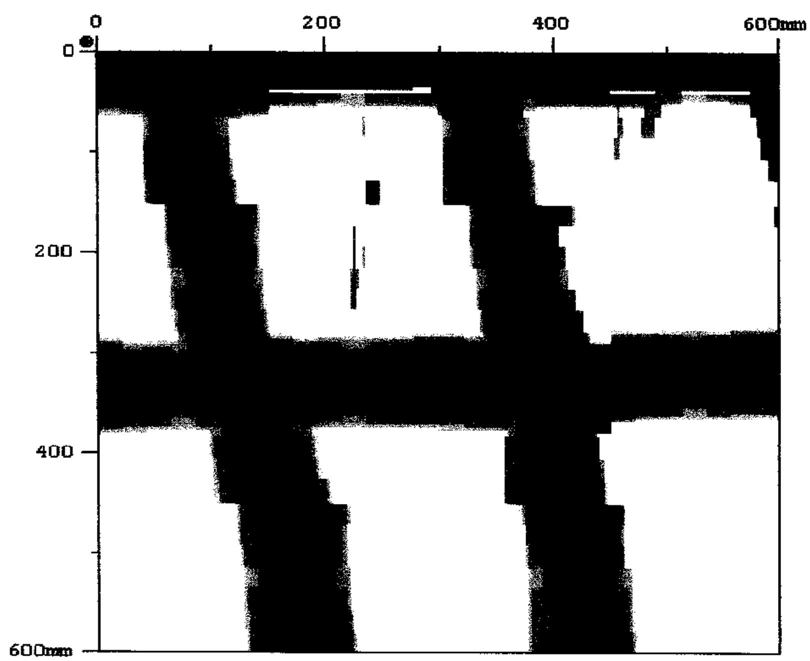


STRUCTURAL PRESERVATION SYSTEMS	SUBJECT: AEP - COOLING TOWER UNIT 1 - BIG SANDY CORE AND POWDER SAMPLE LOCATIONS	
	JOB: 10147	PAGE: FIG. NO. 2
	DESIGNED BY: JOEL MOORE	DATE: 6/21/2002

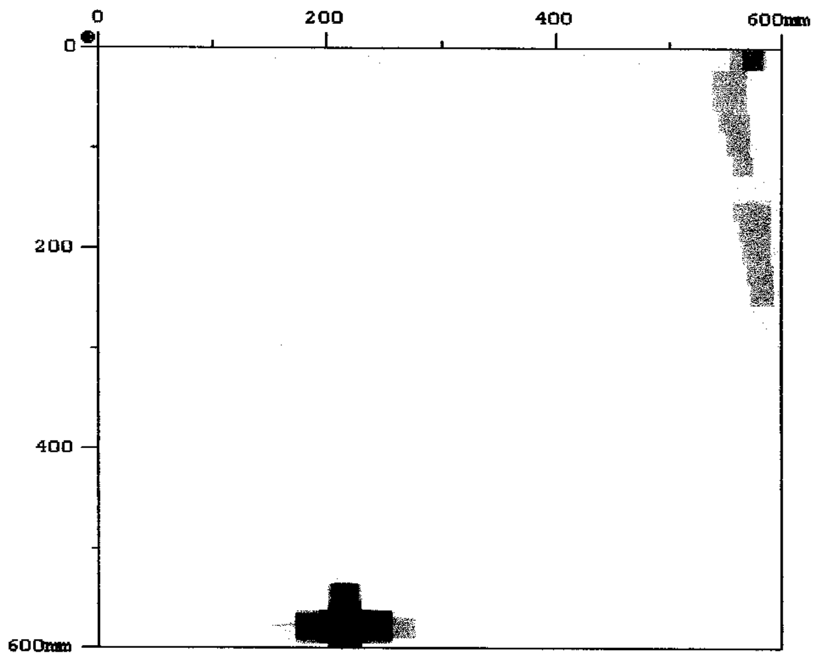




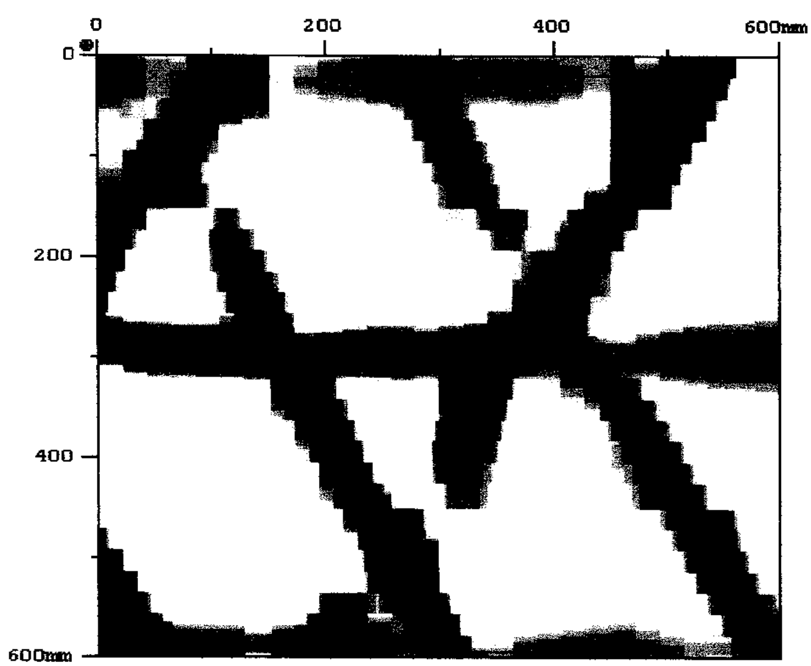
Ferroscan Plot No. 1 Exterior drop at Elevation 184'



Ferroscan Plot No. 2 Exterior drop at Elevation 121'

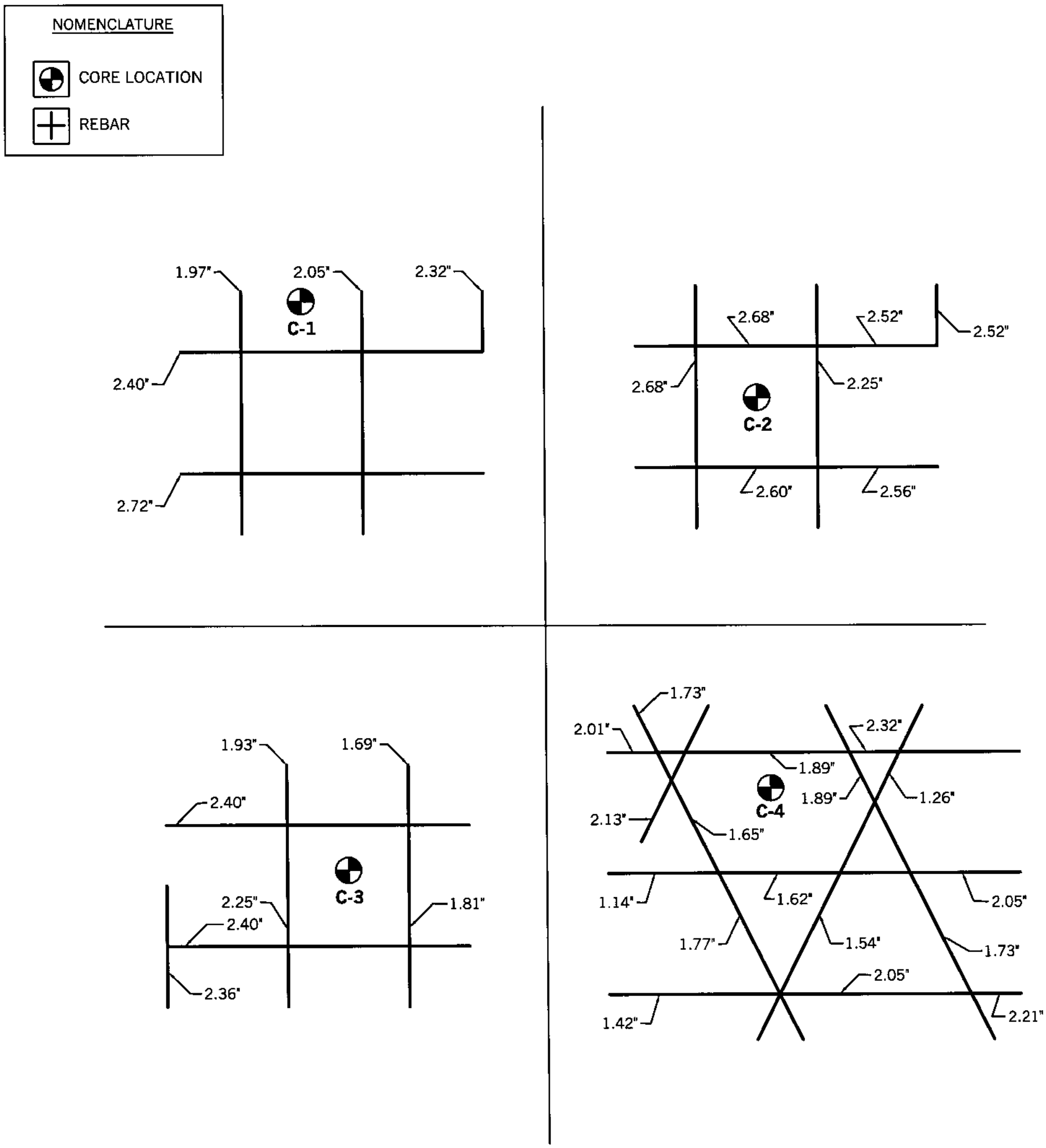


Ferroscan Plot No. 3 Interior drop at Elevation 245'



Ferroscan Plot No. 4 Interior drop at Elevation 50'

STRUCTURAL PRESERVATION SYSTEMS www.structural.net	SUBJECT: Concrete cover measurements with Proceq Pachometer	
	JOB NO: 40147	PAGE: FIG. NO. 3
	DESIGNED BY: JM/LE	DATE: 6/26/2002



STRUCTURAL PRESERVATION SYSTEMS

REBOUND HAMMER DATA (ASTM C-805)

Project Name: AEP - Cooling Tower Unit 1 - Big Sandy **Date:** 5/8/2002

Project No.: 40147 **Inspectors:** Ralph Noble

Location: Louisa, KY **Page** 1 **of** 1

No.	Location	Orientation V, O, H or angle wrt H	Concrete Surface Condition	Measurements	
1	Exterior Drop 184' Above grade	V	Wet	High 42	Low 36
				Mean 39	Strength (psi) 4800
2	Exterior Drop 121' Above grade	V	Wet	High 50	Low 42
				Mean 46	Strength (psi) 6400
3	Interior Drop 245' Above grade	V	Wet	High 42	Low 32
				Mean 37	Strength (psi) 4500
4	Interior Drop 50' Above grade	V	Wet	High 40	Low 32
				Mean 36	Strength (psi) 4100
				High	Low
				Mean	Strength (psi)
				High	Low
				Mean	Strength (psi)
				High	Low
				Mean	Strength (psi)

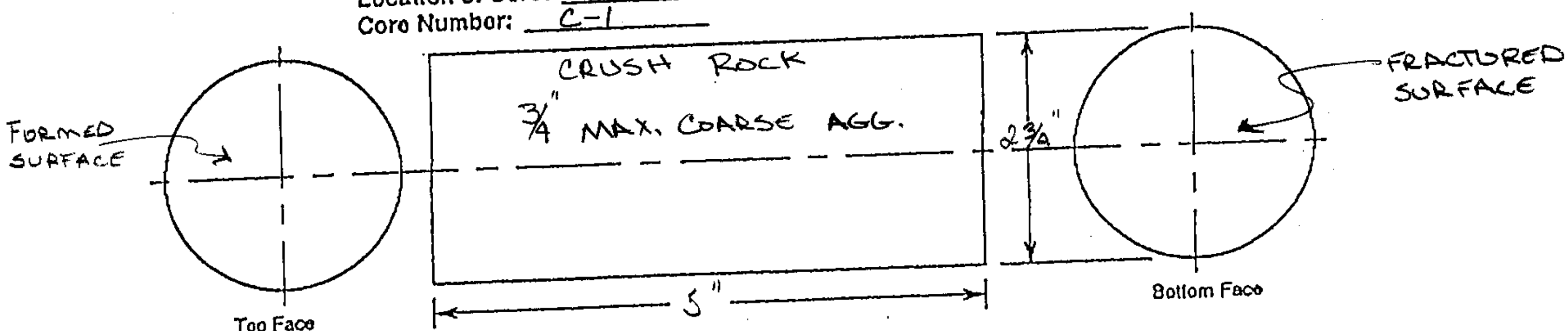
STRUCTURAL PRESERVATION SYSTEMS

CORE LOG

Project Name: AEP
Project No.: 40147
Location: COOLING TOWER UNIT #1

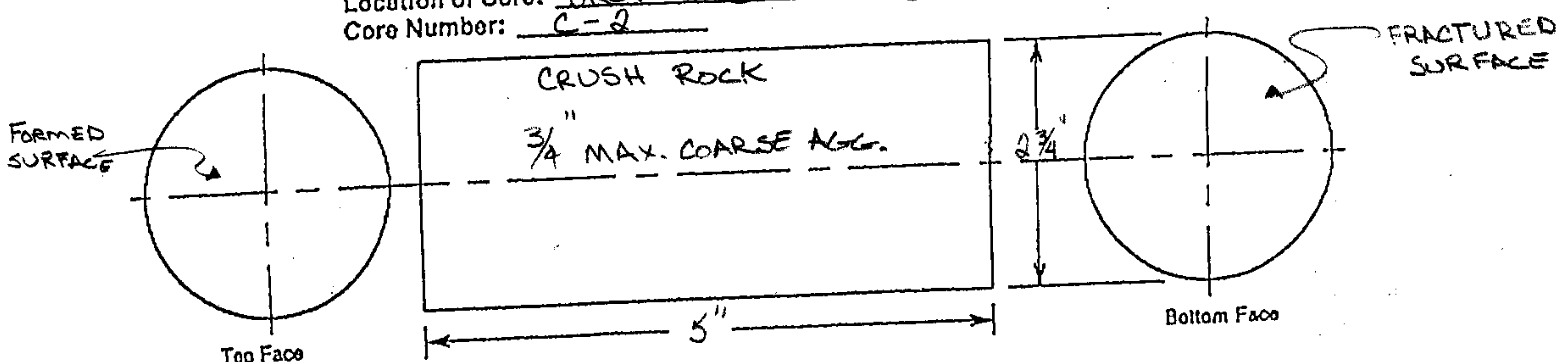
Date: 5/8/02
Inspectors: TK/RN
Page 1 of 2

Location of Core: DROP #1 @ 184' (EXTERIOR)
Core Number: C-1



Depth to Reinforcement from Top Face: N/A
Comments: PH READING 0"-1" 7 1"-5" =11

Location of Core: DROP #1 @ 121' (EXTERIOR)
Core Number: C-2



Depth to Reinforcement from Top Face: N/A
Comments: PH READING 0"-3/8 =7 3/8"-5" -11

FIGURE NO. 4

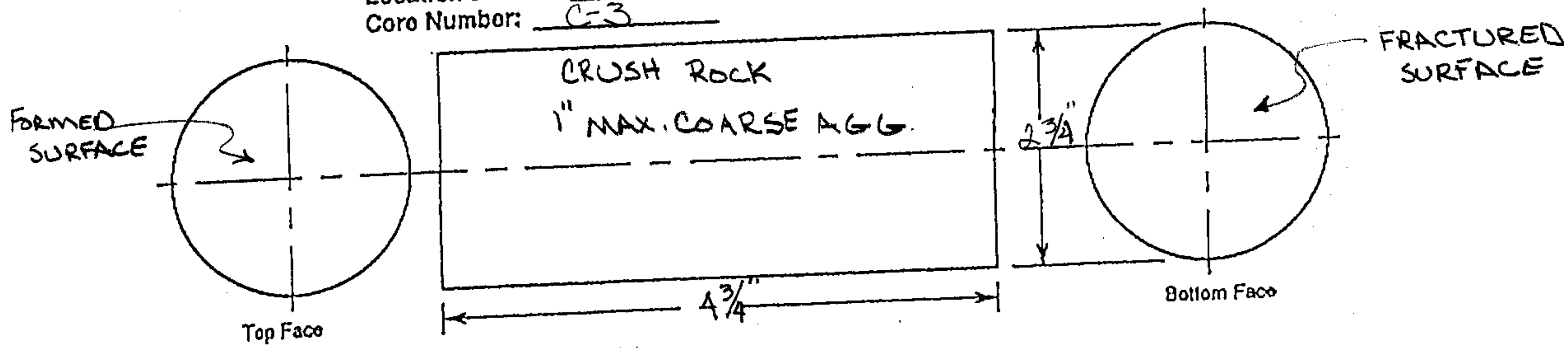
STRUCTURAL PRESERVATION SYSTEMS

CORE LOG

Date: 5/9/02
Inspectors: TK/RN
Page 2 of 2

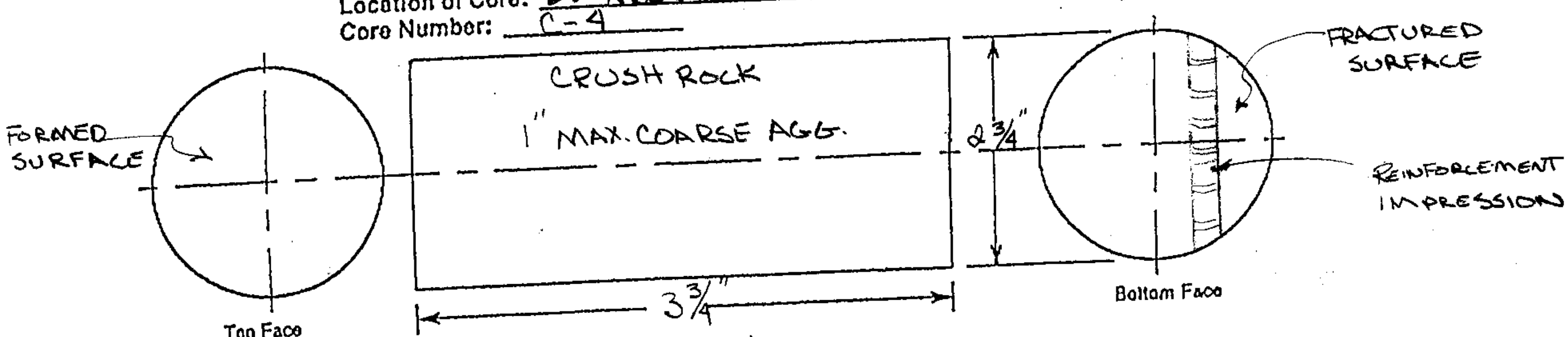
Project Name: A.E.P
Project No.: 40147
Location: COOLING TOWER UNIT #1

Location of Core: 245' ABOVE GRADE (INTERIOR)
Core Number: C-3



Depth to Reinforcement from Top Face: N/A
Comments: PH READING: 0" - 3/8" = 7 3/8" - 4 3/4 = 11

Location of Core: 50' ABOVE GRADE (INTERIOR)
Core Number: C-4



Depth to Reinforcement from Top Face: N/A 2 3/4"
Comments: PH READING: 0" - 1/4 = 7 1/4' - 3 3/4' = 11

FIGURE NO. 5

Core Photograph No. 1 Cores C-1 and C-2

Core Photograph No. 2 Cores C-3 and C-4

WATER SOLUBLE CHLORIDE ION CONTENT OF HARDENED CONCRETE

Report No.	40147-01
Structure:	AEP - Cooling Tower Unit 1 – Big Sandy – Louisa, KY
Date of Testing:	June 1, 2002
Date of Sampling:	May 9, 2002
Testing Entity:	Structural Preservation Systems, Inc. 14713 Jersey Shore Drive Houston, TX 77047 Phone: (713) 433-2155 Fax: (713) 433-2558
Testing Method:	Germann Instruments - Rapid Chloride Test - RCT 500 Kit Chloride Extraction Fluid/Electrode Analysis
Electrode No. 1	
Test Operator:	Ralph Noble

SPS ID	Location	Description*	% Cl (wt.-sample)	% Cl (wt.-cement**)
PS-1	At Core Location #1	Concrete	0.0240	0.1600
PS-2	At Core Location #2	Concrete	0.0210	0.1400
PS-3	At Core Location #3	Concrete	0.0190	0.1267
PS-4	At Core Location #4	Concrete	0.0220	0.1467

* Concrete powder collected using rotary hammer drill collection techniques at a depth ranging from 0 to 3 inches below the exposed concrete surface.

** Percent by weight of cement based on an assumed concrete cement of 564 lbs. per cubic yard.

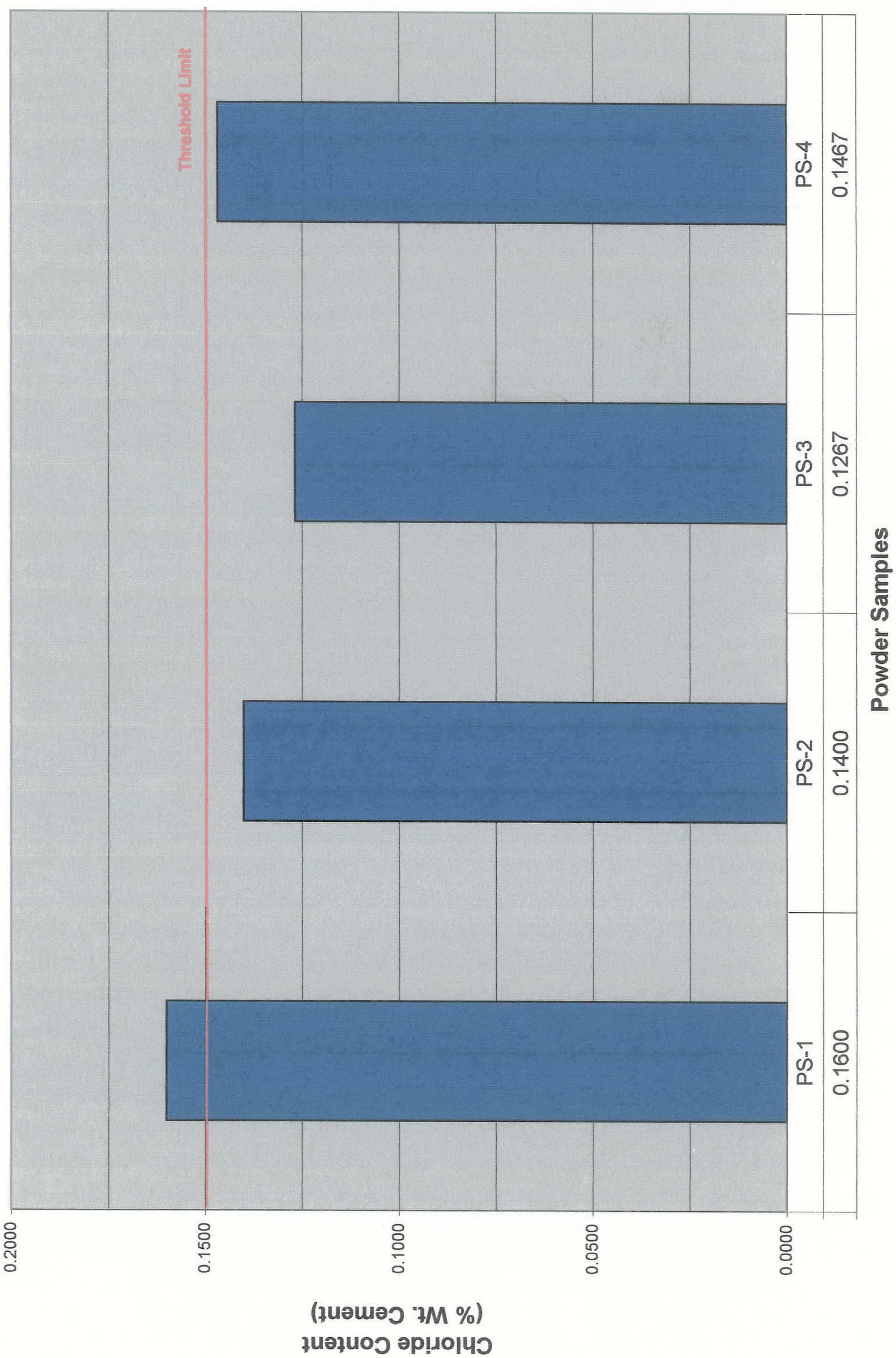


Figure No. 6 Chloride content graph
Cooling Tower Unit 1 - Big Sandy

TERRA-MAR

Consulting Engineers • Geotechnical • Environmental • Construction Materials Testing

AUSTIN • DALLAS • FORT WORTH • HOUSTON • LONGVIEW

DRILLED CORE COMPRESSION TEST REPORT

CLIENT:	Structural Preservation Systems	**DATE:**	5/20/2002
PROJECT:	A.E.P. Louisa Ky.	**TMI PROJECT NO.:**	HC01-099
	PO No.7381	**TMI REPORT NO.:**	008
CONTRACTOR:	N/A		

Date Drilled: N/A		Drilled By:	Contractor
Date Tested: 5/16/2002		Age at Test (days):	40 years
Moisture Condition at Time of Testing: Dry		Design Strength, fc=	3750 psi
Nominal Max. Size of Aggregate: N/A	**0.85 f'c: = 3190 psi**	**0.75 f'c: = 2810 psi**	

LOCATION OF DRILLED CORES

CORE #	LOCATION	CORE LEN. In.
	Cooling Tower	
C-1	**Concrete Shell**	5.10
C-2	**Concrete Shell**	5.20
C-3	**Concrete Shell**	5.05
C-4	**Concrete Shell**	4.00

CORE COMPRESSION TEST RESULTS

CORES OBTAINED AND PREPARED BY TERRA-MAR ARE PER ASTM C42. TESTED PER ASTM C39.

CORE NO.	CUT LENGTH (in.)	CAPPED LENGTH (in.)	DIA (in.)	AREA (sq. in.)	MAX. LOAD (lbs.)	l/d	CORRECTION FACTOR	STRENGTH (psi)
C-1	4.80	5.00	3.00	7.07	23210	1.67	0.9736	3200
C-2	4.95	5.35	3.00	7.07	24440	1.78	0.9816	3390
C-3	4.85	5.15	3.00	7.07	22390	1.72	0.9776	3100
C-4	3.65	3.90	3.00	7.07	27550	1.30	0.9360	3650

Respectfully Submitted
TERRA-MAR, INC.

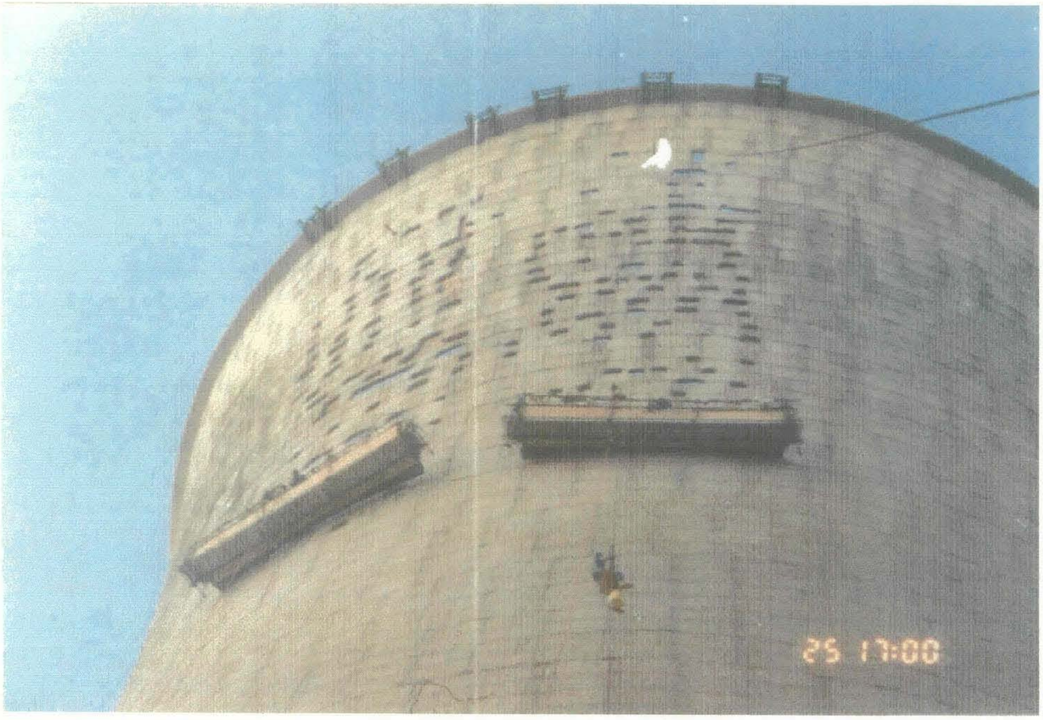
Haddis Tewolde
CMT Department Manager

Note: This report is for the exclusive use of the client addressed. This report may not be reproduced except in its entirety, without the written consent of Terra-Mar, Inc.

J:\CMT-HC\Forms\1997\CORECOMP.xls

APPENDIX C

EXISTING DOCUMENTATION



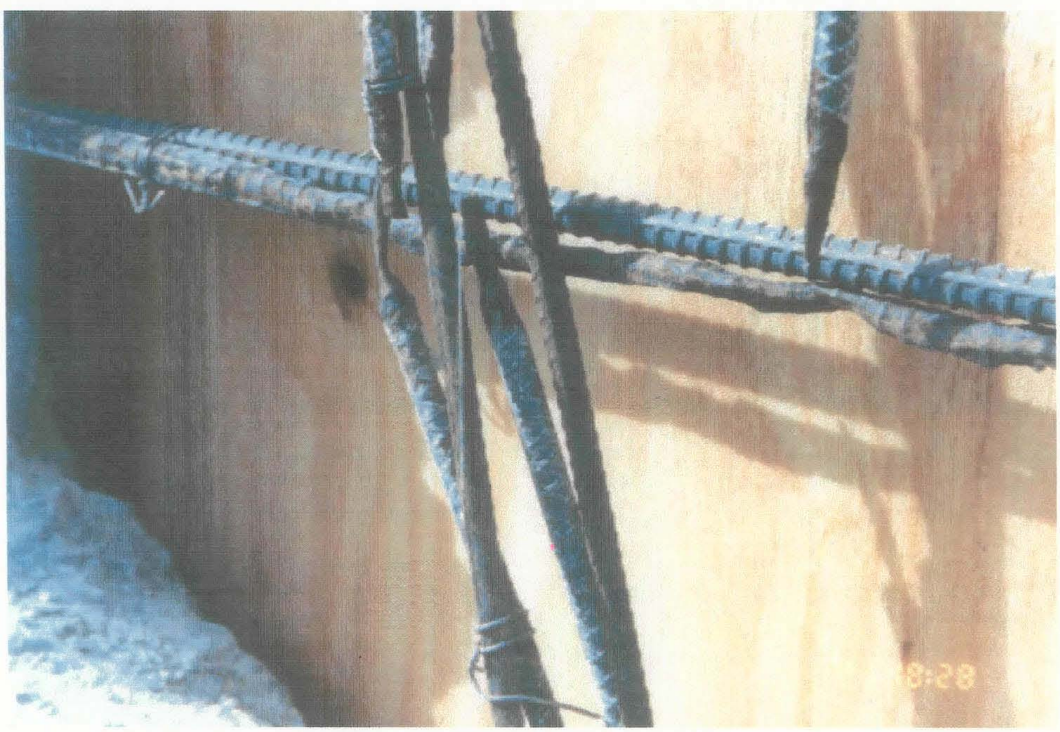
Repair process in progress

Close-up view of scaffold and formed repair areas

Forms on interior of shell

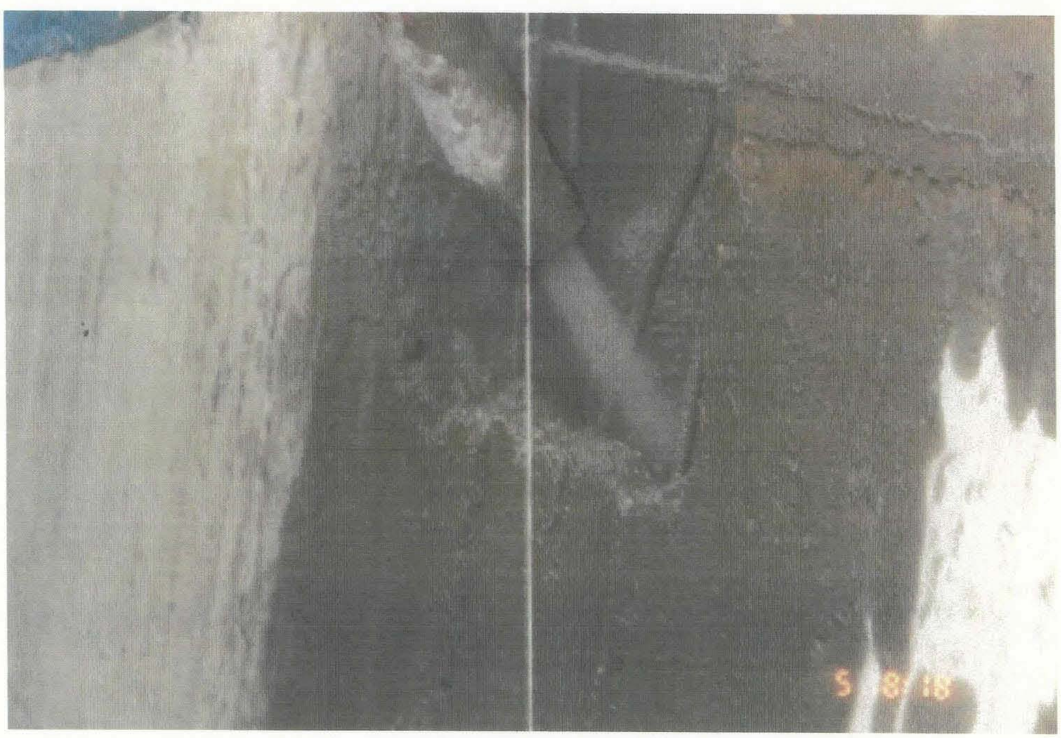
Concrete removal areas with forms

Exposed reinforcement from concrete removal



Reinforcement with corrosion - induced section losses

Saw-cutting around perimeter of repair areas



Shotcrete repair in progress

Shotcrete repair in progress

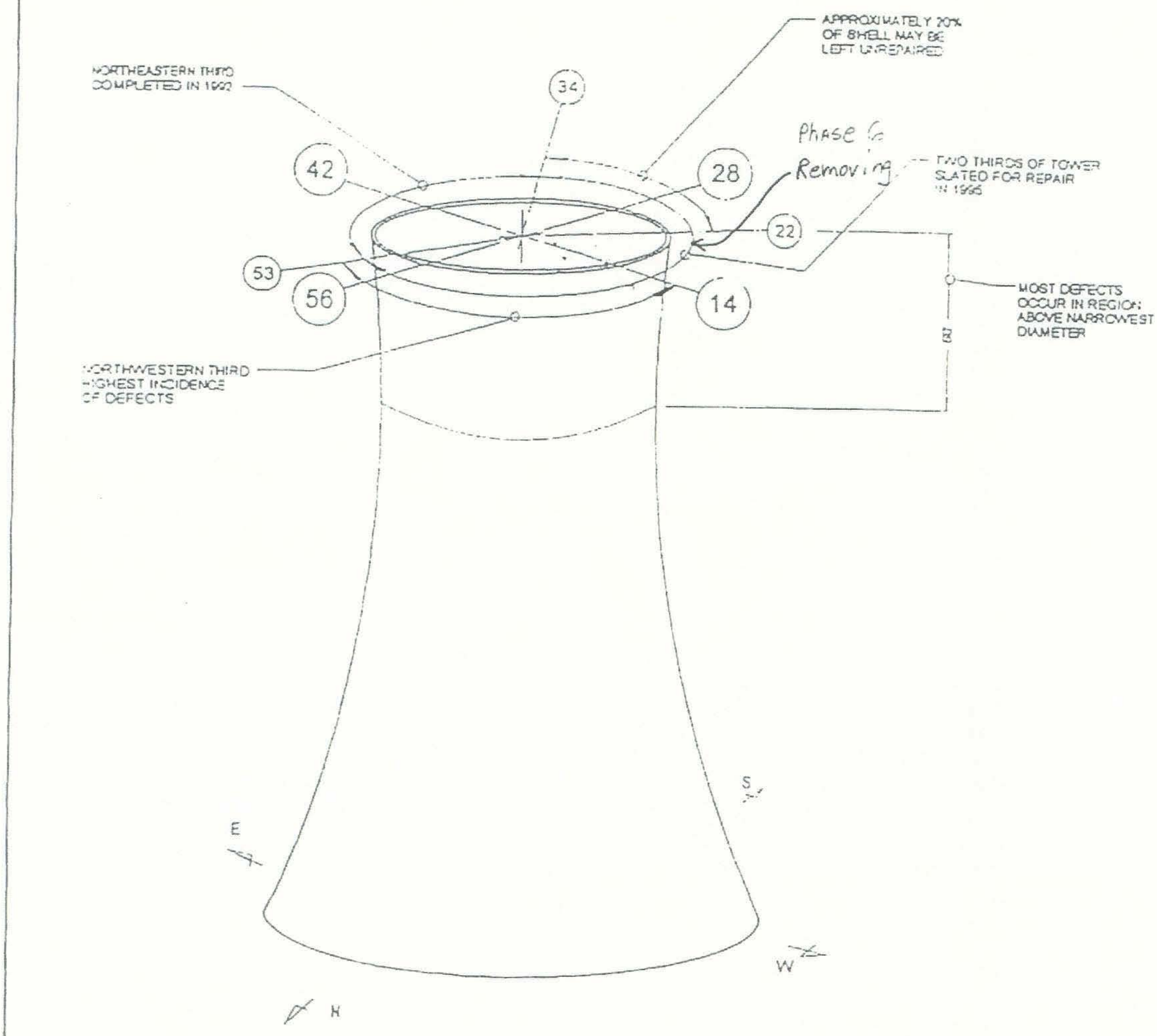
Shotcrete repair in progress

Completed patch repairs

FOSSIL AND HYDRO GENERATION DEPARTMENT
CIVIL ENGINEERING DIVISION
STRUCTURAL ENGINEERING SECTION
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO 43215
(614)223-1000

SHEET 1 OF 1
DATE 8/4/95 BY BNB CK. ______
COMPANY KENTUCKY POWER CO.
PLANT BIG SANDY PLANT U1
SKETCH NO. ______

SUBJECT **ATTACHMENT 1 - PERIMETER DIAGRAM** FILE NO. A:BSORTH.DWZ

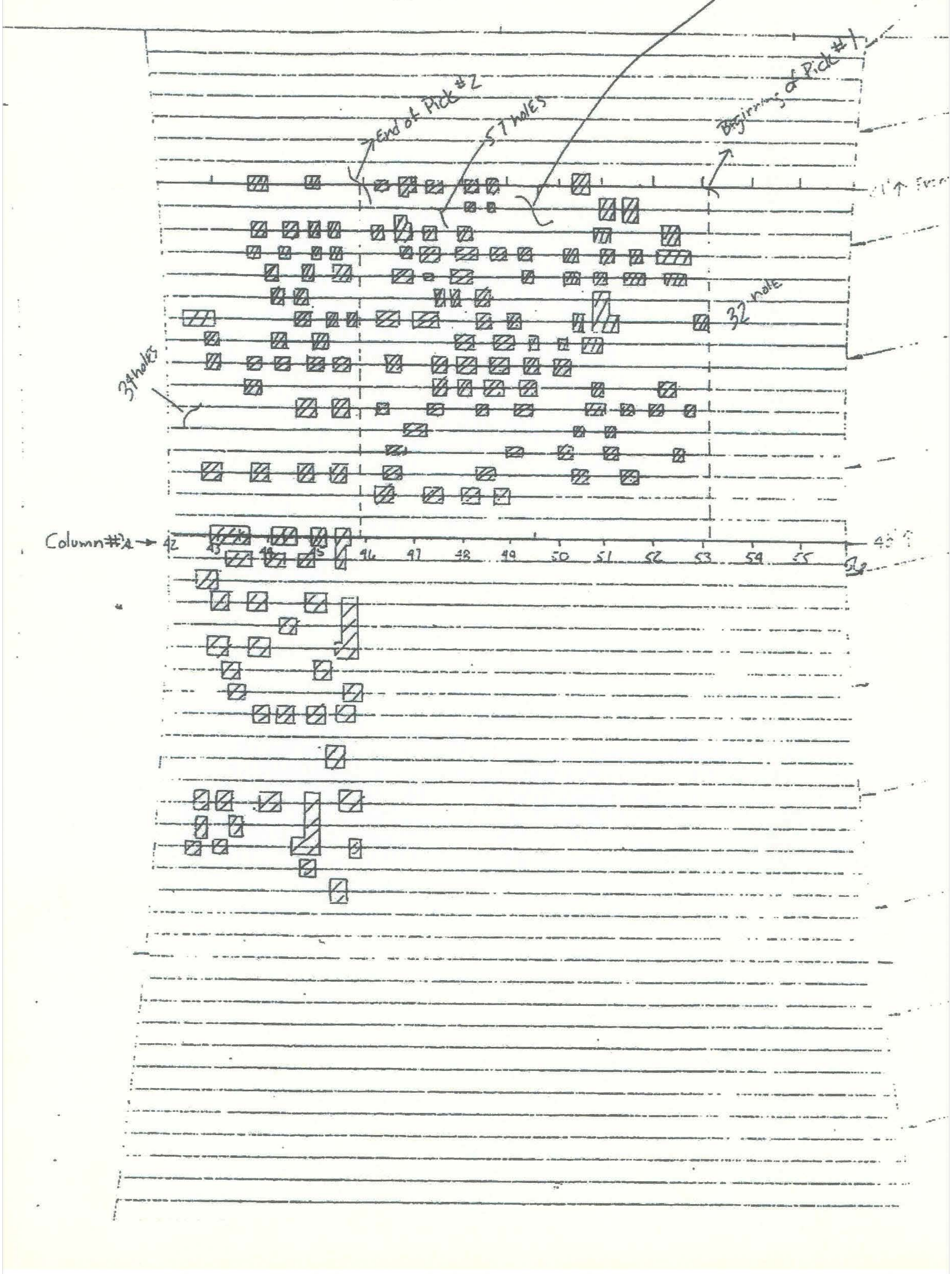


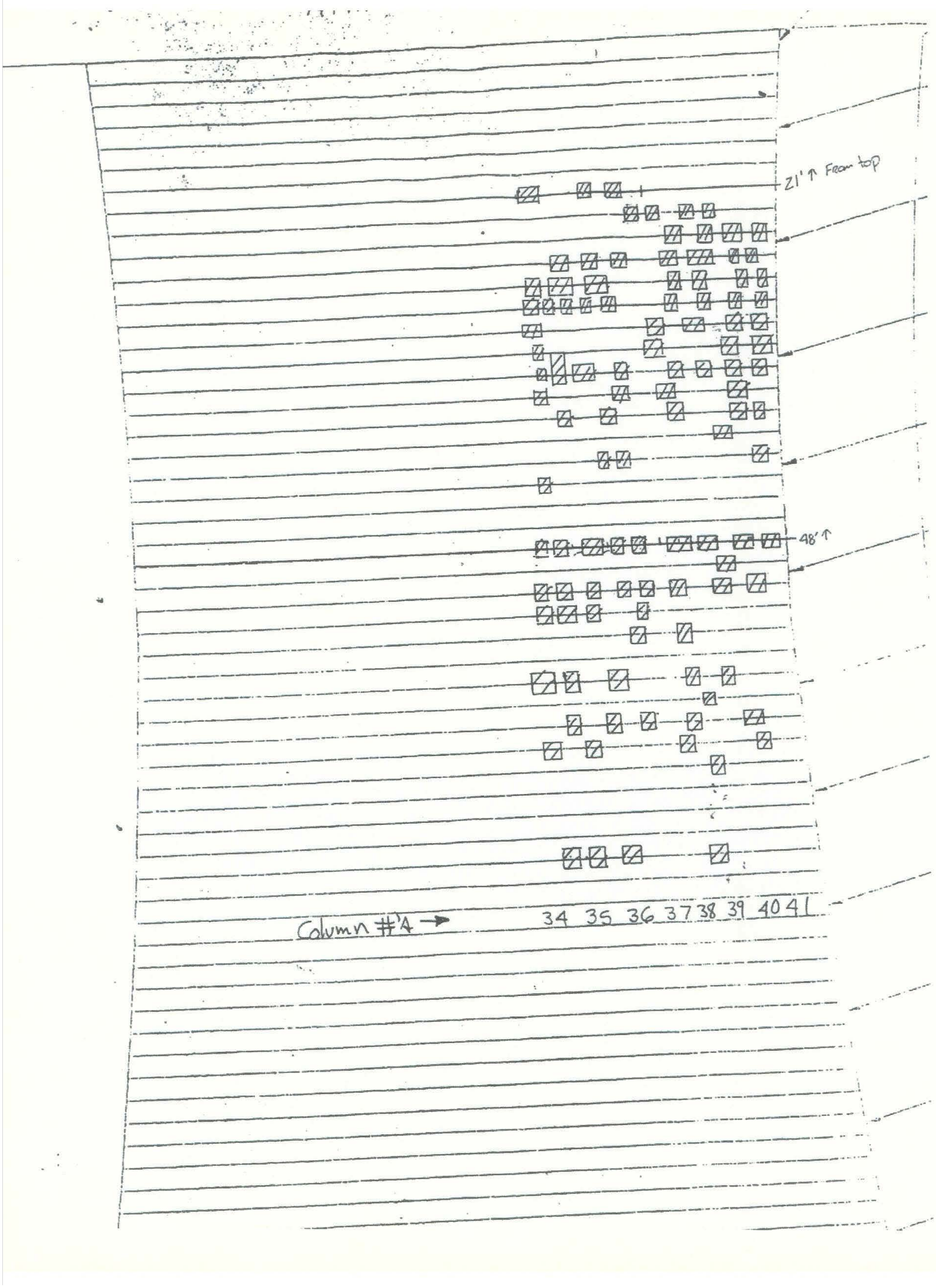
Cooling Tower Chemicals U1

1) Bromine/Bleach-16% Solution = Chlorine
2) Dispersant PY-5200 - Supplied by Betz
3) Sulphuric Acid - Keep PH range 8.3 to 8.8

TOTAL P.02

Attachment 1




21' ↑ From top
48' ↑
Column #4 →
34 35 36 37 38 39 40 41

Reference : ***R 20 LY 1942*** *Version:* ***3***

AMERICAN ELECTRIC POWER

Sterblue

Sites

Customer
AEP, Columbus, USA

Data capture, Expertise, Central platform
Sterblue, Los Angeles, USA
Sites, Dardilly, France

External visual inspection of the Big Sandy cooling tower

June 4th 2020

1. Revision History

STERBLUE REFERENCES					
Project number	3546 LY	Work number	362055	Inspection date	2020-04-20 - 2020-04-22

CUSTOMER REFERENCES			
N° Order	Ah-cde-selor-D19LY6739_V3	Name	AEP

Version	Date	Writer	Controller	Approving	Modifications
3	2020-07-28	DRABER			*Updated figures and scales to be in feet only.*
2	2020-06-08	DRABER			*Edited graphs and typo in section 8 specifying wrong crack and corrosion lengths*
1	2020-06-03	BOUCHE	COLLARD	DAUXIN	*Initial release*

2. Table of contents

3. Scope of work

3.1. Stakeholders

Sterblue builds the central platform for infrastructure inspections. It develops the tools to capture clean data from multiple sources like drones, helicopters, smartphones or satellites. Sterblue builds the interfaces and tools to provide customers with insightful analytics.

- 25 employees
- 3 offices: Los Angeles (USA), Nantes (France), Lisbon (Portugal)
- 4 applications: Cooling towers, Distribution/Transmission grid and Wind Turbines

In the frame of this project Sterblue automated the data capture, generated the low resolution orthopicture and made all the data available on its platform.

Sites is a structural health monitoring pioneer and a specialist engineering company dedicated to infrastructure performance and service life.

- 400 employees
- 35 years of experience
- Over 1,000 structures monitored each year

In the frame of this project Sites generated the high resolution orthopicture and analysed the images.

3.2. Project

This document deals with the visual and photogrammetric inspection of the shell of the Big Sandy Plant Unit 1 cooling tower.
This document aims at giving the map of defects, their characteristics and some statistics about the shell.

This report is completed by appendices:
- Appendix 1 presents the table of defects
- Appendix 2 presents the map of defects
- Appendix 3 presents the map of defects with falling risk overlaying the orthophotography
- Appendix 4 presents the map of defects with orthophotography (low resolution)
- Appendix 5 present the map of distortions
- Appendix 6 present the map of defects overlaying the distortions map

The orthophotography distortion is joined to this report with the listing of the defects and their XYZ coordinates.

4. General points

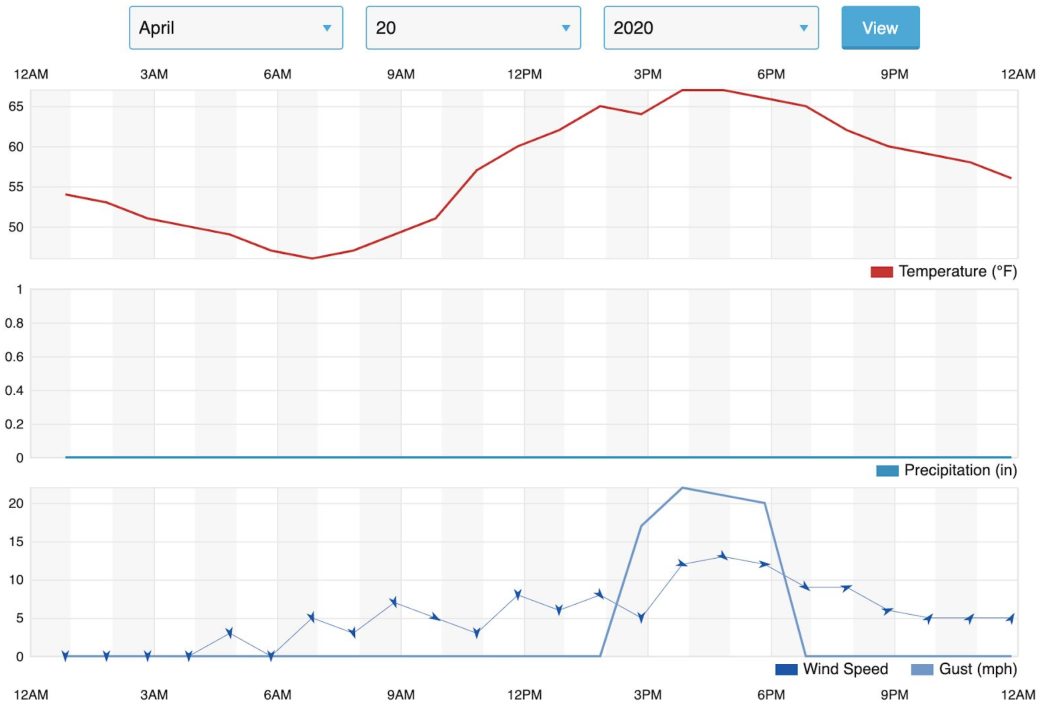
4.1. Tools

Images were captured from the 20th to the 22nd of April 2020 by two different UAVs:

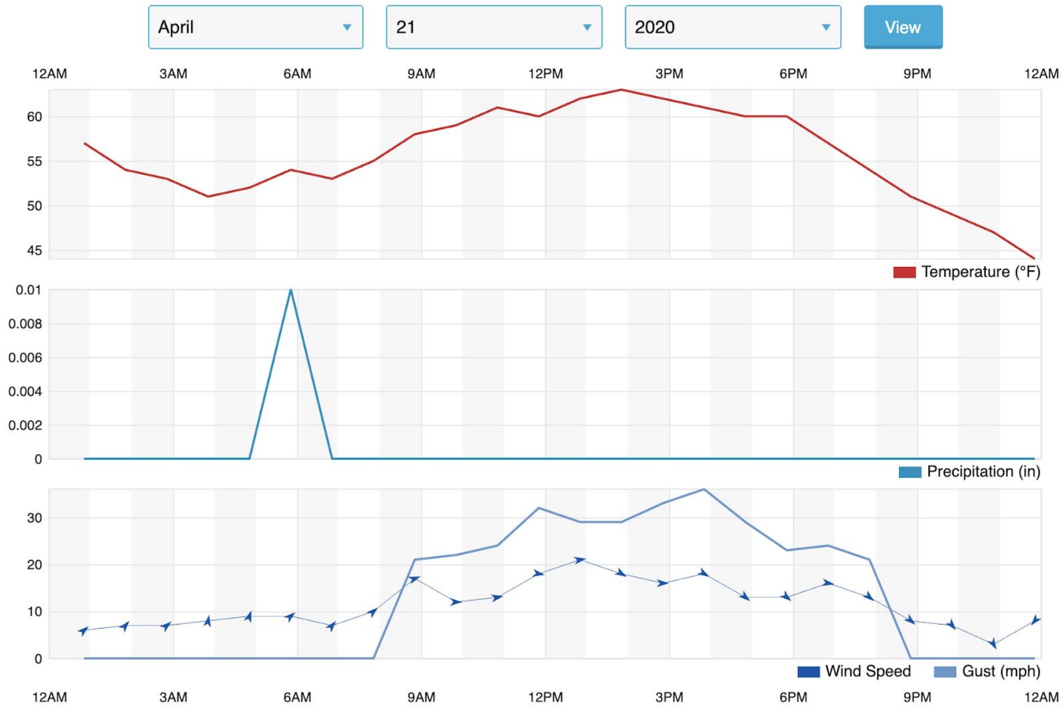
- One low resolution inspection has been performed with a 20 megapixel camera on a Phantom 4 Pro
- One high resolution inspection has been performed with a 24 megapixel camera (DJI X5s on a Matrice 210 RTK v2 UAV).

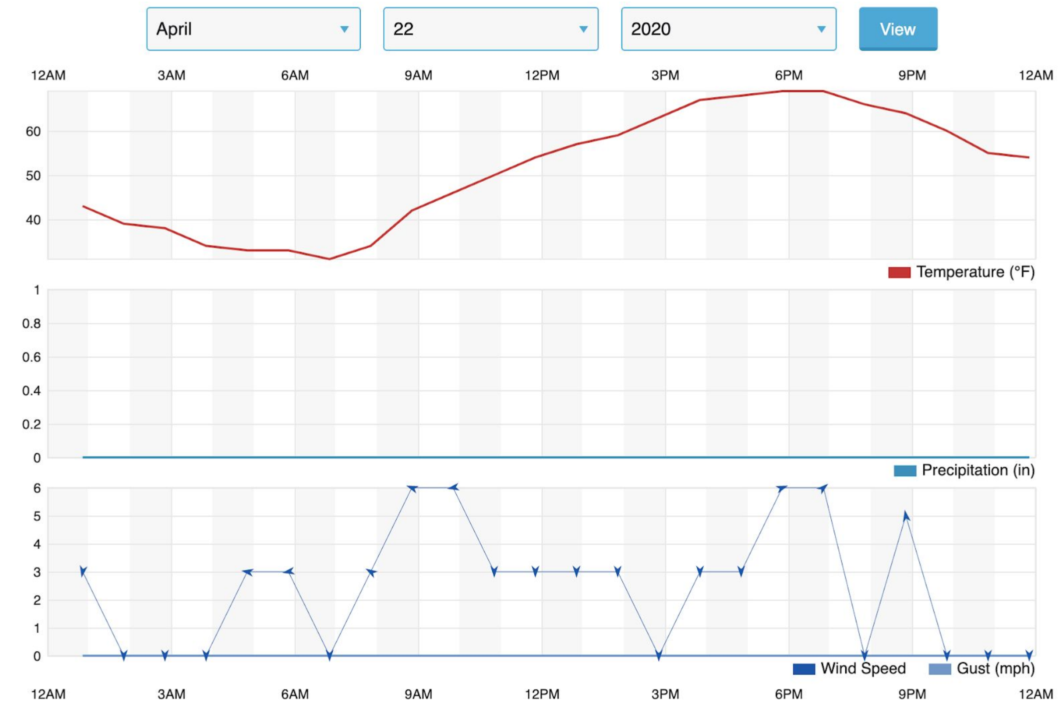
4.2. Weather

Cloudy with some sun and some rain.



Sterblue - Big Sandy Cooling Tower External Visual Inspection - Report date: June 2020





Context of post-processing:
All of the necessary post-processing steps for creating the orthophotography were done at our office in France.

The model was georeferenced thanks to the coordinate of the first RTK base used during the UAV flights and reported in the flight journal and the theoretical shape.
The theoretical model of the shell has been created using the document “bsp_1_lgmp_21061-7_0.pdf”

4.3. Coordinate system

All the 3D data are known in the NAD83 / Kentucky Single Zone (EPSG : 3090) coordinate system.
The scaling error of this coordinate system is less than 5 mm (0.2 in) on the 97 m (320 ft) of this structure.

4.4. References

Due to the absence of measured topographical points on the structure or on the site, GPS coordinates were used in order to georeference the tower.
All flights were performed with a DJI Matrice 210 RTK v2 UAV. For each picture taken, the GPS coordinates of the UAV were recorded with an accuracy within 4 in relative to the RTK base.
To be able to fly all around the tower, the RTK antenna has been positioned on two different points. Each of these points have been determined in real time thanks to GPS data, with an accuracy within 16.4 ft.

The coordinates of the first RTK base used during the UAV flights have been chosen as reference to locate the 3D model in the NAD83 / Kentucky Single Zone coordinate system. As coordinates of the RTK base were reported in the WGS84 system, they were post-converted into the NAD83 / Kentucky Single Zone system.

RTK base coordinates in WGS84 system		
Longitude (°)	Latitude (°)	Altitude (ft)
38.17039453	-82.62030865	456.47

RTK base coordinates in NAD83 / Kentucky single zone system		
East (ft)	North (ft)	Altitude (ft)
5820791.86	3964831.52	456.47

Coordinates of the RTK base used as reference (20 april 2020)

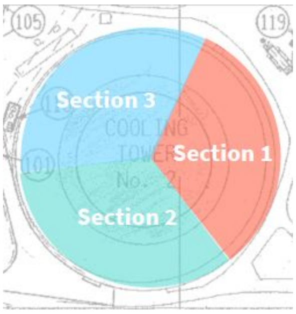
The theoretical shape of the cooling tower has also been used to scale the cooling tower.

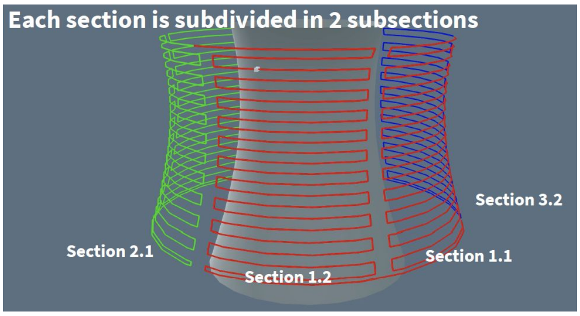
5. Data acquisition and treatment

5.1. UAV flights

2 types of flights have been performed at a distance of about 40 ft from the structure:
- The first one for overview and photogrammetric structure with the DJI camera on a Phantom4 Pro UAV. Pixel size (GSD) : 0.14 in,
- The second one for inspection with the DJI X5s + 45mm camera on a Matrice 210 RTK v2 UAV. Pixel size (GSD): 0.04 in.

The acquisition of the high resolution pictures was organized by dividing the area to be covered in 3 sections and each section in 2 subsections, according to the following flight plan.



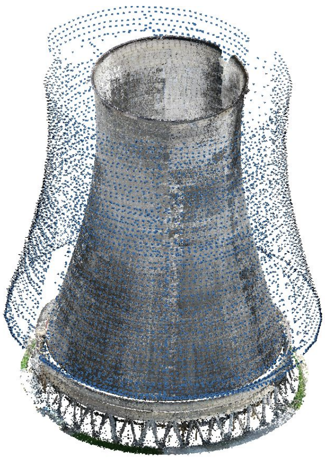


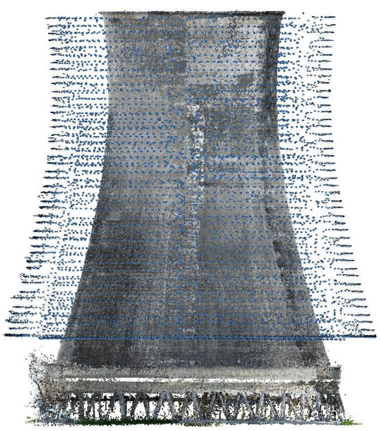
Flight plan

These flights allowed the capture of 1766 photos for the low resolution flight, and 8812 photos for the high resolution flight.
A photogrammetric treatment is used to calculate 3D positioning of these photos and 3D reconstruction of the tower as a point cloud and 3D mesh.

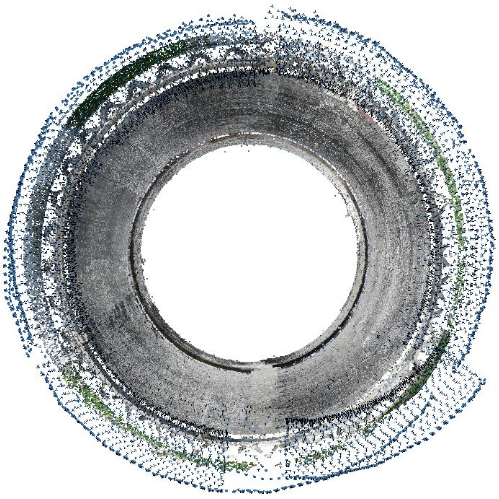
5.2. Camera alignment

Following captures show the position of pictures taken during both flights.





Perspective view of the cameras positions – Elevation view of the cameras positions



View from the top of the cameras positions

5.3. Georeferencing of 3D model

The image coordinates of each image, known in the WGS84 system, have been converted to NAD83 / Kentucky Single Zone system (meters) and used to locate and pre-scale the 3D model.

Not every picture's coordinates were used: first, only the coordinates of pictures captured during flights referenced with the first RTK base were taken into account, because of the shift in coordinates that occurs when changing the RTK base. However, some flights referenced on the first RTK base are still presenting inconsistencies in the photos coordinates. They were ignored for the georeferencing step. Taking into account picture coordinates allows faster location convergence when building the 3D model.

After combining all factors that can affect the accuracy of the georeferencing, we can estimate that the 3D model of the tower has been located within +/- 16.4 ft. It should be noted that this localization error is composed of translations only, and that the orientation to the North of the model is correct.

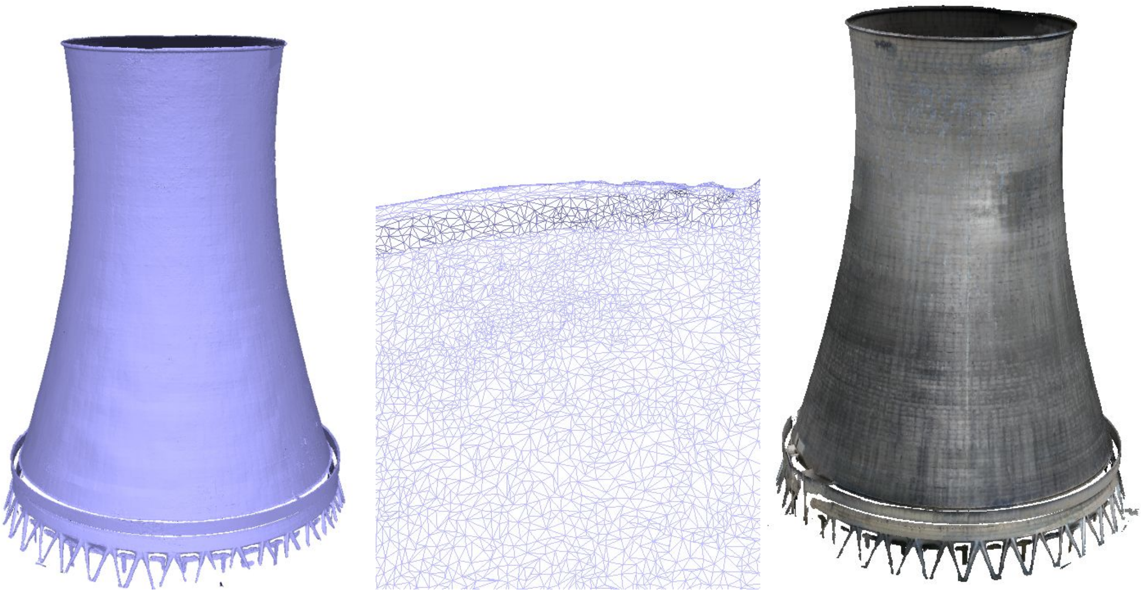
5.4. Scaling 3D model

As the inspection step requires a better accuracy than the one obtained from the georeferencing, the scaling of the tower was done manually. Three different lengths were measured on the model: height of the tower, radius at the top and at the bottom. Thanks to the corresponding theoretical values, a mean scaling factor was calculated and applied to the model.

5.5. Point cloud and 3D model

After aligning cameras, georeferencing and scaling the tower, we can generate a point cloud made of 160 million 3D points (colored), and we can generate a mesh of triangles. After generating this 3D data, we can generate the texture of the mesh.
The mesh is composed of 1 million triangles.

3D point cloud (colored)



3D mesh of triangles (left : not textured) – right : textured

This data is delivered as a .las file for the point cloud and an .obj file for the 3D textured mesh.
Units are meter and coordinate system is NAD83 / Kentucky Single Zone (Meters). For a better display of these objects, they were exported with a shift in their coordinates.

Shift X (ft)	Shift Y (ft)	Shift Z (ft)

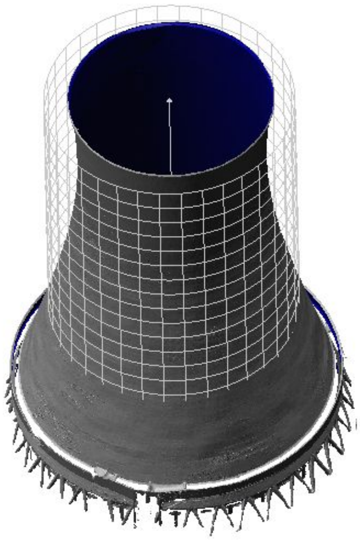
5,820,209.974	3,963,254.593	0

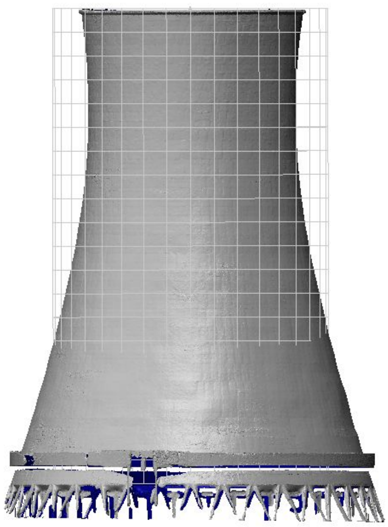
5.6. Orthophotography

The textured 3D model has been unwrapped following a cylinder. The parameters of the cylinder are:

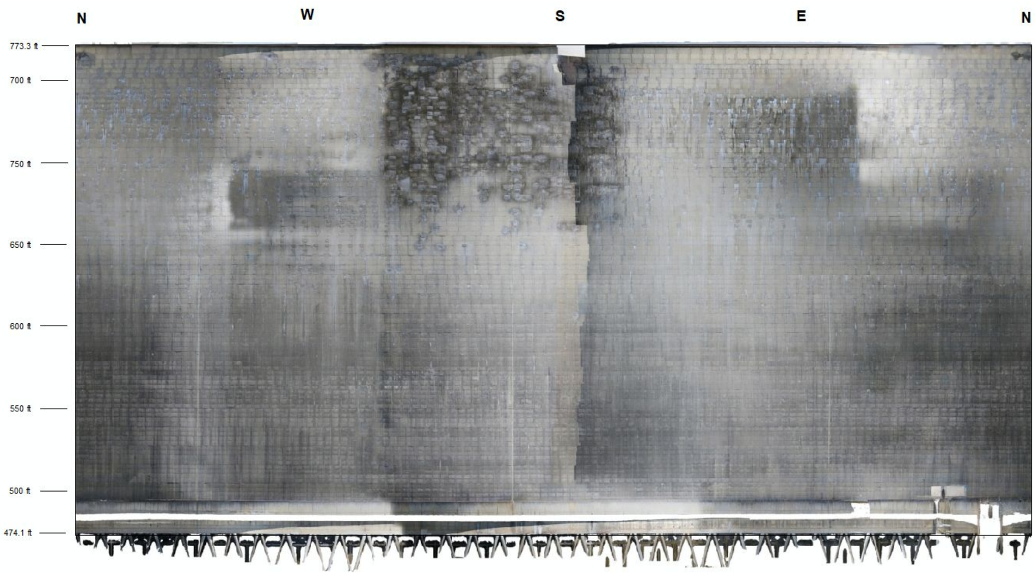
- Center:
  - East (X) = 3,963,254.593 ft
  - North (Y) = 3,964,656.092 ft
- Radius: 92.720 us ft (radius of the cylinder is the average of the top and bottom cylinder of the cooling tower)
- Cut : North
- Unwrap rotation : natural view from outside

5.6.1. Cylindrical projection





Cylinder used for the data unwrapping



Cylindrical unwrapping

This projection on the cylinder and unwrapping leads to some scaling error on lengths which is corrected in the database by computing the 3D coordinates of the defects on the shell and re-computing the lengths.

5.6.2. Orthophoto resolution

Two orthophotos have been generated:

- 1 pixel = 0.04 in for the orthopicture generated from high resolution pictures (M210 RTK v2 UAV + X5s + 45mm lens)
- 1 pixel = 0.14 in for the orthopicture generated from low resolution pictures (Phantom 4 Pro camera)

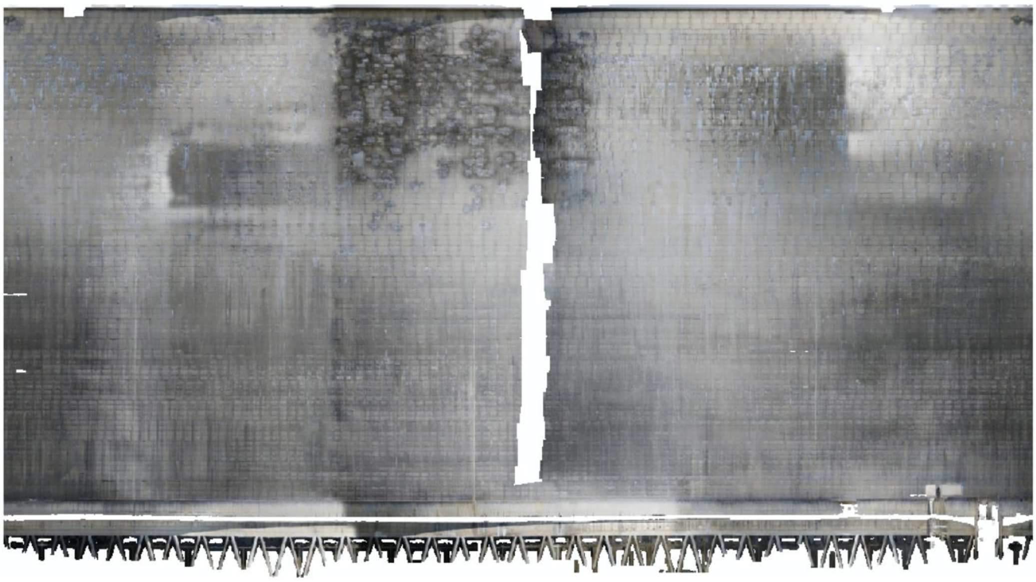
The low resolution ortho picture was helpful to integrate pixels in areas not covered with highly detailed images.

Units of the orthophotos are meters.

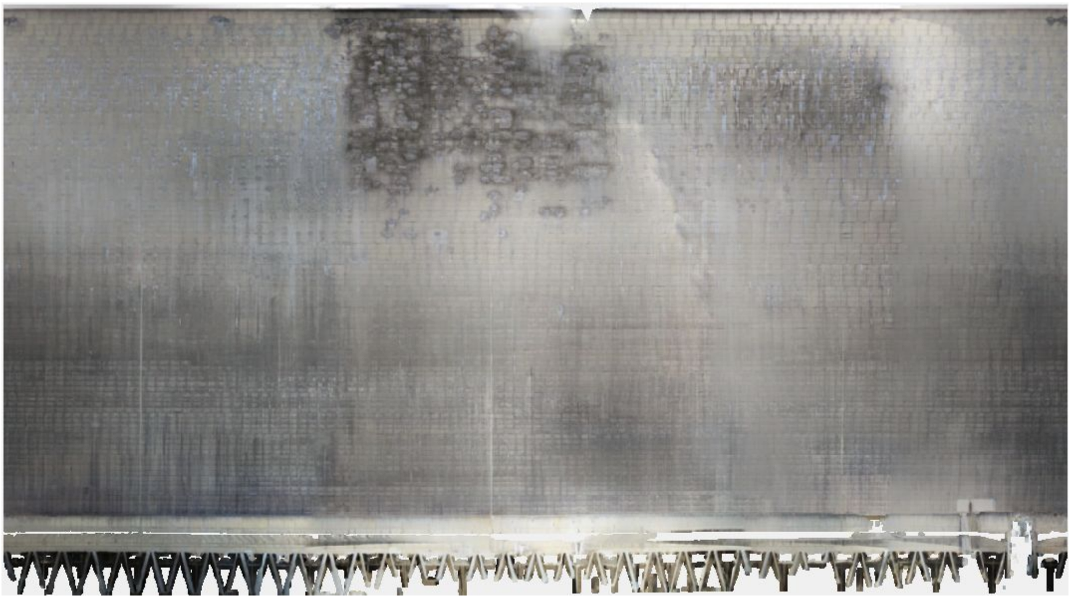
The orthophotos are georeferenced on a X, Y flat coordinate system. For this cylindrical projection:

- X= circonference position. X is between 0 ft (0°) to 582.575 ft (360°)
- Y= elevation, from 474.1us ft (bottom of the shell in the NAD83 reference system) to 773.3 us ft (top of the shell).

One single file with these 2 orthophotos overlaying gives the better of each image: the 0.04 in image is on top of the 0.14 in.



1 pixel = 0.04 in



1 pixel = 0.14 in

5.6.3. Orthophoto visualisation

The orthophotography is delivered as a .tiff file, linked to its georeferencing file (.tfw). It can be read with any GIS software (ArcGis, Qgis, Mapinfo,…).

An html viewer is provided to easily view the orthophotography without the defects and without measurements.

6. Inspection characteristics

From the orthophotography, a visual inspection was carried out to identify defects of the shell. Cracks have been drawn with an opening of more than 0.08 mm (0.03 in). Corrosion, concrete cracks, seepage, spalling or visible steel are drawn if visible.

According to their geometric characteristics, the defects can be recorded as:

- linear defects (for example cracks),
- surface defects (for example crazing area),
- punctual defects (for example a corroded rebar piercing the concrete).

6.1. Defects id

Each defect has a single number (id) which is written on the map in order to facilitate the identification of the type and features.

6.2. Defects types

The following list includes defect types identified, and coded:

- cracks (CR),
- corrosions (CO),
- seepages (SE),
- unstickings (US),
- crazings (CA),
- miscellaneous defects not covered by the types above (DX) (could be then considered as OT, EF, CS, HC).

6.3. Defects secondary feature(s)

A defect's secondary feature is a physical feature that completes defect type classification and coded:

- efflorescence (EF),
- concrete spit (CS),
- seepage (SE),
- crazing (CA - network of fine random cracks),
- unsticking (US),
- visible steel (VS),
- rust trace (RT),
- honeycombing (HC),
- repair (REP),
- other (OT).

A defect may be allocated with one, two or even no secondary features.

6.4. Defects location

- on reinforced concrete (RCO),
- on sealing (SEA - corresponds to zones which have been already repaired)

6.5. Defects particularities

- concrete rework (CRE),
- formwork hole (FH),
- with falling risk (FR).

6.6. Defects measured features

Measured features describe defect characteristics that may be quantified using a numerical value:
- position (X, Y, Z) (m),
- length (m and ft),
- average opening (mm and in), for cracks,
- surface area (m^2 and ft^2), if the defect is a surface,
- orientation : 0° is vertical, 90° is horizontal, between 15° and 75°, it is inclined.

6.7. Evolution

For a future inspection of the wall, a second orthophotography overlaying exactly the first one will enable us to give the evolution of the defects. These names would be used as a new property:
- CRE : New defect,
- EVO : Evolutionary defect,
- NEV : No evolution,
- FUS : Defect merged with another one (name of this defect in the remark),
- FUSF : defect that has been merged with a FUS defect and then deleted,
- SUP : defect deleted,
- REP : defect deleted because it has been repaired,
- NOB: no observation (because no image of this area).

6.8. Accuracy of photogrammetric inspection

The expected performance as a result of the measurement distance are as follows:
- detected cracks : opening average above 0.008-0.012 in
- defect location precision in the XYZ coordinate system : 0.8 in,
- defects length : accuracy 2 in.

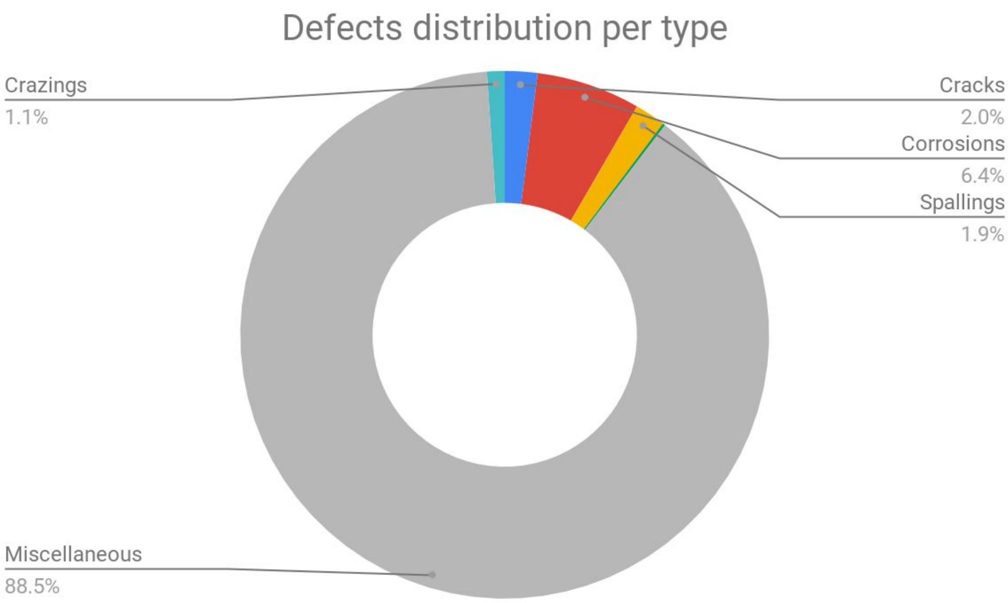
Note that only cracks with openings larger than 0.032 in were labelled.

7. General results

The following tables give some statistical results of the inspection.

7.1. Defects distribution per type

	Cracks	Corrosions	Spallings	Seepages	Miscellaneous	Crazings	Total
	CR	CO	SP	SE	DX	CA	
Number of defects	48	153	45	4	2133	26	2409
Cumulative length (ft)	268	81	58	3	6443	345	7199

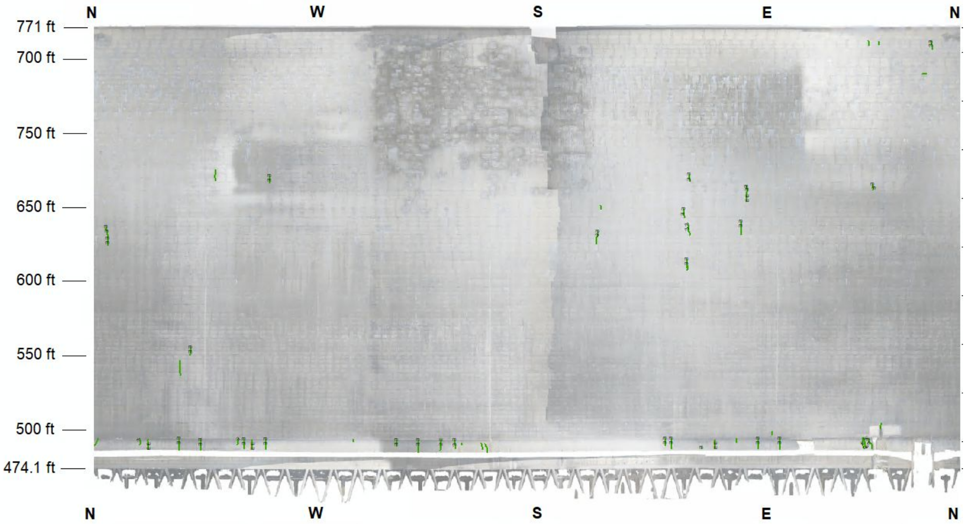


Defects are spread all over the tower, except on the upper southwest part, which has undergone repairs in 2010. Other quadrants were repaired in the late 80's early 90's.

The big majority of defects are miscellaneous defects (2133). Most of the miscellaneous defects are efflorescences with no seepage. When an efflorescence has water seepage, it is classified as a seepage with efflorescence.

7.2. Cracks

There are some cracks and most of them are with efflorescence. A half of them are located on the basin wall. The cracks under 0.03 in (0.8mm) in opening were not drawn. The following capture shows the distribution of the cracks on the entire shell:

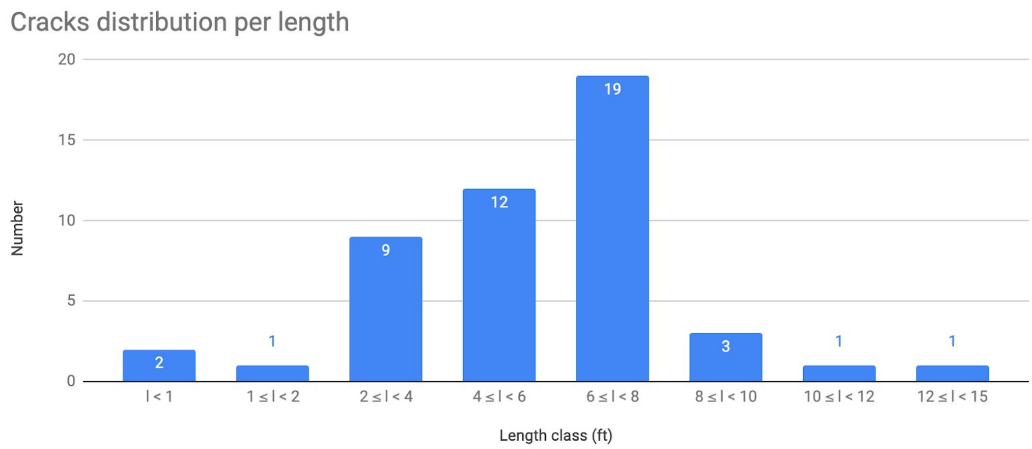


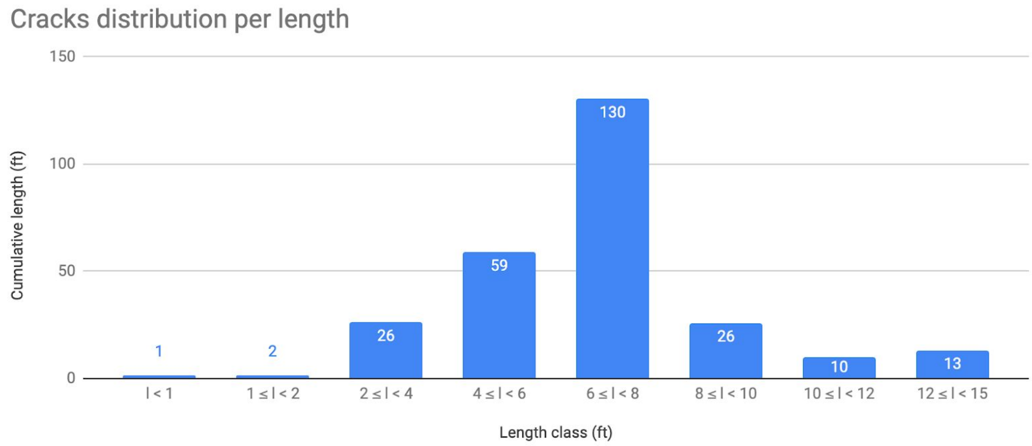
Distribution of cracks

7.2.1. Crack distribution and histogram per length classification

Length class (ft)	l < 1	1 ≤ l < 2	2 ≤ l < 4	4 ≤ l < 6	6 ≤ l < 8	8 ≤ l < 10	10 ≤ l < 12	12 ≤ l < 15
Number	2	1	9	12	19	3	1	1
Cumulative length (ft)	1	2	26	59	130	26	10	13

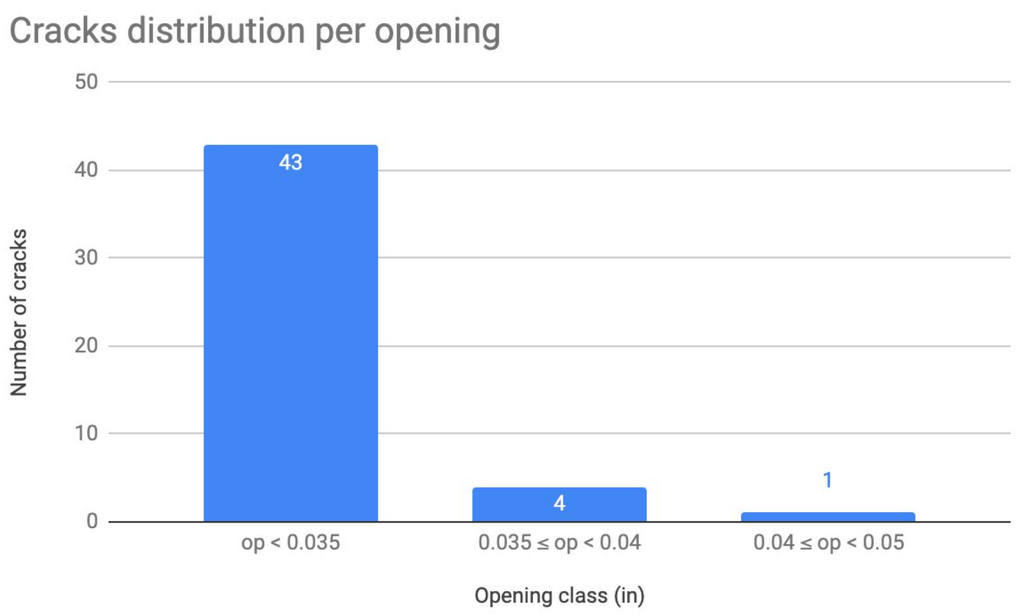
All the cracks are smaller than 16.4 ft and 77% of them are between 3.3 ft and 13.1 ft long.

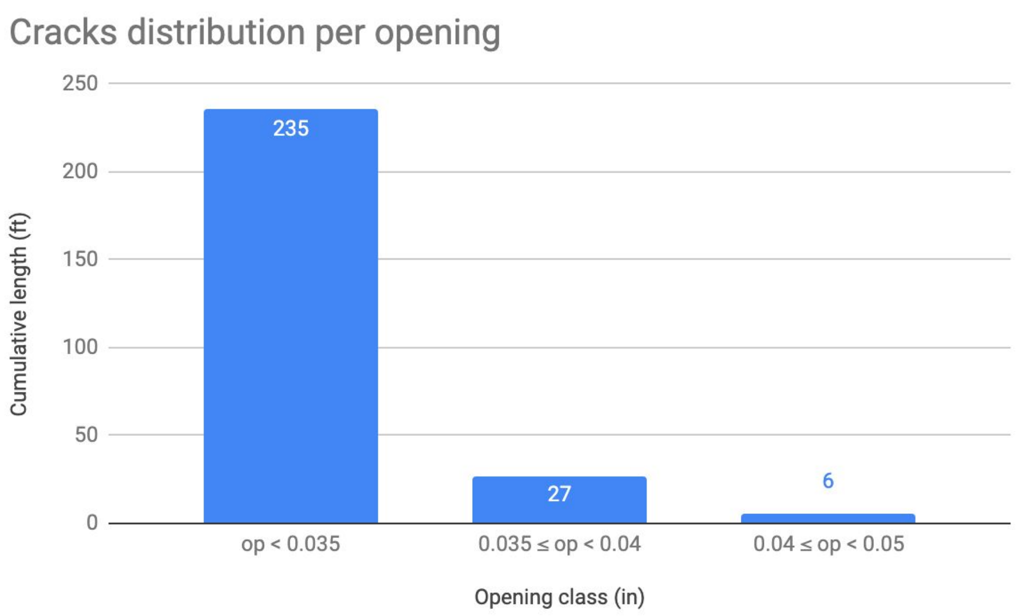




7.2.2. Crack distribution and histogram per opening classification (mm)

Opening class (in)	op < 0.035	0.035 ≤ op < 0.04	0.04 ≤ op < 0.05
Number	43	4	1
Cumulative length (ft)	235	27	6



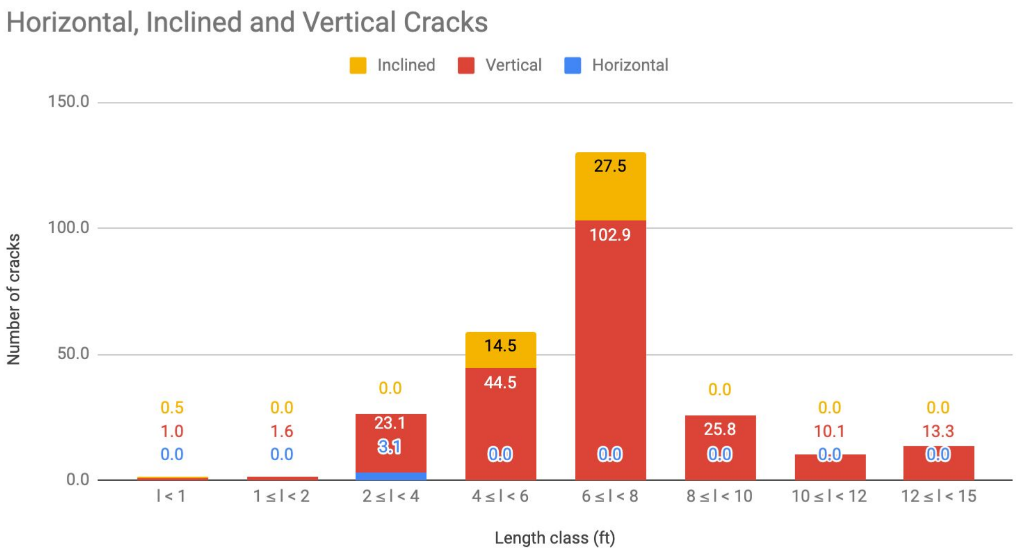


7.2.3. Crack distribution per orientation

A crack is horizontal if its angle between the start point and end point is less than 15 degrees.

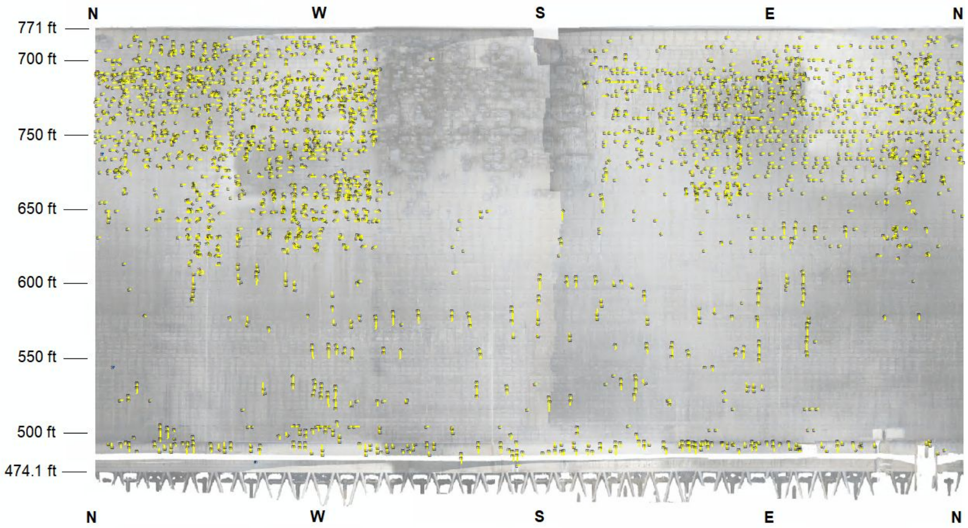
	Length class (ft)	l < 1	1 ≤ l < 2	2 ≤ l < 4	4 ≤ l < 6	6 ≤ l < 8	8 ≤ l < 10	10 ≤ l < 12	12 ≤ l < 15
Cumulative length (ft)	Horizontal	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0
	Vertical	1.0	1.6	23.1	44.5	102.9	25.8	10.1	13.3
	Inclined	0.5	0.0	0.0	14.5	27.5	0.0	0.0	0.0

Most of the cracks are vertical.



7.3. Seepage and efflorescence

The following capture shows the distribution of the seepage and efflorescence:



Distribution of seepage and efflorescence

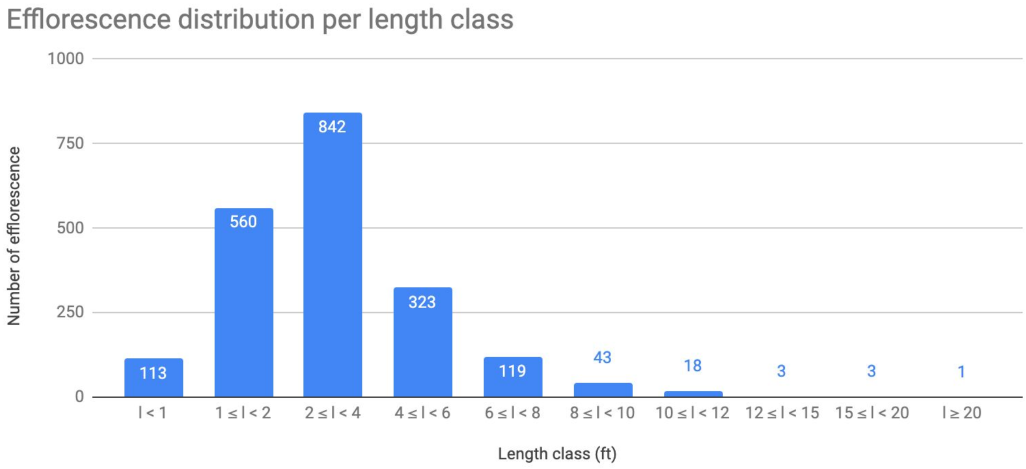
An efflorescence with seepage is classified as seepage because the water leak is more important than an efflorescence. Most of the seepage is on the bottom part of the cooling tower.

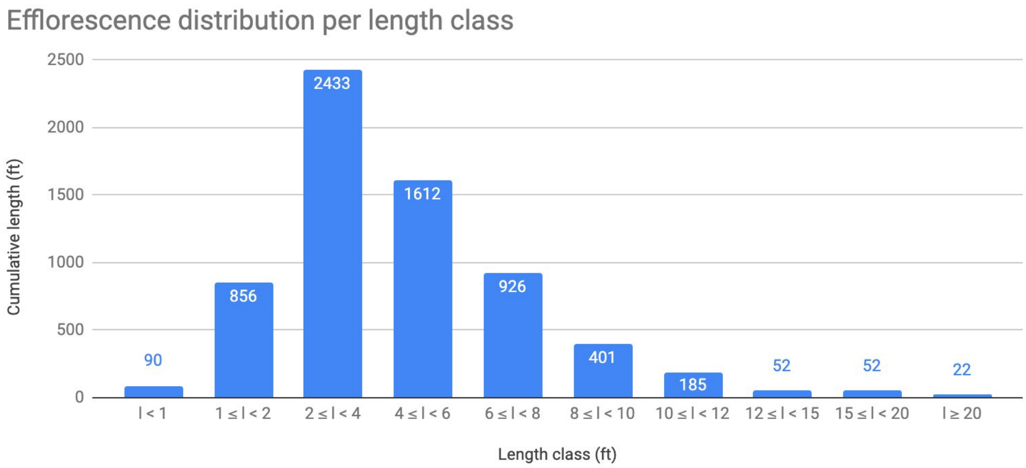
The efflorescences are mostly small cracks with traces of efflorescence, but the opening of the crack is not visible because of the efflorescence. A lot of efflorescences are located on the northern part of the shell, between 623 ft and 754 ft.

7.3.1. Efflorescence distribution and histogram per length classification

Length class (ft)	**l < 1**	**1 ≤ l < 2**	**2 ≤ l < 4**	**4 ≤ l < 6**	**6 ≤ l < 8**	**8 ≤ l < 10**	**10 ≤ l < 12**	**12 ≤ l < 15**	**15 ≤ l < 20**	**l ≥ 20**
Number	113	560	842	323	119	43	18	3	3	1
Cumulative length (ft)	90	856	2433	1612	926	401	185	52	52	22

More than a half of efflorescences are shorter than 3.28 ft and almost all of them are shorter than 6.56 ft.





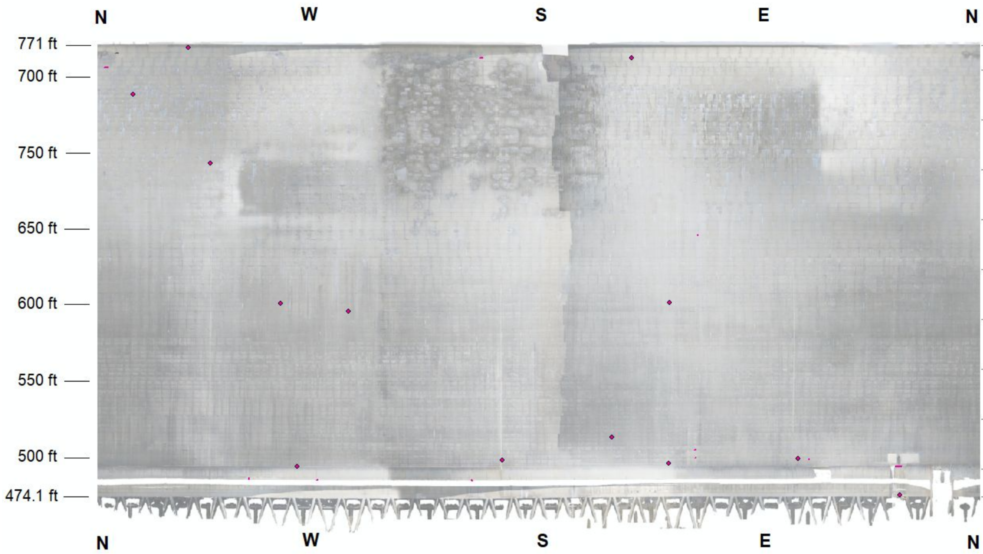
7.4. Holes and falling risk

7.4.1. Defects with falling risk

11 defects with falling risks were detected. All of them are spallings: 10 lines and 1 surface.

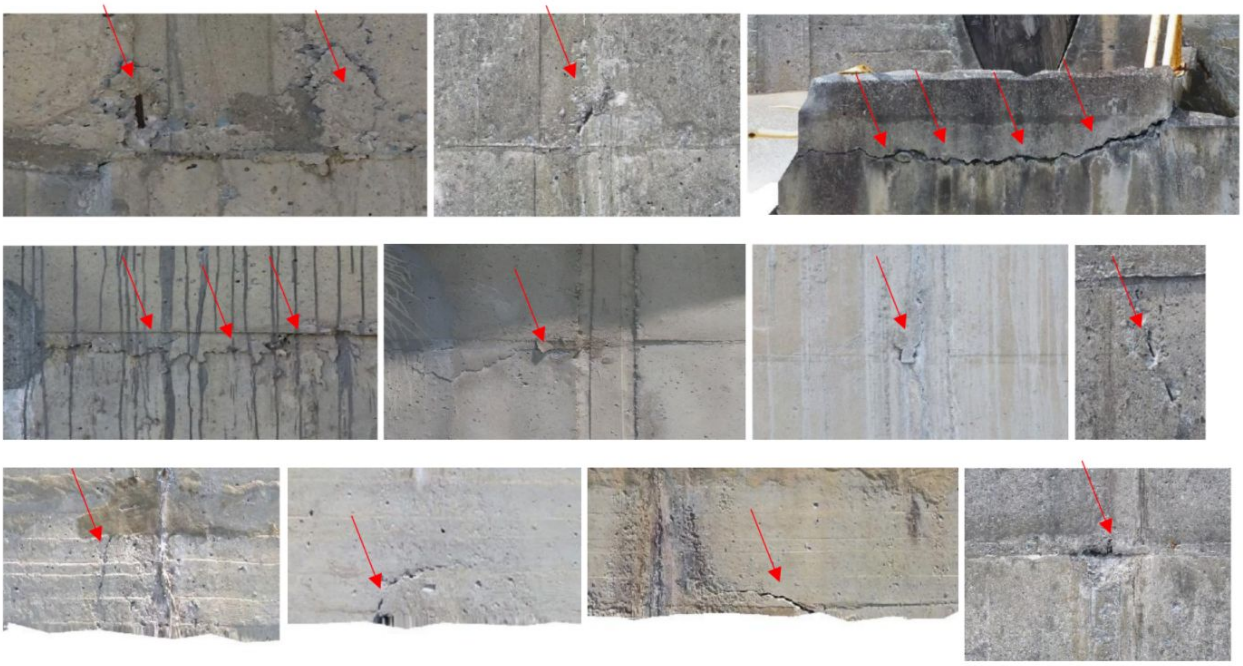
Labels on the orthopicture are either points ("0" dimensional defects, can be approximated by a point), lines: 1 dimensional defects, 1 dimension much larger than the other or surfaces: 2 dimensions.

The following map gives the location of all of these falling risks.



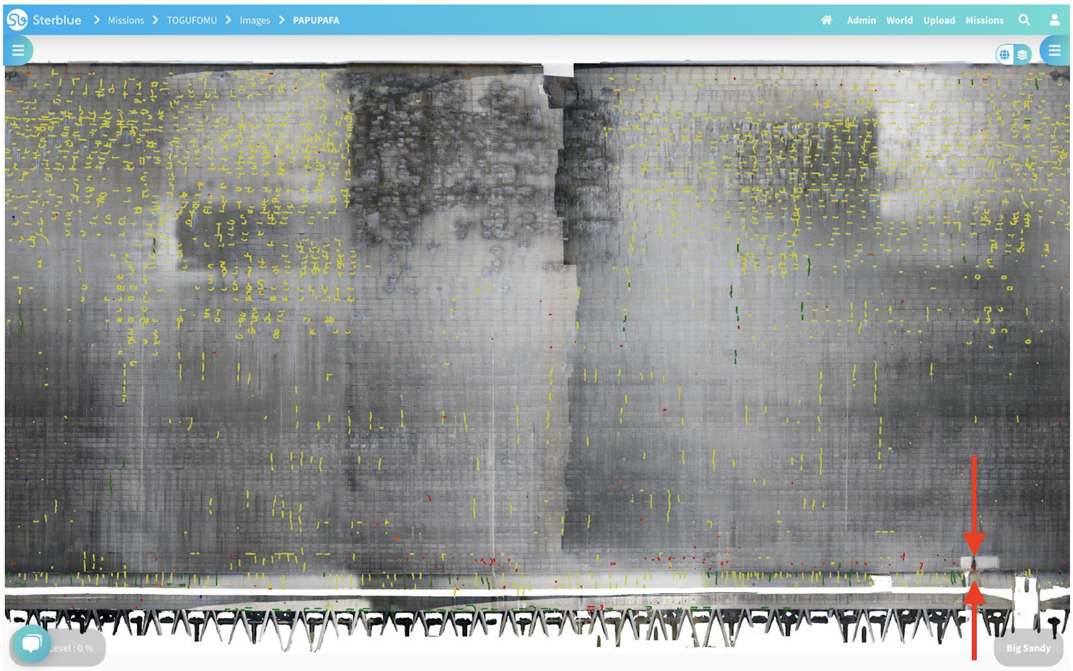
Defects with falling risk

Defects with falling risks are represented on the figure above by pink dots and lines. Please refer to the 2d files + QGIS to precisely locate defects on the tower. The following captures show examples of these spalling defects with falling risks.



Defects with falling risk

The upper right crack shown above is located on the bottom of the North-North-East side of the tower:



8. Inspection synthesis

- Total amount of defects: 2409
- Cumulative length of cracks: 267.9 ft
- Cumulative length of corrosions (visible steels): 80.7 ft
- Surface of shell: ≈ 167 549 ft^2
- Number of defect per surface unit: 0.01 def/ft^2
- Length of cracks per surface unit: 0.017 ft/ft^2
- Length of corrosions (visible steels) per surface unit: 0.005 ft/ft^2

The defects identified on the structure are mainly efflorescences which represent 90% of defects. The origin of efflorescence is due to the functioning of cooling towers: the steam circulating inside the tower involves water movement in the concrete by capillarity.

Most cracks are localized on the bottom part of the shell. The other cracks are localized on different parts of the shell and with short lengths and significant openings.

Spalling with falling risks represent 2% of the total defects identified.

9. Links to the images on the Sterblue Cloud

The ortho picture is visible on the Sterblue Cloud together with all the defects. You will need access to the Sterblue Cloud and to the Big Sandy inspection mission. Ask your Sterblue contact for an access or write to operations@sterblue.com.

- Link to the mission and all the inspection images: here
- High resolution ortho picture + defects: here
- Low resolution ortho picture: here

You can download the images using the Sterblue Desktop app.

10. Distortion analysis

10.1. Theoretical model

The theoretical model has been built from the document "bsp_1_lgmp_21061-7_0.pdf" with the help of drawings and the equation of the hyperbolic curve.

10.2. Comparison and unwrapping

We are able to compare the theoretical model to the real model after aligning them in the same coordinate system. The alignment process has been done by using the altitude of the bottom, the top and the neck of the shell.
The comparison gives distances between the two surfaces. These distances are coded with colors:

- Green for no distortions,
- Hot color (yellow, red) for outside distortions,
- Cold colors (blue, purple) for inside distortions.

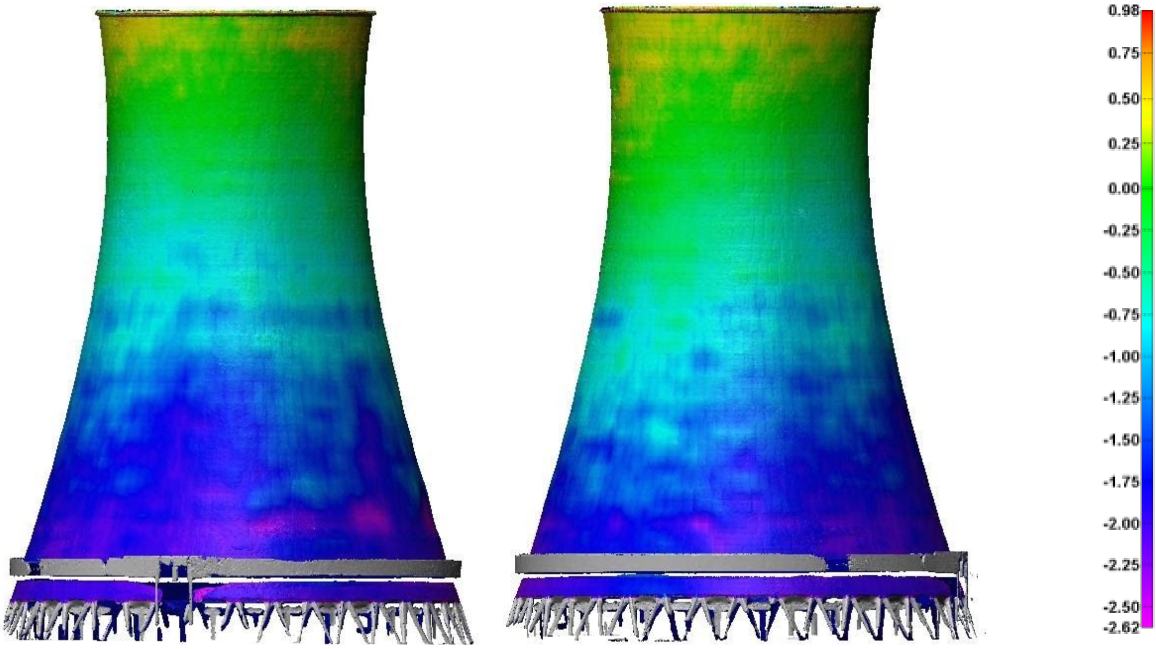
● Outside distorsion: present shape of the tower is on the outside of the Big Sandy cooling tower theoretical shape.

● Inside distorsion: present shape of the tower is on the inside of the Big Sandy cooling tower theoretical shape.

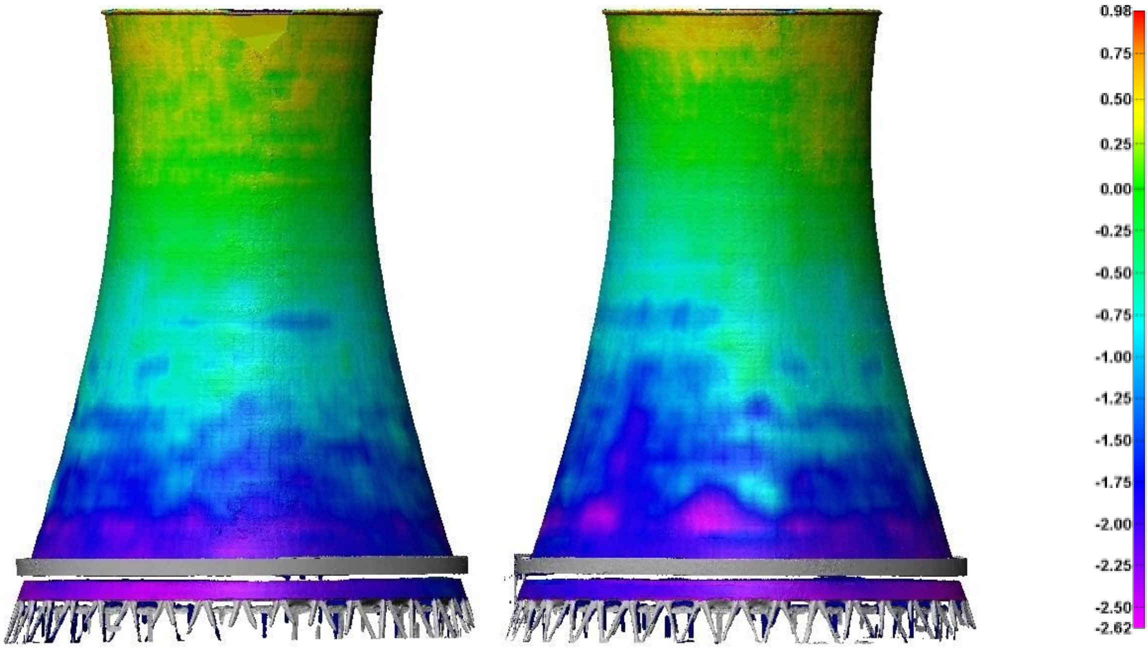
The scaling is not symmetrical: the maximum inside measured distortion is -2.62 ft and the maximum outside distortion is 0.98 ft.

As the lower mid of the model has a continuous deformation, we can conclude that the photogrammetric model doesn't match perfectly the theoretical model which must be a little larger between 144 m (472.4 ft) and 190 m (623.4 ft) of altitude. However, deformations are visible by looking at the variations of the deformation map. A purple zone in the blue zone will indicate a deformation of about 8 in.

There is a difference of about 8 in between a blue zone and a purple zone (2ft vs 2.62ft). Purple zones inside blue zones are very likely caused by structure deformation during the lifetime of the asset.

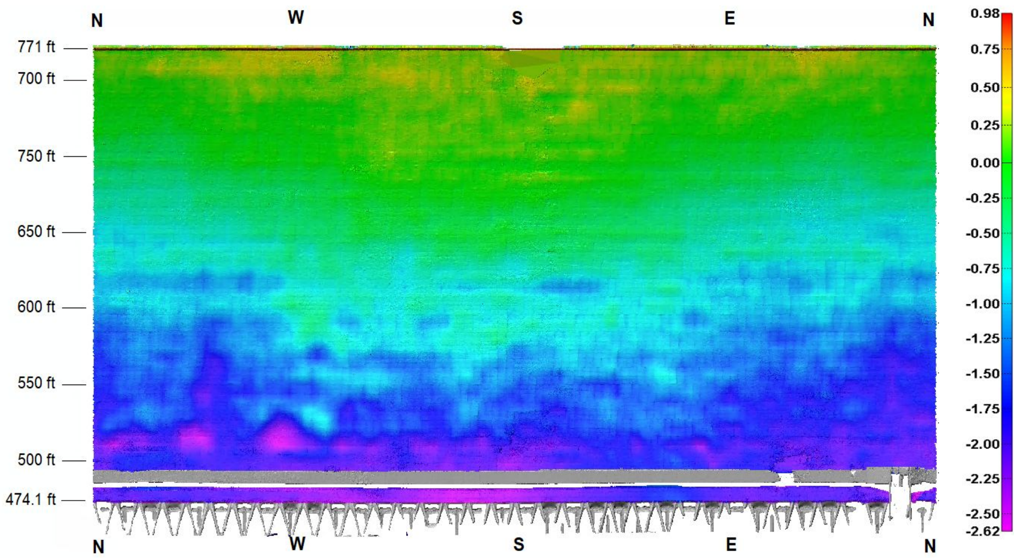


Views from North and East (scale in foot)



Views from South and West (scale in foot)

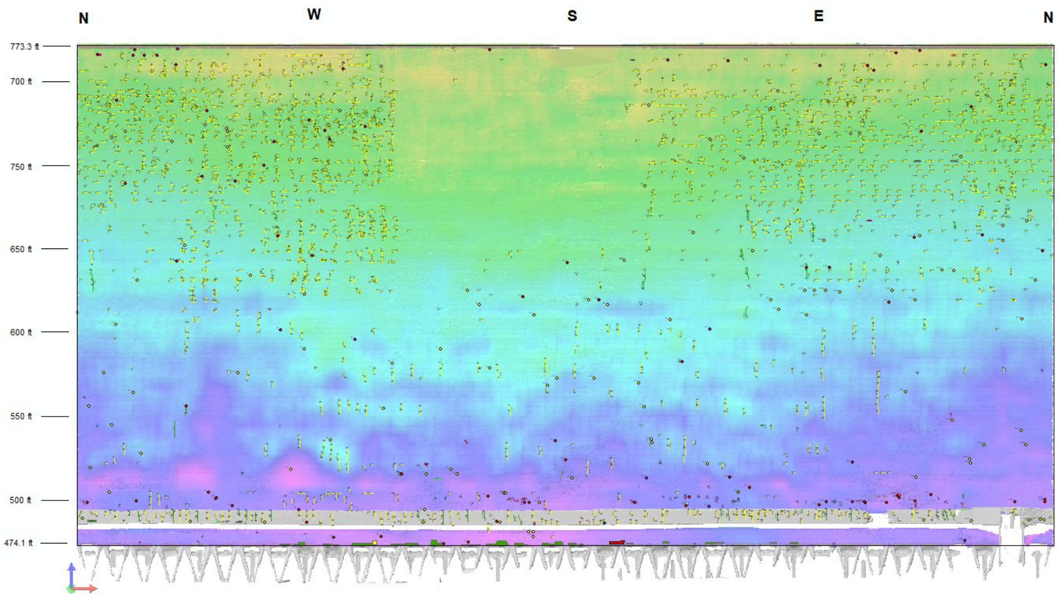
It is possible to unwrap these distortions in the same way we developed the orthophotography:



Cylindrical unwrapping of the distortions (scale in feet)

10.3. Defect overlying

It is now possible to overlay the visual defects of the shell with the geometrical distortions of the shell:



There is no obvious correlation between defects and distortions.

11. Data

The following data is provided with this report:

- Table of defects and table of defects with 3D coordinates of all the points
- PDF of mappings
- .tiff file of the orthophotography compatible with GIS software
- Shape files of defects
- Point cloud as .las file
- 3D textured model as .OBJ file

12. Flight analysis and experience feedback

6 different flight trajectories were flown with the RTK antenna placed on two different points. For better accuracy, the RTK base should be placed on a point known in XYZ on the floor, and these 3D coordinates should be written in the base software to get the precise location of each photo. If the base is placed on 2 or 3 points on the floor, we should know the exact location of these 3 points (and height above the ground of the antenna). The trajectories of the UAV should be based on the same locations to prevent losing some parts of the cooling tower (South).

The next inspection flights will be optimized to capture the lower part of the basin and the low part of the shell as well as increase the overlap between tower sections.
At the top of the cooling tower, the south part is hidden by the smoke. These hidden parts depend on the wind and should be retaken at a later date when there is no wind or with a different direction.

The photos are sharp, the flight speed is good compared to the shutter speed.

13. Conclusion

This report has presented the visual inspection of the Big Sandy cooling tower with images taken with a UAV and automatic flights.

The data provided defines a visual archive of the shell on the 22nd of April 2020. It does not define an accurate geometry archive because of the lack of 3D references.

It is possible to combine this data with future photo coverage of the tower to give an accurate evolution of the defects on the tower.

14. Appendices 1 to 6

Appendix 1 : table of defects
Appendix 2 : map of defects
Appendix 3 : map of defects with falling risk overlaying the orthophotography
Appendix 4 : map of defects overlaying the orthophotography
Appendix 5 : map of distortions
Appendix 6 : map of defects overlaying the distortions

Defect Id	Geometry	Type	Secondary feature 1	Secondary feature 2	Location	Particularity 1	Particularity 2	Remark	Average opening (in)	Length 3D (ft)	Area (ft²)	Orientation (°)	Orientation	**Center X (ft) (circumference position)**	**Center Y (ft) (Elevation)**
1	PT	DX	EF		RCO									0.27	45.52
2	PT	CO	VS		RCO									0.54	46.38
3	PT	DX	EF		RCO	CRE								0.62	51.74
4	PT	DX	EF		RCO	CRE								0.71	48.30
5	PT	CO	VS		RCO									1.12	71.30
6	PT	DX	EF		RCO	CRE								1.47	53.60
7	PT	DX	EF		RCO	CRE								1.77	46.98
8	PT	DX	EF		RCO									1.92	66.70
9	PT	DX	EF		RCO	CRE								1.92	50.68
10	PT	DX	EF		RCO	CRE								2.14	56.30
11	PT	US			RCO	CRE								2.18	68.76
12	PT	CO	RT		RCO			Corroded bolt						2.65	64.13
13	PT	DX	EF		RCO									2.68	67.03
14	PT	DX	EF		RCO									3.08	52.52
15	PT	CO	VS		RCO	CRE								3.08	71.27
16	PT	CO	VS		RCO									3.17	71.56
17	PT	CO	VS		RCO									3.27	46.49
18	PT	DX	EF		RCO	CRE								3.30	58.76
19	PT	DX	EF		RCO	CRE								3.54	49.10
20	PT	CO	VS		RCO	CRE								3.71	71.28
21	PT	CO	VS		RCO									4.41	71.28
22	PT	DX	EF		RCO									5.27	66.48
23	PT	CO	VS		RCO									5.46	70.72
24	PT	CO	RT		RCO									5.52	59.82
25	PT	US			RCO									5.58	71.60
26	PT	DX	EF		RCO	CRE								5.94	60.68
27	PT	CO	VS		RCO	CRE								6.06	51.74
28	PT	DX	EF		RCO									6.24	45.33
29	PT	US			SEA									6.93	64.54
30	PT	DX	EF		RCO	CRE								7.09	67.37
31	PT	CO	RT		RCO									7.20	68.17
32	PT	CO	VS		RCO									7.27	46.95
33	PT	CO	VS		RCO									7.68	46.61
34	PT	CO	VS		RCO									7.71	46.67
35	PT	DX	EF		SEA									8.27	67.22
36	PT	DX	EF		RCO	CRE								8.34	66.14
37	PT	DX	EF		SEA									8.35	67.02
38	PT	CO	VS		RCO									8.60	46.20
39	PT	CO	RT		SEA									8.78	64.26
40	PT	DX	EF		RCO	CRE								8.89	53.59
41	PT	DX	EF		RCO	CRE								9.62	59.02
42	PT	CO	RT		SEA									10.37	65.13
43	PT	DX	EF		RCO									10.41	45.26
44	PT	CO	RT		SEA									10.94	66.44
45	PT	CO	RT		SEA									11.14	61.22
46	PT	US			RCO									11.27	55.98
47	PT	DX	EF		RCO	CRE								11.84	48.23
48	PT	US			RCO									12.28	45.99
49	PT	DX	EF		RCO	CRE								12.60	57.95
50	PT	DX	EF		RCO	CRE								12.61	54.94
51	PT	CO	VS		RCO									12.73	45.29
52	PT	CO	RT		SEA									12.86	67.66
53	PT	CO	RT		SEA									13.05	60.13
54	PT	CO	RT		SEA									13.73	67.08
55	PT	CO	RT		SEA									14.02	66.58
56	PT	DX	CS		RCO									14.07	49.86
57	PT	CO	VS		RCO									14.23	44.43
58	PT	DX	EF		SEA									14.60	68.17
59	PT	CO	RT		RCO									14.78	70.52

60	PT	US			RCO									15.42	55.47
61	PT	CO	RT		SEA									15.97	67.28
62	PT	DX	EF		RCO	CRE								16.04	64.61
63	PT	DX	EF		SEA									16.87	70.66
64	PT	CO	RT		RCO									16.88	44.50
65	PT	DX	EF		RCO									17.03	51.61
66	PT	DX	EF		RCO	CRE								17.48	54.13
67	PT	DX	EF		RCO									17.93	47.99
68	PT	DX	EF		RCO									17.98	47.99
69	PT	CO	VS		RCO									18.03	47.97
70	PT	DX	EF		RCO									19.21	45.30
71	PT	DX	CS		RCO									19.29	45.97
72	PT	DX	EF		RCO	CRE								19.40	47.98
73	PT	DX	EF		RCO	CRE								20.16	54.93
74	PT	CO	VS		RCO									20.35	44.11
75	PT	DX	EF		RCO	CRE								20.73	48.24
76	PT	DX	EF		RCO	CRE								21.11	47.96
77	PT	DX	EF		RCO	CRE								21.65	58.18
78	PT	CO	RT		RCO									21.71	44.18
79	PT	DX	CS		RCO	CRE								22.32	57.38
80	PT	CO	VS		RCO									22.81	46.74
81	PT	CO	VS		RCO									22.90	71.55
82	PT	DX	EF		RCO	CRE								22.90	53.86
83	LI	CR			RCO				0.0315	6.74		101	Hz	0.14	45.77
84	SF	CA			SEA						5.11			0.79	45.38
85	LI	DX	EF		RCO					1.21		173	Vertical	0.75	45.84
86	PT	CO	VS		RCO									23.30	45.33
87	LI	DX	EF		RCO					2.81		179	Vertical	1.01	45.76
88	LI	CO	VS		RCO					1.31		31	Inclined	0.36	46.42
89	PT	DX	EF		RCO									23.46	45.29
90	LI	DX	EF		RCO					2.64		179	Vertical	1.59	45.72
91	PT	DX	CS		RCO									23.70	46.89
92	PT	DX	CS		RCO									23.77	46.89
93	LI	CO	VS		RCO					0.41		30	Inclined	3.44	44.20
94	LI	DX	EF		RCO					1.75		168	Vertical	1.87	45.87
95	LI	DX	EF		RCO					5.72		178	Vertical	2.12	45.65
96	LI	DX	EF		RCO					0.66		2	Vertical	2.59	45.36
97	LI	DX	EF		RCO					0.67		163	Inclined	2.41	46.23
98	LI	CR	EF		RCO				0.0315	4.74		109	Inclined	2.89	45.78
99	LI	CR	EF		RCO				0.0315	6.87		109	Inclined	3.37	45.66
100	LI	DX	EF		RCO					4.66		120	Inclined	3.95	45.45
101	LI	DX	EF		RCO					5.83		98	Hz	3.71	45.79
102	PT	CO	VS		RCO									24.77	57.82
103	PT	US			RCO									24.86	46.38
104	LI	DX	EF		RCO					2.94		168	Vertical	4.28	45.67
105	PT	DX	EF		RCO									25.04	44.77
106	LI	DX	EF		RCO					2.52		90	Hz	1.59	48.56
107	PT	CO	VS		RCO									25.10	46.38
108	LI	DX	EF		RCO					7.24		131	Inclined	4.69	45.59
109	LI	DX	EF		RCO					11.21		162	Inclined	4.06	46.50
110	PT	DX	EF		RCO									25.32	44.49
111	PT	DX	EF		RCO									25.34	44.76
112	PT	DX	EF		RCO	CRE								25.36	56.84
113	LI	DX	EF		RCO					3.83		163	Inclined	2.08	48.71
114	LI	DX	EF		RCO					1.55		10	Vertical	5.01	45.79
115	LI	CO	VS		RCO					0.85		153	Inclined	6.70	44.19
116	LI	CR	EF		RCO	CRE			0.0315	7.65		180	Vertical	5.31	45.63
117	LI	DX	EF		RCO					0.62		17	Inclined	4.89	46.16
118	LI	DX	EF		RCO					7.69		161	Inclined	4.53	46.52
119	LI	DX	EF		RCO					9.66		141	Inclined	5.71	45.59
120	LI	DX	EF		RCO					1.13		180	Vertical	5.45	45.86
121	PT	DX	CS		RCO									25.67	46.38
122	LI	CO	VS		RCO					0.98		32	Inclined	6.96	44.56

123	LI	DX	EF		RCO					1.36		162	Inclined	4.95	46.67
124	LI	DX	EF		RCO					7.94		176	Vertical	6.13	45.63
125	LI	SE			RCO	CRE				0.96		89	Hz	1.10	50.68
126	LI	DX	EF		RCO					6.79		161	Inclined	2.60	49.32
127	LI	DX	EF		RCO	CRE				0.60		90	Hz	3.39	48.57
128	PT	DX	EF		RCO									26.10	52.91
129	LI	CR	EF		RCO	CRE			0.0315	6.88		179	Vertical	6.67	45.59
130	LI	DX	EF		RCO					1.20		161	Inclined	6.11	46.25
131	LI	CO	VS		RCO					0.45		165	Vertical	0.40	52.22
132	LI	DX	EF		RCO					5.36		175	Vertical	7.24	45.59
133	PT	CO	VS		RCO									26.55	49.80
134	LI	US			SEA					4.77		101	Hz	7.81	45.33
135	PT	DX	EF		RCO	CRE								26.64	53.31
136	LI	DX	EF		RCO					5.60		71	Inclined	7.69	45.68
137	SF	CA			SEA						0.65			8.31	45.35
138	LI	DX	EF		RCO	CRE				6.56		179	Vertical	8.02	45.64
139	LI	DX	EF		RCO					5.57		178	Vertical	8.46	45.66
140	PT	CO	VS		RCO									27.11	48.76
141	SF	CA			SEA						2.16			8.97	45.32
142	LI	CO	VS		RCO					0.41		102	Hz	10.34	44.02
143	PT	CO	VS		RCO									27.24	59.73
144	LI	US			RCO		FR			1.20		1	Vertical	9.33	45.24
145	LI	SE			RCO					1.05		180	Vertical	9.96	44.75
146	LI	CR	EF		RCO				0.0315	4.04		171	Vertical	8.98	45.79
147	PT	DX	EF		RCO	CRE								27.50	47.73
148	LI	CR	EF		RCO	CRE			0.0315	6.44		178	Vertical	9.40	45.66
149	LI	DX	EF		RCO					5.24		176	Vertical	9.66	45.60
150	LI	CR	EF		RCO				0.0315	6.07		177	Vertical	9.88	45.64
151	SF	CA			SEA						3.74			11.52	44.08
152	LI	DX	EF		RCO					6.45		169	Vertical	10.28	45.48
153	LI	CR			RCO				0.0315	10.49		162	Inclined	5.37	50.45
154	SF	CA			SEA						0.55			12.07	44.06
155	LI	CR	EF		RCO	CRE			0.0315	6.62		180	Vertical	10.76	45.64
156	LI	DX	EF		RCO	CRE				1.59		90	Hz	9.56	46.94
157	SF	CA			SEA						6.08			12.43	44.10
158	LI	DX	EF		RCO	CRE				0.71		89	Hz	9.81	46.94
159	PT	DX	EF		RCO	CRE								28.40	57.64
160	LI	DX	EF		RCO					0.91		137	Inclined	3.09	53.85
161	LI	CO	VS		RCO					0.78		171	Vertical	0.02	56.96
162	LI	DX	EF		RCO	CRE				0.85		92	Hz	9.19	48.00
163	LI	US			SEA					0.48		69	Inclined	12.64	44.57
164	LI	CO	VS	RT	RCO	CRE				0.89		91	Hz	9.19	48.01
165	PT	DX	EF		RCO	CRE								28.72	53.31
166	LI	CR	EF		RCO	CRE			0.03937	5.84		160	Inclined	6.04	51.47
167	LI	DX	EF		RCO	CRE				1.02		91	Hz	2.12	55.49
168	LI	DX	EF		RCO					3.08		161	Inclined	11.51	46.28
169	SF	CA			SEA						3.59			13.88	44.05
170	PT	CO	VS		RCO									29.00	57.65
171	LI	DX	EF		RCO					4.23		179	Vertical	12.40	45.73
172	LI	CO	VS		RCO					0.65		143	Inclined	11.51	46.71
173	LI	DX	EF		RCO					3.14		24	Inclined	11.91	46.46
174	SF	CA			SEA						1.64			14.35	44.04
175	LI	DX	EF		RCO					4.35		178	Vertical	12.79	45.70
176	PT	SE			RCO									29.30	45.26
177	LI	US			RCO		FR			1.40		91	Hz	13.50	45.14
178	LI	DX	EF		RCO					4.93		179	Vertical	13.12	45.70
179	LI	DX	EF		RCO	CRE				2.26		165	Vertical	13.49	45.34
180	LI	DX	EF		RCO	CRE				0.81		91	Hz	1.79	57.11
181	PT	DX	EF		RCO	CRE								29.46	57.37
182	LI	DX	EF		RCO	CRE				0.99		93	Hz	0.20	58.75
183	LI	DX	EF		RCO	CRE				3.67		15	Inclined	12.74	46.61
184	LI	DX	EF		SEA					6.13		90	Hz	12.44	46.92
185	LI	US			RCO	CRE				0.93		91	Hz	0.80	58.77

186	LI	CR	EF		RCO				0.0315	13.20		162	Inclined	0.85	58.74
187	LI	DX	EF		RCO					4.94		163	Inclined	13.14	46.45
188	LI	DX	EF		RCO					7.34		168	Vertical	14.14	45.46
189	LI	DX	EF		RCO					8.62		20	Inclined	10.44	49.33
190	SF	CA			SEA						14.84			15.80	44.08
191	LI	DX	EF		RCO					3.41		165	Vertical	13.59	46.63
192	SF	DX	HC		RCO						6.74			16.50	44.15
193	LI	DX	EF		RCO					2.78		161	Inclined	13.95	46.80
194	LI	DX	EF		RCO					1.51		156	Inclined	6.03	54.73
195	PT	CO	VS		RCO	CRE								30.39	59.85
196	PT	DX	EF		RCO	CRE								30.39	59.84
197	LI	DX	EF		RCO					8.15		11	Vertical	0.78	60.02
198	LI	DX	EF		SEA					1.51		94	Hz	6.07	54.92
199	LI	DX	EF		RCO					3.75		164	Inclined	14.40	46.68
200	LI	DX	EF		RCO	CRE				10.90		90	Hz	14.22	46.92
201	LI	DX	EF		RCO	CRE				1.45		91	Hz	0.76	60.40
202	LI	DX	EF		RCO	CRE				3.73		11	Vertical	6.06	55.21
203	LI	DX	EF		RCO	CRE				0.85		86	Hz	2.04	59.30
204	LI	DX	EF		RCO					4.23		17	Inclined	14.81	46.58
205	LI	DX	EF		RCO					3.35		90	Hz	0.48	60.94
206	LI	DX	EF		RCO					5.80		20	Inclined	15.22	46.20
207	LI	DX	EF		RCO	CRE				1.15		93	Hz	1.32	60.40
208	SF	CA			SEA						6.07			17.71	44.06
209	PT	CO	VS		RCO									30.94	46.38
210	LI	DX	EF		RCO					7.94		13	Vertical	6.09	55.89
211	LI	US			RCO					0.48		163	Inclined	11.34	50.68
212	LI	DX	EF		RCO					1.84		165	Inclined	8.40	53.65
213	LI	DX	EF		RCO	CRE				9.06		163	Inclined	12.35	49.72
214	LI	CR			RCO				0.0315	1.58		179	Vertical	16.23	45.86
215	LI	DX	EF		RCO					3.30		156	Inclined	15.09	47.05
216	LI	DX	EF		RCO					3.58		179	Vertical	16.53	45.71
217	LI	DX	EF		RCO					7.48		179	Vertical	16.87	45.50
218	PT	DX	EF		RCO	CRE								31.20	53.05
219	LI	DX	EF		RCO					1.28		15	Vertical	6.08	56.47
220	LI	DX	EF		RCO	CRE				1.15		91	Hz	3.26	59.30
221	LI	DX	EF		RCO					3.96		164	Inclined	13.63	48.97
222	SF	CA			SEA						8.16			18.56	44.08
223	LI	US			RCO	CRE				0.68		89	Hz	13.61	49.06
224	LI	DX	EF		RCO					4.28		172	Vertical	17.15	45.67
225	LI	DX	EF		SEA					4.33		102	Hz	5.80	57.08
226	LI	DX	EF		RCO					6.84		24	Inclined	9.47	53.48
227	PT	DX	EF		RCO	CRE								31.48	51.72
228	LI	DX	EF		RCO					4.47		161	Inclined	14.12	48.87
229	PT	DX	EF		RCO	CRE								31.52	64.00
230	LI	DX	EF		SEA					7.69		89	Hz	16.18	46.91
231	LI	DX	EF		SEA					7.76		90	Hz	6.61	56.49
232	LI	DX	EF		SEA					0.81		86	Hz	0.29	62.83
233	LI	DX	EF		RCO					10.03		164	Inclined	14.54	48.61
234	LI	DX	EF		RCO					5.94		179	Vertical	17.59	45.57
235	LI	DX	EF		RCO					0.60		172	Vertical	17.88	45.30
236	PT	US			RCO									31.60	47.77
237	LI	DX	EF		RCO					6.27		159	Inclined	13.71	49.56
238	LI	DX	EF		RCO	CRE				1.02		86	Hz	1.79	61.50
239	LI	DX	EF		SEA					1.45		76	Hz	1.74	61.71
240	LI	DX	EF		SEA					3.21		11	Vertical	1.81	61.67
241	PT	DX	EF		SEA									31.76	68.48
242	LI	DX	EF		RCO					4.18		160	Inclined	14.15	49.41
243	LI	DX	EF		SEA					0.58		86	Hz	0.80	62.77
244	LI	DX	EF		RCO	CRE				16.41		160	Inclined	14.97	48.71
245	LI	DX	EF		SEA					3.73		71	Inclined	3.97	59.77
246	LI	DX	EF		RCO					5.97		170	Vertical	18.17	45.58
247	LI	DX	EF		RCO					3.01		159	Inclined	10.83	52.96
248	LI	DX	EF		SEA					1.57		140	Inclined	0.88	62.92

249	PT	DX	EF		RCO									31.91	49.89
250	PT	DX	EF		RCO	CRE								31.91	49.73
251	LI	DX	EF		SEA					2.42		82	Hz	1.41	62.52
252	LI	DX	EF		SEA					1.49		80	Hz	5.22	58.73
253	SF	CA			SEA						14.83			19.85	44.15
254	LI	DX	EF		SEA					8.43		89	Hz	6.50	57.56
255	LI	DX	EF		SEA					4.00		70	Inclined	0.53	63.64
256	LI	DX	EF		SEA					2.97		90	Hz	1.37	62.85
257	LI	DX	EF		RCO					1.89		173	Vertical	1.48	62.75
258	LI	DX	EF		SEA					1.45		172	Vertical	1.33	62.92
259	LI	DX	EF		SEA					2.37		86	Hz	6.38	57.88
260	LI	DX	EF		RCO					2.78		171	Vertical	18.54	45.72
261	LI	DX	EF		RCO					0.75		171	Vertical	6.43	57.84
262	LI	DX	EF		RCO					2.99		19	Inclined	15.91	48.37
263	LI	DX	EF		SEA					3.04		82	Hz	1.34	62.98
264	LI	CO	VS		RCO					0.36		150	Inclined	17.53	46.88
265	LI	SE			RCO	CRE				0.56		90	Hz	0.44	64.00
266	LI	DX	EF		RCO					4.37		18	Inclined	17.74	46.71
267	LI	DX	EF		SEA					5.44		101	Hz	6.29	58.19
268	LI	DX	EF		SEA					4.99		89	Hz	5.80	58.71
269	LI	DX	EF		RCO					0.86		171	Vertical	6.44	58.09
270	LI	DX	EF		SEA					5.59		77	Hz	4.15	60.41
271	LI	DX	EF		RCO					1.66		174	Vertical	19.25	45.33
272	LI	DX	EF		SEA					1.72		169	Vertical	5.82	58.79
273	LI	CR	EF		RCO	CRE			0.0315	4.54		179	Vertical	18.96	45.71
274	LI	DX	EF		SEA					3.00		100	Hz	7.66	57.02
275	LI	DX	EF		SEA					0.94		85	Hz	0.06	64.72
276	LI	DX	EF		SEA					2.25		95	Hz	1.16	63.64
277	LI	DX	EF		SEA					2.96		103	Hz	1.74	63.09
278	LI	DX	EF		SEA					4.37		114	Inclined	7.20	57.64
279	LI	DX	EF		RCO	CRE				1.55		91	Hz	16.35	48.50
280	LI	DX	EF		SEA					1.22		92	Hz	0.53	64.46
281	LI	DX	EF		SEA					4.32		94	Hz	5.20	59.78
282	LI	DX	EF		RCO					1.78		171	Vertical	19.66	45.36
283	LI	DX	EF		RCO					6.01		148	Inclined	2.12	62.90
284	LI	DX	EF		SEA					6.43		89	Hz	6.35	58.70
285	LI	DX	EF		SEA					3.33		79	Hz	5.83	59.24
286	LI	DX	EF		RCO	CRE				1.32		88	Hz	0.24	64.83
287	LI	DX	EF		RCO	CRE				6.61		12	Vertical	8.92	56.19
288	LI	DX	EF		RCO					2.25		171	Vertical	3.81	61.34
289	LI	DX	EF		RCO					9.12		164	Inclined	13.59	51.59
290	LI	DX	EF		RCO					1.42		178	Vertical	19.47	45.74
291	LI	DX	EF		RCO	CRE				1.42		93	Hz	0.10	65.12
292	LI	DX	EF		SEA					2.85		97	Hz	1.09	64.20
293	LI	DX	EF		SEA					3.62		85	Hz	7.70	57.59
294	LI	DX	EF		SEA					1.52		10	Vertical	7.67	57.66
295	LI	DX	EF		SEA					2.10		105	Hz	1.77	63.65
296	LI	DX	EF		SEA					0.60		87	Hz	0.43	65.05
297	LI	DX	EF		RCO					7.63		164	Inclined	1.89	63.60
298	LI	DX	EF		RCO	CRE				0.55		90	Hz	3.72	61.78
299	LI	DX	EF		RCO					3.64		167	Vertical	7.03	58.48
300	LI	DX	EF		RCO					5.63		137	Inclined	19.84	45.67
301	LI	DX	EF		RCO	CRE				2.42		90	Hz	0.16	65.39
302	LI	DX	EF		SEA					4.32		110	Inclined	7.72	57.88
303	LI	DX	EF		SEA					4.77		86	Hz	5.85	59.77
304	PT	US	RT		RCO									32.83	70.98
305	LI	DX	EF		SEA					2.00		90	Hz	0.72	65.00
306	LI	DX	EF		SEA					1.88		69	Inclined	1.26	64.48
307	LI	DX	EF		RCO					3.96		14	Vertical	8.85	56.94
308	LI	DX	EF		SEA					3.40		118	Inclined	7.68	58.13
309	LI	DX	EF		SEA					9.18		90	Hz	7.17	58.67
310	LI	CR	EF		RCO	CRE			0.0315	8.50		179	Vertical	20.32	45.53
311	PT	DX	EF		RCO	CRE								32.94	56.55

312	LI	DX	EF		SEA					1.93		169	Vertical	7.12	58.76
313	SF	CA			SEA						7.16			21.84	44.04
314	LI	DX	EF		RCO	CRE				3.14		163	Inclined	17.64	48.39
315	LI	DX	EF		SEA					1.88		82	Hz	1.03	65.06
316	LI	DX	EF		RCO					2.57		179	Vertical	20.86	45.24
317	LI	DX	EF		RCO					0.50		91	Hz	1.84	64.27
318	LI	DX	EF		SEA					6.01		90	Hz	6.32	59.80
319	LI	DX	EF		SEA					6.43		87	Hz	5.85	60.31
320	LI	DX	EF		RCO					9.06		165	Inclined	14.57	51.64
321	LI	DX	EF		SEA					4.23		84	Hz	1.46	64.77
322	LI	DX	EF		SEA					5.32		77	Hz	3.08	63.16
323	LI	DX	EF		RCO					9.01		162	Inclined	10.07	56.16
324	LI	DX	EF		SEA					1.94		171	Vertical	5.87	60.41
325	LI	DX	EF		SEA					6.16		89	Hz	7.06	59.24
326	LI	DX	EF		SEA					3.66		87	Hz	7.66	58.69
327	LI	DX	EF		SEA					2.14		108	Inclined	2.50	63.92
328	LI	DX	EF		SEA					2.62		73	Inclined	0.28	66.14
329	LI	DX	EF		RCO					3.83		168	Vertical	20.75	45.75
330	LI	CO	VS		RCO					0.55		31	Inclined	19.87	46.64
331	LI	DX	EF		SEA					1.37		82	Hz	0.11	66.42
332	LI	DX	EF		RCO	CRE				2.10		91	Hz	18.03	48.51
333	LI	DX	EF		RCO					2.15		11	Vertical	1.96	64.65
334	LI	DX	EF		SEA					1.64		88	Hz	0.83	65.87
335	LI	DX	EF		SEA					4.95		90	Hz	5.84	60.89
336	LI	DX	EF		SEA					2.49		97	Hz	2.58	64.20
337	LI	DX	EF		SEA					6.64		93	Hz	6.43	60.35
338	LI	DX	EF		SEA					1.28		102	Hz	1.49	65.30
339	LI	DX	EF		SEA					1.78		172	Vertical	5.81	60.98
340	LI	DX	EF		SEA					2.74		96	Hz	3.20	63.62
341	LI	DX	EF		SEA					1.52		53	Inclined	1.77	65.06
342	LI	DX	EF		SEA					5.67		74	Inclined	7.11	59.73
343	LI	DX	EF		RCO					7.03		163	Inclined	15.08	51.76
344	LI	DX	EF		RCO					4.64		167	Vertical	21.12	45.73
345	LI	DX	EF		SEA					0.78		86	Hz	2.15	64.77
346	LI	DX	EF		SEA					3.18		164	Inclined	0.92	66.01
347	LI	DX	EF		RCO					5.14		14	Vertical	10.08	56.87
348	LI	DX	EF		SEA					3.90		68	Inclined	0.55	66.44
349	LI	CO	VS		RCO					0.55		65	Inclined	20.45	46.61
350	LI	DX	EF		RCO					1.30		151	Inclined	13.25	53.82
351	LI	DX	EF		SEA					0.82		89	Hz	4.02	63.08
352	LI	DX	EF		SEA					2.19		94	Hz	0.17	66.98
353	LI	DX	EF		SEA					0.74		87	Hz	3.26	63.91
354	LI	DX	EF		RCO	CRE				0.70		88	Hz	2.62	64.56
355	LI	DX	EF		RCO					4.38		156	Inclined	15.56	51.65
356	LI	DX	EF		SEA					0.81		120	Inclined	0.53	66.68
357	LI	DX	EF		SEA					1.01		13	Vertical	0.98	66.24
358	LI	DX	EF		SEA					2.47		105	Inclined	1.05	66.17
359	PT	CO	VS		RCO									33.61	54.22
360	LI	DX	EF		SEA					3.12		132	Inclined	4.05	63.23
361	LI	CR	EF		RCO	CRE			0.0315	7.04		180	Vertical	21.69	45.60
362	LI	DX	EF		RCO					5.33		11	Vertical	8.84	58.45
363	LI	DX	EF		SEA					1.13		24	Inclined	1.08	66.24
364	LI	DX	EF		SEA					2.27		87	Hz	3.22	64.10
365	LI	DX	EF		SEA					1.50		98	Hz	0.10	67.26
366	LI	DX	EF		RCO					1.41		167	Vertical	7.20	60.15
367	LI	CO	VS		RCO					0.48		155	Inclined	18.94	48.42
368	LI	DX	EF		SEA					2.08		89	Hz	2.38	65.12
369	LI	DX	EF		RCO					7.14		160	Inclined	16.04	51.47
370	LI	DX	EF		SEA					2.51		81	Hz	3.29	64.22
371	LI	DX	EF		SEA					2.92		84	Hz	2.21	65.32
372	LI	DX	EF		SEA					1.51		84	Hz	2.79	64.76
373	SF	CA			SEA						24.64			23.44	44.12
374	LI	DX	EF		SEA					1.80		111	Inclined	0.15	67.42

375	LI	DX	EF		RCO	CRE				1.68		90	Hz	5.50	62.07
376	LI	DX	EF		RCO	CRE				1.63		90	Hz	20.70	46.90
377	LI	DX	EF		SEA					6.23		91	Hz	8.80	58.82
378	LI	DX	EF		SEA					3.01		60	Inclined	6.48	61.14
379	PT	CO	VS		RCO									33.82	46.21
380	LI	US			SEA	CRE				5.22		90	Hz	20.01	47.72
381	LI	CO	VS	EF	RCO	CRE				0.83		91	Hz	10.64	57.12
382	LI	DX	EF		SEA					3.05		18	Inclined	8.92	58.84
383	LI	DX	EF		SEA					1.63		90	Hz	2.79	65.02
384	LI	DX	EF		RCO					5.85		1	Vertical	22.88	44.93
385	LI	DX	EF		SEA					2.81		105	Inclined	1.42	66.44
386	LI	DX	EF		SEA					1.03		87	Hz	4.78	63.10
387	LI	DX	EF		RCO					1.69		7	Vertical	7.18	60.70
388	SF	US			RCO	CRE					0.75			19.36	48.54
389	LI	DX	EF		SEA					4.17		99	Hz	6.48	61.42
390	LI	DX	EF		RCO					2.56		19	Inclined	19.38	48.53
391	LI	DX	EF		SEA					3.58		112	Inclined	6.23	61.69
392	LI	DX	EF		RCO	CRE				1.61		90	Hz	19.42	48.51
393	LI	DX	EF		SEA					3.66		95	Hz	7.15	60.79
394	LI	DX	EF		SEA					1.01		86	Hz	0.94	67.01
395	LI	DX	EF		SEA					1.88		54	Inclined	2.09	65.89
396	LI	CO	VS		RCO					0.43		40	Inclined	21.28	46.70
397	PT	CO	VS		RCO									34.00	46.69
398	LI	DX	EF		RCO	CRE				8.88		14	Vertical	11.88	56.16
399	LI	DX	EF		SEA					0.91		95	Hz	3.81	64.28
400	LI	DX	EF		SEA					0.83		88	Hz	0.70	67.39
401	LI	DX	EF		SEA					2.98		106	Inclined	4.48	63.66
402	LI	US			RCO		FR			2.53		90	Hz	23.00	45.15
403	LI	DX	EF		SEA					2.44		86	Hz	7.89	60.27
404	LI	DX	EF		SEA					1.14		175	Vertical	3.38	64.80
405	LI	DX	EF		SEA					1.12		90	Hz	0.47	67.71
406	LI	DX	EF		RCO					6.03		14	Vertical	12.42	55.77
407	LI	CO	VS		RCO					0.78		156	Inclined	21.90	46.32
408	LI	DX	EF		SEA					3.79		101	Hz	6.21	62.02
409	LI	CR	EF		RCO				0.0315	6.04		171	Vertical	22.60	45.64
410	LI	DX	EF		SEA					1.35		114	Inclined	2.14	66.15
411	LI	DX	EF		RCO					2.87		10	Vertical	14.86	53.47
412	LI	DX	EF		RCO	CRE				2.08		90	Hz	9.03	59.29
413	LI	DX	EF		SEA					3.62		146	Inclined	2.38	65.99
414	LI	DX	EF		SEA					2.09		68	Inclined	1.13	67.28
415	LI	DX	EF		SEA					1.87		153	Inclined	1.05	67.36
416	PT	DX	EF		SEA									34.20	61.41
417	LI	DX	EF		SEA					1.13		90	Hz	1.55	67.00
418	LI	DX	EF		SEA					1.84		96	Hz	2.13	66.44
419	LI	DX	EF		SEA					2.17		63	Inclined	4.62	63.96
420	LI	DX	EF		SEA					1.59		86	Hz	7.15	61.45
421	LI	DX	EF		SEA					3.46		81	Hz	3.59	65.05
422	SF	CA			SEA						8.04			24.58	44.07
423	LI	CR			RCO				0.0315	0.99		179	Vertical	23.01	45.66
424	LI	DX	EF		SEA					0.74		71	Inclined	0.28	68.39
425	LI	DX	EF		SEA					1.41		13	Vertical	7.18	61.51
426	LI	DX	EF		SEA					1.55		88	Hz	1.67	67.13
427	LI	DX	EF		RCO					1.28		177	Vertical	2.15	66.66
428	LI	DX	EF		SEA					1.38		72	Inclined	2.98	65.88
429	LI	DX	EF		SEA					2.35		52	Inclined	1.59	67.27
430	LI	DX	EF		SEA					2.55		88	Hz	4.14	64.75
431	LI	DX	EF		RCO					8.31		174	Vertical	3.67	65.24
432	LI	DX	EF		SEA					2.77		103	Hz	5.25	63.67
433	LI	DX	EF		SEA					0.81		72	Inclined	0.70	68.23
434	LI	DX	EF		SEA					1.78		102	Hz	2.07	66.86
435	LI	DX	EF		RCO					4.34		19	Inclined	22.26	46.69
436	LI	DX	EF		SEA					2.27		70	Inclined	7.53	61.43
437	LI	DX	EF		SEA					3.26		169	Vertical	0.08	68.91

438	LI	DX	EF		SEA					3.10		88	Hz	5.94	63.10
439	LI	DX	EF		RCO					3.04		168	Vertical	14.82	54.26
440	LI	DX	EF		RCO	CRE				0.99		94	Hz	0.90	68.18
441	LI	DX	EF		SEA					2.94		107	Inclined	0.55	68.54
442	LI	DX	EF		SEA					1.41		93	Hz	0.09	69.06
443	LI	DX	EF		SEA					4.42		104	Hz	5.17	64.00
444	LI	DX	EF		RCO	CRE				1.47		90	Hz	22.29	46.90
445	LI	DX	EF		SEA					2.26		82	Hz	7.52	61.67
446	LI	DX	EF		SEA					4.01		92	Hz	0.51	68.68
447	LI	DX	EF		SEA					1.78		92	Hz	10.26	58.95
448	LI	DX	EF		SEA					5.20		108	Inclined	2.81	66.42
449	LI	DX	EF		SEA					1.84		62	Inclined	3.61	65.62
450	LI	DX	EF		SEA					1.70		176	Vertical	0.49	68.76
451	LI	DX	EF		SEA					3.64		103	Hz	4.22	65.05
452	LI	DX	EF		SEA					2.24		76	Hz	1.19	68.10
453	LI	DX	EF		SEA					2.48		169	Vertical	10.23	59.07
454	LI	DX	EF		RCO					5.31		22	Inclined	15.96	53.37
455	LI	DX	EF		SEA					2.42		72	Inclined	10.27	59.09
456	LI	DX	EF		SEA					2.46		91	Hz	6.81	62.56
457	LI	DX	EF		SEA					1.38		170	Vertical	1.75	67.63
458	LI	DX	EF		RCO	CRE				2.21		91	Hz	0.35	69.03
459	LI	DX	EF		RCO					2.59		7	Vertical	4.74	64.65
460	LI	DX	EF		SEA					1.59		92	Hz	2.70	66.70
461	LI	DX	EF		SEA					5.98		89	Hz	10.70	58.70
462	LI	DX	EF		SEA					3.22		78	Hz	1.89	67.55
463	LI	DX	EF		SEA					2.07		114	Inclined	3.56	65.88
464	LI	DX	EF		SEA					3.76		101	Hz	7.54	61.96
465	LI	DX	EF		SEA					1.27		61	Inclined	2.23	67.29
466	LI	DX	EF		SEA					1.55		73	Inclined	1.45	68.10
467	LI	DX	EF		SEA					5.67		89	Hz	5.92	63.64
468	LI	DX	EF		SEA					1.16		79	Hz	10.29	59.28
469	LI	DX	EF		RCO	CRE				6.87		179	Vertical	23.96	45.61
470	LI	DX	EF		SEA					2.31		88	Hz	1.20	68.39
471	LI	DX	EF		SEA					2.07		9	Vertical	7.56	62.05
472	LI	DX	EF		SEA					2.67		91	Hz	4.31	65.33
473	LI	DX	EF		RCO					4.29		163	Inclined	18.01	51.65
474	LI	DX	EF		SEA					1.88		91	Hz	0.69	68.98
475	LI	DX	EF		SEA					1.66		36	Inclined	4.83	64.85
476	LI	DX	EF		SEA					1.19		70	Inclined	4.22	65.48
477	LI	DX	EF		RCO	CRE				0.59		94	Hz	8.49	61.23
478	LI	DX	EF		SEA					1.15		86	Hz	4.95	64.77
479	LI	DX	EF		SEA					0.92		7	Vertical	4.34	65.38
480	LI	DX	EF		RCO					0.95		157	Inclined	1.13	68.62
481	LI	DX	EF		SEA					2.94		81	Hz	4.84	64.92
482	LI	CR			RCO				0.0315	4.22		167	Vertical	24.28	45.50
483	LI	DX	EF		SEA					2.07		96	Hz	1.94	67.84
484	LI	DX	EF		SEA					5.97		85	Hz	11.97	57.84
485	LI	DX	EF		SEA					1.75		18	Inclined	1.70	68.19
486	LI	DX	EF		SEA					2.97		93	Hz	3.47	66.42
487	LI	DX	EF		SEA					2.30		81	Hz	1.91	67.99
488	LI	DX	EF		SEA					0.99		136	Inclined	4.47	65.45
489	LI	DX	EF		SEA					0.91		53	Inclined	4.86	65.06
490	LI	DX	EF		SEA					2.69		75	Hz	6.01	63.92
491	LI	DX	EF		RCO					1.56		11	Vertical	10.83	59.10
492	LI	DX	EF		RCO					1.14		10	Vertical	4.98	64.99
493	LI	DX	EF		SEA					1.95		1	Vertical	3.46	66.53
494	LI	CR			RCO				0.03937	6.66		156	Inclined	24.59	45.41
495	LI	DX	EF		RCO					3.53		12	Vertical	14.80	55.22
496	PT	DX	EF		RCO	CRE								35.01	48.56
497	LI	DX	EF		SEA					1.69		30	Inclined	1.17	68.88
498	LI	DX	EF		SEA					2.55		96	Hz	1.11	68.97
499	LI	CR			RCO				0.0315	7.76		12	Vertical	7.57	62.53
500	LI	DX	EF		RCO	CRE				0.57		93	Hz	8.31	61.79

501	LI	DX	EF		SEA					3.22		83	Hz	9.76	60.34
502	LI	DX	EF		SEA					1.09		92	Hz	3.06	67.05
503	LI	DX	EF		SEA					1.25		168	Vertical	1.64	68.48
504	LI	DX	EF		SEA					1.22		92	Hz	10.87	59.28
505	LI	DX	EF		SEA					2.10		98	Hz	6.52	63.63
506	LI	DX	EF		SEA					0.88		111	Inclined	4.26	65.89
507	LI	DX	EF		SEA					1.11		165	Inclined	1.71	68.47
508	PT	US			RCO									35.09	46.16
509	LI	DX	EF		RCO	CRE				1.54		91	Hz	2.85	67.35
510	LI	DX	EF		RCO					4.25		17	Inclined	16.48	53.73
511	LI	DX	EF		SEA					2.49		101	Hz	2.71	67.55
512	PT	US			RCO	CRE								35.13	56.02
513	PT	DX	EF		RCO	CRE								35.14	66.58
514	LI	DX	EF		SEA					3.68		117	Inclined	5.12	65.18
515	LI	DX	EF		SEA					1.62		164	Inclined	1.82	68.48
516	LI	DX	EF		RCO	CRE				0.96		92	Hz	9.09	61.22
517	LI	DX	EF		SEA					2.10		78	Hz	1.93	68.40
518	LI	DX	EF		SEA					4.40		2	Vertical	3.52	66.82
519	LI	DX	EF		SEA					4.73		98	Hz	1.79	68.55
520	LI	DX	EF		SEA					0.86		72	Inclined	4.31	66.04
521	LI	DX	EF		SEA					1.23		12	Vertical	1.11	69.30
522	LI	DX	EF		SEA					1.27		83	Hz	1.47	68.97
523	LI	DX	EF		SEA					1.60		88	Hz	3.12	67.33
524	LI	US			RCO					0.69		136	Inclined	23.99	46.51
525	LI	DX	EF		SEA					4.38		88	Hz	7.40	63.11
526	LI	CO	VS		RCO					0.84		139	Inclined	23.95	46.57
527	LI	DX	EF		RCO					6.22		162	Inclined	19.05	51.47
528	LI	DX	EF		SEA					2.51		172	Vertical	11.96	58.57
529	LI	DX	EF		SEA					3.72		89	Hz	2.45	68.12
530	LI	DX	EF		SEA					2.36		91	Hz	0.20	70.38
531	LI	CO	VS		RCO					0.39		90	Hz	25.38	45.20
532	LI	DX	EF		SEA					2.01		98	Hz	3.55	67.03
533	SF	CA			SEA						17.24			26.47	44.11
534	LI	DX	EF		SEA					3.42		90	Hz	1.91	68.69
535	LI	DX	EF		SEA					2.75		75	Inclined	9.17	61.44
536	LI	DX	EF		SEA					2.45		109	Inclined	1.08	69.52
537	LI	CO	VS		RCO					1.19		179	Vertical	25.40	45.22
538	LI	DX	EF		RCO					2.20		14	Vertical	7.61	63.00
539	LI	DX	EF		RCO	CRE				2.09		89	Hz	0.76	69.86
540	LI	DX	EF		SEA					6.81		90	Hz	12.55	58.10
541	LI	DX	EF		SEA					2.92		84	Hz	8.14	62.54
542	LI	DX	EF		RCO	CRE				2.76		89	Hz	4.17	66.52
543	LI	DX	EF		SEA					3.16		80	Hz	10.48	60.30
544	LI	DX	EF		SEA					3.22		11	Vertical	12.53	58.26
545	LI	DX	EF		SEA					5.78		90	Hz	2.25	68.56
546	LI	CO	VS		RCO					1.73		141	Inclined	24.39	46.46
547	LI	CO	VS		RCO					1.30		36	Inclined	24.24	46.61
548	LI	DX	EF		SEA					1.49		168	Vertical	12.09	58.77
549	LI	DX	EF		RCO					3.77		164	Inclined	7.41	63.45
550	LI	DX	EF		SEA					1.18		10	Vertical	3.19	67.69
551	LI	DX	EF	RT	RCO					2.49		90	Hz	26.41	44.48
552	LI	DX	EF		RCO	CRE				0.47		80	Hz	9.13	61.78
553	LI	US			RCO		FR			2.04		90	Hz	0.50	70.42
554	LI	DX	EF		SEA					2.24		91	Hz	7.31	63.61
555	LI	DX	EF		SEA					2.25		67	Inclined	3.65	67.28
556	LI	DX	EF		RCO	CRE				6.84		179	Vertical	25.33	45.61
557	LI	DX	EF		SEA					3.68		94	Hz	6.73	64.22
558	LI	DX	EF		SEA					1.05		88	Hz	3.37	67.60
559	LI	DX	EF		SEA					5.04		95	Hz	2.03	68.94
560	LI	DX	EF		SEA					1.87		90	Hz	5.64	65.34
561	LI	DX	EF		SEA					1.88		77	Hz	4.26	66.72
562	LI	DX	EF		SEA					0.81		92	Hz	5.05	65.94
563	LI	DX	EF		RCO					9.33		163	Inclined	17.54	53.45

564	LI	DX	EF		SEA					2.26		92	Hz	6.20	64.79
565	LI	DX	EF		SEA					1.36		117	Inclined	1.50	69.49
566	LI	DX	EF		SEA					7.11		90	Hz	12.19	58.82
567	LI	DX	EF		SEA					2.11		8	Vertical	6.69	64.33
568	LI	DX	EF		RCO					2.01		62	Inclined	3.18	67.87
569	LI	DX	EF		SEA					3.51		95	Hz	7.97	63.08
570	LI	DX	EF		SEA					4.98		108	Inclined	9.01	62.04
571	LI	CO	VS		RCO					0.75		33	Inclined	24.70	46.37
572	LI	DX	EF		SEA					3.13		89	Hz	8.23	62.86
573	LI	DX	EF		SEA					1.06		19	Inclined	3.42	67.72
574	LI	DX	EF		SEA					5.05		95	Hz	12.17	58.97
575	LI	DX	EF		SEA					3.48		88	Hz	6.72	64.42
576	LI	DX	EF		SEA					1.80		85	Hz	8.88	62.28
577	LI	DX	EF		SEA					5.41		72	Inclined	1.37	69.79
578	LI	DX	EF		SEA					1.41		166	Vertical	2.42	68.74
579	LI	DX	EF		SEA					3.70		95	Hz	2.12	69.06
580	LI	DX	EF		RCO					2.32		178	Vertical	26.09	45.09
581	LI	DX	EF		RCO					1.56		170	Vertical	12.55	58.63
582	LI	DX	EF		RCO					2.73		133	Inclined	10.49	60.70
583	LI	DX	EF		SEA					3.48		92	Hz	3.08	68.12
584	LI	DX	EF		SEA					5.30		105	Hz	10.28	60.93
585	LI	DX	EF		RCO					2.25		175	Vertical	25.86	45.36
586	LI	DX	EF		SEA					2.17		82	Hz	4.30	66.99
587	LI	DX	EF		SEA					1.51		92	Hz	6.82	64.47
588	LI	DX	EF		SEA					3.86		89	Hz	2.49	68.81
589	LI	CO	VS		RCO					2.43		144	Inclined	24.75	46.56
590	LI	CO	VS		RCO					2.75		151	Inclined	21.59	49.74
591	LI	DX	EF		SEA					1.88		95	Hz	3.09	68.26
592	LI	DX	EF		SEA					3.45		89	Hz	4.84	66.52
593	LI	DX	EF		SEA					1.69		173	Vertical	4.31	67.07
594	LI	DX	EF		SEA					1.80		88	Hz	8.86	62.56
595	LI	DX	EF		SEA					2.76		88	Hz	11.14	60.33
596	LI	CO	VS		RCO					1.12		147	Inclined	24.87	46.60
597	LI	DX	EF		RCO					3.25		179	Vertical	26.38	45.10
598	LI	DX	EF		SEA					3.01		116	Inclined	3.09	68.41
599	LI	DX	EF		SEA					2.01		75	Inclined	11.73	59.80
600	LI	DX	EF		RCO					1.16		18	Inclined	12.62	58.92
601	LI	DX	EF		SEA					4.99		111	Inclined	12.81	58.74
602	LI	DX	EF		SEA					3.53		85	Hz	7.93	63.64
603	LI	DX	EF		RCO	CRE				2.21		90	Hz	2.55	69.03
604	SF	CA			SEA						3.74			27.49	44.09
605	LI	DX	EF		SEA					5.58		77	Hz	12.63	59.00
606	LI	DX	EF		SEA					6.31		90	Hz	13.78	57.87
607	LI	DX	EF		SEA					2.67		92	Hz	4.93	66.72
608	LI	DX	EF		SEA					0.64		82	Hz	4.09	67.57
609	LI	DX	EF		SEA					1.28		82	Hz	6.33	65.34
610	LI	DX	EF		SEA					3.80		91	Hz	2.42	69.25
611	LI	DX	EF		SEA					1.00		101	Hz	3.19	68.56
612	LI	DX	EF		SEA					1.31		87	Hz	6.29	65.47
613	LI	DX	EF		SEA					2.75		99	Hz	3.65	68.13
614	LI	DX	EF		SEA					1.57		85	Hz	2.84	68.96
615	LI	DX	EF		SEA					1.93		79	Hz	4.56	67.29
616	LI	DX	EF		SEA					4.45		75	Hz	10.36	61.50
617	LI	DX	EF		RCO					0.97		158	Inclined	13.79	58.08
618	LI	DX	EF		SEA					5.37		90	Hz	13.76	58.13
619	LI	DX	EF		RCO					2.59		2	Vertical	26.69	45.21
620	LI	DX	EF		SEA					4.01		106	Inclined	4.95	66.96
621	LI	DX	EF		SEA					2.83		86	Hz	8.02	63.89
622	LI	DX	EF		SEA					3.30		116	Inclined	12.65	59.27
623	LI	DX	EF		RCO	CRE				3.91		91	Hz	4.01	67.91
624	LI	DX	EF		SEA					1.52		75	Hz	3.63	68.30
625	LI	DX	EF		SEA					1.68		12	Vertical	7.96	63.99
626	LI	DX	EF		SEA					5.18		88	Hz	11.62	60.34

627	LI	DX	EF		SEA					6.84		117	Inclined	7.73	64.24
628	LI	DX	EF		SEA					2.15		87	Hz	7.62	64.39
629	LI	DX	EF		SEA					5.45		90	Hz	12.26	59.78
630	SF	CA			SEA						0.87			27.98	44.08
631	LI	CO	VS		RCO					1.04		29	Inclined	26.01	46.09
632	LI	DX	EF		SEA					5.02		177	Vertical	7.02	65.08
633	LI	DX	EF		RCO					2.67		179	Vertical	26.31	45.81
634	LI	DX	EF		SEA					7.34		91	Hz	13.46	58.68
635	LI	DX	EF		RCO					1.72		165	Inclined	11.14	61.06
636	LI	DX	EF		SEA					1.14		99	Hz	2.89	69.32
637	LI	DX	EF		RCO					1.94		168	Vertical	16.39	55.82
638	LI	DX	EF		RCO	CRE				1.20		89	Hz	25.32	46.91
639	LI	DX	EF		SEA					2.23		81	Hz	7.17	65.07
640	LI	CO	VS		RCO					0.45		33	Inclined	25.63	46.61
641	LI	DX	EF		SEA					2.13		90	Hz	7.69	64.56
642	LI	DX	EF		RCO					2.10		10	Vertical	1.55	70.71
643	LI	DX	EF		RCO					9.24		164	Inclined	18.59	53.68
644	LI	DX	EF		SEA					4.65		86	Hz	11.69	60.58
645	LI	DX	EF		SEA					2.94		115	Inclined	3.01	69.27
646	LI	DX	EF		SEA					6.01		90	Hz	11.12	61.16
647	LI	DX	EF		RCO					3.71		160	Inclined	26.00	46.28
648	LI	DX	EF		SEA					1.26		89	Hz	3.18	69.12
649	LI	DX	EF		RCO					4.53		25	Inclined	12.50	59.81
650	PT	CO	RT		RCO									36.16	70.96
651	LI	DX	EF		SEA					4.37		102	Hz	5.10	67.23
652	LI	DX	EF		SEA					1.49		8	Vertical	3.28	69.06
653	LI	DX	EF		SEA					2.10		93	Hz	7.61	64.73
654	LI	DX	EF		SEA					3.07		120	Inclined	13.41	58.95
655	LI	DX	EF		SEA					3.31		117	Inclined	2.58	69.79
656	LI	DX	EF		SEA					1.55		170	Vertical	4.74	67.65
657	LI	DX	EF		RCO	CRE				1.16		90	Hz	19.14	53.31
658	LI	DX	EF		SEA					3.56		121	Inclined	12.31	60.13
659	LI	DX	EF		SEA					2.21		93	Hz	4.74	67.72
660	LI	DX	EF		SEA					3.61		76	Hz	3.80	68.67
661	SF	US			RCO		FR				1.78			1.18	71.30
662	PT	CO	VS		RCO									36.25	47.79
663	LI	DX	EF		SEA					1.73		62	Inclined	7.18	65.32
664	LI	DX	EF		SEA					4.23		108	Inclined	11.02	61.48
665	LI	DX	EF		SEA					2.24		63	Inclined	3.28	69.23
666	LI	DX	EF		RCO	CRE				1.99		88	Hz	16.50	56.01
667	LI	DX	EF		SEA					2.33		114	Inclined	8.33	64.19
668	LI	DX	EF		RCO	CRE				1.53		90	Hz	3.48	69.04
669	LI	DX	EF		RCO	CRE				0.86		89	Hz	9.64	62.89
670	LI	DX	EF		SEA					1.87		100	Hz	4.73	67.82
671	LI	DX	EF		RCO					1.13		174	Vertical	11.17	61.40
672	LI	DX	EF		SEA					4.22		82	Hz	8.69	63.95
673	LI	DX	EF		SEA					2.67		92	Hz	5.64	67.00
674	LI	DX	EF		SEA					2.16		113	Inclined	2.72	69.94
675	LI	DX	EF		SEA					3.07		104	Hz	13.97	58.70
676	LI	DX	EF		SEA					2.14		92	Hz	7.65	65.05
677	LI	DX	EF		SEA					2.48		57	Inclined	4.45	68.26
678	LI	DX	EF		SEA					4.08		6	Vertical	3.87	68.86
679	LI	DX	EF		SEA					4.10		81	Hz	6.30	66.44
680	LI	DX	EF		SEA					1.86		104	Hz	11.04	61.70
681	LI	DX	EF		SEA					0.88		164	Inclined	11.11	61.66
682	LI	DX	EF		SEA					2.88		13	Vertical	3.79	68.99
683	LI	DX	EF		SEA					3.78		106	Inclined	10.26	62.54
684	LI	DX	EF		SEA					0.76		89	Hz	7.16	65.64
685	LI	DX	EF		SEA					2.03		170	Vertical	12.44	60.37
686	LI	DX	EF		SEA					0.80		14	Vertical	6.23	66.60
687	LI	DX	EF		SEA					2.10		19	Inclined	6.28	66.55
688	LI	DX	EF		SEA					1.54		136	Inclined	3.87	68.98
689	LI	DX	EF		SEA					3.80		93	Hz	5.27	67.58

690	LI	DX	EF		SEA					2.36		117	Inclined	11.72	61.15
691	LI	DX	EF		RCO	CRE				1.47		90	Hz	2.16	70.71
692	LI	DX	EF		SEA					1.47		10	Vertical	5.21	67.67
693	LI	DX	EF		SEA					4.73		66	Inclined	6.95	65.94
694	LI	DX	EF		SEA					1.99		80	Hz	8.38	64.51
695	LI	DX	EF		RCO	CRE				0.61		90	Hz	2.74	70.16
696	LI	DX	EF		SEA					1.92		86	Hz	4.55	68.38
697	LI	DX	EF		RCO	CRE				1.53		91	Hz	6.13	66.80
698	LI	DX	EF		SEA					6.27		89	Hz	12.48	60.46
699	LI	DX	EF		SEA					2.84		99	Hz	13.99	58.98
700	LI	DX	EF		SEA					1.75		179	Vertical	5.35	67.66
701	LI	DX	EF		SEA					4.30		66	Inclined	9.24	63.79
702	LI	DX	EF		RCO					10.70		164	Inclined	23.86	49.19
703	LI	DX	EF		SEA					3.38		67	Inclined	13.01	60.06
704	LI	DX	EF		SEA					3.61		82	Hz	8.88	64.21
705	LI	DX	EF		SEA					1.86		88	Hz	6.36	66.73
706	LI	DX	EF		RCO	CRE				2.33		90	Hz	4.05	69.05
707	LI	DX	EF		RCO	CRE				1.67		90	Hz	3.27	69.87
708	LI	DX	EF		SEA					2.30		92	Hz	4.49	68.68
709	LI	DX	EF		RCO					1.50		2	Vertical	27.98	45.23
710	LI	DX	EF		SEA					1.52		104	Hz	5.08	68.14
711	LI	DX	EF		SEA					0.99		93	Hz	11.77	61.45
712	LI	DX	EF		SEA					2.22		29	Inclined	3.94	69.30
713	LI	CR	EF		RCO				0.0315	4.67		173	Vertical	11.00	62.28
714	LI	DX	EF		RCO					8.40		169	Vertical	12.40	60.89
715	LI	DX	EF		SEA					1.88		97	Hz	14.08	59.22
716	LI	DX	EF		RCO	CRE				2.41		174	Vertical	3.82	69.50
717	LI	DX	EF		RCO	CRE				3.54		89	Hz	5.42	67.91
718	LI	DX	EF		SEA					2.47		105	Hz	4.37	68.97
719	LI	DX	EF		RCO	CRE				7.39		173	Vertical	9.50	63.86
720	LI	DX	EF		SEA					1.85		90	Hz	12.99	60.37
721	LI	DX	EF		RCO	CRE				0.77		87	Hz	7.16	66.24
722	PT	DX	CS		RCO									36.71	46.96
723	LI	DX	EF		RCO	CRE				3.72		2	Vertical	8.48	65.03
724	LI	CO	VS		RCO					0.53		156	Inclined	28.01	45.51
725	LI	DX	EF		SEA					7.47		89	Hz	12.91	60.62
726	LI	DX	EF		SEA					3.23		88	Hz	9.05	64.49
727	LI	DX	EF		SEA					1.35		91	Hz	8.33	65.21
728	LI	DX	EF		SEA					2.50		73	Inclined	11.03	62.52
729	LI	DX	EF		SEA					1.34		171	Vertical	13.68	59.87
730	LI	DX	EF		SEA					2.21		167	Vertical	13.08	60.47
731	LI	DX	EF		RCO					4.73		168	Vertical	2.81	70.75
732	LI	DX	EF		SEA					7.56		89	Hz	13.78	59.80
733	LI	DX	EF		SEA					2.32		74	Inclined	4.38	69.25
734	LI	DX	EF		SEA					3.59		80	Hz	5.06	68.58
735	LI	DX	EF		RCO					2.09		177	Vertical	28.37	45.28
736	LI	DX	EF		SEA					1.84		4	Vertical	6.89	66.78
737	LI	DX	EF		SEA					5.82		165	Inclined	4.60	69.08
738	LI	DX	EF		RCO					2.25		178	Vertical	2.42	71.28
739	LI	DX	EF		SEA					4.97		98	Hz	15.64	58.09
740	LI	DX	EF		SEA					2.82		110	Inclined	9.53	64.21
741	LI	DX	EF		SEA					2.04		165	Vertical	12.47	61.34
742	LI	DX	EF		RCO	CRE				2.30		89	Hz	6.17	67.64
743	LI	DX	EF		RCO	CRE				4.94		179	Vertical	7.06	66.76
744	LI	DX	EF		RCO	CRE				2.03		91	Hz	2.55	71.27
745	LI	DX	EF		SEA					1.91		17	Inclined	15.65	58.18
746	LI	DX	EF		SEA					2.78		96	Hz	5.14	68.70
747	LI	DX	EF		SEA					1.62		113	Inclined	12.42	61.44
748	LI	DX	EF		RCO					4.84		165	Inclined	10.99	62.86
749	LI	DX	EF		SEA					1.68		12	Vertical	9.57	64.30
750	LI	DX	EF		SEA					2.35		90	Hz	10.82	63.09
751	LI	DX	EF		SEA					0.89		144	Inclined	5.77	68.15
752	LI	DX	EF		SEA					2.09		96	Hz	9.17	64.75

753	LI	DX	EF		SEA					1.65		10	Vertical	5.15	68.78
754	LI	DX	EF		SEA					6.33		93	Hz	15.25	58.69
755	LI	DX	EF		SEA					1.39		91	Hz	6.97	67.00
756	LI	DX	EF		SEA					0.64		11	Vertical	5.24	68.72
757	LI	DX	EF		RCO					8.90		164	Inclined	20.20	53.79
758	LI	DX	EF		RCO	CRE				2.24		90	Hz	4.94	69.05
759	LI	DX	EF		SEA					3.16		99	Hz	13.66	60.33
760	LI	DX	EF		RCO					2.88		178	Vertical	28.72	45.29
761	LI	DX	EF		SEA					3.34		104	Hz	14.26	59.79
762	LI	DX	EF		SEA					2.72		113	Inclined	5.20	68.85
763	PT	DX	EF		RCO	CRE								37.03	65.55
764	LI	DX	EF		SEA					1.68		61	Inclined	8.43	65.62
765	LI	DX	EF		RCO					2.08		11	Vertical	8.55	65.51
766	LI	DX	EF		SEA					3.68		81	Hz	9.05	65.04
767	LI	DX	EF		RCO					8.18		169	Vertical	3.49	70.61
768	LI	DX	EF		SEA					1.87		89	Hz	11.52	62.60
769	LI	DX	EF		SEA					1.68		10	Vertical	14.28	59.87
770	SF	CO	RT		RCO						14.98			29.98	44.16
771	LI	DX	EF		SEA					2.77		57	Inclined	5.86	68.29
772	LI	DX	EF		SEA					1.48		175	Vertical	9.59	64.58
773	LI	DX	EF		SEA					2.06		19	Inclined	9.05	65.13
774	LI	DX	EF		SEA					1.29		154	Inclined	9.10	65.10
775	LI	DX	EF		SEA					3.88		107	Inclined	9.71	64.49
776	LI	DX	EF		RCO					6.01		3	Vertical	10.87	63.37
777	LI	DX	EF		SEA					3.26		90	Hz	5.25	69.00
778	LI	DX	EF		SEA					4.39		175	Vertical	12.48	61.81
779	LI	DX	EF		SEA					1.55		106	Inclined	4.03	70.27
780	LI	DX	EF		SEA					1.76		92	Hz	7.30	67.03
781	LI	DX	EF		SEA					2.83		96	Hz	12.35	61.99
782	LI	DX	EF		SEA					1.35		145	Inclined	9.17	65.18
783	LI	DX	EF		SEA					1.53		91	Hz	9.73	64.63
784	LI	DX	EF		SEA					1.90		93	Hz	8.46	65.91
785	LI	DX	EF		SEA					2.00		177	Vertical	5.92	68.46
786	LI	DX	EF		RCO					2.43		178	Vertical	29.11	45.28
787	LI	DX	EF		SEA					2.81		78	Hz	5.18	69.25
788	LI	DX	EF		SEA					5.09		104	Hz	10.21	64.23
789	LI	DX	EF		SEA					1.44		6	Vertical	12.34	62.10
790	LI	DX	EF		SEA					1.57		94	Hz	7.74	66.73
791	LI	DX	EF		SEA					2.22		84	Hz	9.72	64.76
792	LI	DX	EF		RCO					3.08		174	Vertical	28.69	45.80
793	LI	DX	EF		SEA					1.58		174	Vertical	5.17	69.32
794	LI	DX	EF		SEA					1.32		86	Hz	10.88	63.64
795	LI	DX	EF		SEA					2.73		92	Hz	13.12	61.44
796	LI	DX	EF		SEA					3.72		160	Inclined	8.51	66.07
797	LI	DX	EF		SEA					2.03		101	Hz	11.48	63.09
798	LI	DX	EF		RCO					2.81		180	Vertical	29.30	45.28
799	LI	DX	EF		RCO	CRE				5.92		174	Vertical	4.14	70.44
800	LI	DX	EF		SEA					3.20		97	Hz	5.91	68.68
801	LI	DX	EF		SEA					1.88		2	Vertical	10.30	64.31
802	LI	DX	EF		SEA					1.89		71	Inclined	6.82	67.79
803	LI	DX	EF		RCO	CRE				2.45		90	Hz	3.62	71.00
804	LI	DX	EF		SEA					2.99		94	Hz	6.08	68.55
805	LI	DX	EF		SEA					2.17		82	Hz	14.31	60.33
806	LI	DX	EF		SEA					1.80		149	Inclined	5.90	68.77
807	PT	CO	VS		RCO									37.34	47.23
808	LI	DX	EF		SEA					1.23		117	Inclined	7.82	66.88
809	LI	DX	EF		SEA					1.90		87	Hz	7.70	67.01
810	LI	DX	EF		SEA					2.47		77	Hz	13.02	61.69
811	LI	DX	EF		SEA					1.73		80	Hz	6.78	67.96
812	LI	DX	EF		SEA					2.08		70	Inclined	6.46	68.28
813	LI	DX	EF		SEA					2.02		104	Hz	8.30	66.45
814	LI	DX	EF		SEA					3.18		95	Hz	5.92	68.85
815	LI	DX	EF		SEA					1.25		164	Inclined	6.60	68.19

816	SF	CA			SEA						2.29			30.68	44.11
817	LI	DX	EF		SEA					1.16		88	Hz	6.44	68.36
818	LI	DX	EF		SEA					2.63		170	Vertical	13.10	61.72
819	LI	DX	EF		SEA					2.53		99	Hz	10.33	64.49
820	LI	DX	EF		SEA					6.25		87	Hz	13.66	61.18
821	LI	DX	EF		SEA					3.13		88	Hz	11.49	63.38
822	LI	DX	EF		RCO	CRE				3.04		83	Hz	9.75	65.13
823	LI	DX	EF		SEA					3.44		72	Inclined	15.11	59.78
824	LI	DX	EF		SEA					4.33		89	Hz	14.31	60.61
825	LI	DX	EF		RCO					2.08		179	Vertical	29.07	45.85
826	LI	DX	EF		SEA					2.16		152	Inclined	6.49	68.43
827	LI	DX	EF		SEA					3.32		88	Hz	16.81	58.16
828	LI	DX	EF		RCO					6.49		160	Inclined	25.74	49.22
829	LI	DX	EF		RCO					3.08		160	Inclined	4.77	70.20
830	LI	DX	EF		SEA					2.68		84	Hz	12.16	62.81
831	LI	DX	EF		RCO	CRE				3.61		90	Hz	4.81	70.17
832	LI	DX	EF		SEA					4.35		96	Hz	7.41	67.57
833	LI	DX	EF		RCO	CRE				1.31		90	Hz	26.99	47.99
834	LI	DX	EF		SEA					2.27		84	Hz	7.70	67.31
835	LI	DX	EF		SEA					2.86		166	Vertical	5.90	69.12
836	LI	DX	EF		SEA					2.13		94	Hz	6.36	68.68
837	PT	DX	EF		RCO	CRE								37.52	60.38
838	LI	DX	EF		RCO					2.11		8	Vertical	8.45	66.63
839	LI	DX	EF		SEA					0.77		113	Inclined	8.34	66.74
840	LI	DX	EF		SEA					2.62		96	Hz	6.98	68.12
841	LI	DX	EF		SEA					1.76		169	Vertical	7.51	67.65
842	LI	DX	EF		SEA					2.85		84	Hz	7.38	67.78
843	LI	DX	EF		SEA					1.31		94	Hz	10.41	64.75
844	LI	DX	EF		SEA					3.92		106	Inclined	7.44	67.72
845	LI	DX	EF		SEA					3.29		93	Hz	4.83	70.35
846	LI	DX	EF		SEA					2.41		165	Inclined	16.39	58.81
847	LI	DX	EF		SEA					2.09		103	Hz	13.74	61.46
848	LI	DX	EF		SEA					3.65		126	Inclined	6.68	68.54
849	LI	DX	EF		SEA					3.23		71	Inclined	14.99	60.25
850	LI	DX	EF		SEA					2.54		60	Inclined	5.87	69.40
851	LI	DX	EF		SEA					5.10		77	Hz	11.61	63.68
852	LI	DX	EF		SEA					6.02		67	Inclined	16.60	58.69
853	LI	DX	EF		SEA					2.40		167	Vertical	16.49	58.80
854	LI	DX	EF		RCO	CRE				1.54		91	Hz	11.02	64.28
855	LI	DX	EF		SEA					4.42		78	Hz	6.46	68.86
856	LI	DX	EF		RCO					2.80		179	Vertical	30.03	45.29
857	LI	DX	EF		SEA					2.92		86	Hz	12.23	63.10
858	LI	DX	EF		SEA					1.99		17	Inclined	16.57	58.78
859	LI	DX	EF		SEA					3.28		157	Inclined	9.89	65.47
860	LI	DX	EF		SEA					1.65		96	Hz	4.92	70.47
861	LI	DX	EF		SEA					3.86		14	Vertical	8.40	66.99
862	LI	DX	EF		RCO					1.30		10	Vertical	10.49	65.00
863	LI	DX	EF		SEA					3.41		88	Hz	7.09	68.40
864	LI	DX	EF		RCO					3.98		4	Vertical	9.19	66.33
865	LI	DX	EF		SEA					2.76		75	Inclined	14.38	61.15
866	LI	DX	EF		RCO					6.97		161	Inclined	24.07	51.48
867	LI	DX	EF		SEA					4.15		19	Inclined	11.09	64.49
868	LI	DX	EF		SEA					2.06		76	Hz	17.45	58.13
869	LI	DX	EF		SEA					2.53		75	Hz	9.96	65.63
870	LI	DX	EF		RCO					3.73		177	Vertical	29.84	45.78
871	LI	DX	EF		RCO	CRE				5.29		174	Vertical	4.89	70.72
872	LI	DX	EF		SEA					2.99		91	Hz	9.90	65.73
873	LI	DX	EF		RCO	CRE				2.70		89	Hz	4.38	71.27
874	LI	DX	EF		RCO	CRE				0.89		91	Hz	8.87	66.80
875	LI	DX	EF		SEA					6.64		90	Hz	5.35	70.32
876	LI	DX	EF		SEA					0.66		119	Inclined	15.83	59.92
877	LI	DX	EF		RCO	CRE				1.30		91	Hz	8.69	67.08
878	LI	DX	EF		SEA					3.18		85	Hz	6.51	69.28

879	LI	DX	EF		SEA					4.00		90	Hz	12.13	63.67
880	LI	DX	EF		SEA					2.37		88	Hz	9.09	66.72
881	LI	DX	EF		RCO					2.91		8	Vertical	15.67	60.15
882	LI	DX	EF		SEA					2.01		92	Hz	14.37	61.45
883	LI	DX	EF		SEA					4.05		68	Inclined	15.53	60.31
884	SF	CA			SEA						0.27			31.74	44.10
885	LI	DX	EF		SEA					2.49		91	Hz	6.47	69.38
886	LI	DX	EF		SEA					1.65		73	Inclined	11.15	64.76
887	LI	DX	EF		SEA					2.57		100	Hz	7.22	68.70
888	LI	DX	EF		SEA					1.70		177	Vertical	11.09	64.84
889	LI	DX	EF		SEA					2.33		87	Hz	7.55	68.42
890	LI	DX	EF		SEA					2.88		60	Inclined	12.00	63.98
891	LI	DX	EF		SEA					3.18		90	Hz	12.97	63.10
892	LI	DX	EF		SEA					1.56		122	Inclined	11.05	65.02
893	LI	DX	EF		RCO					2.56		178	Vertical	30.77	45.30
894	LI	DX	EF		SEA					2.13		104	Hz	14.36	61.72
895	LI	DX	EF		RCO					2.26		174	Vertical	5.47	70.61
896	LI	DX	EF		RCO					1.70		167	Vertical	15.07	61.03
897	LI	DX	EF		RCO					7.10		165	Inclined	22.29	53.82
898	LI	DX	EF		SEA					3.39		91	Hz	13.56	62.56
899	LI	DX	EF		RCO	CRE				0.91		121	Inclined	8.49	67.65
900	LI	DX	EF		SEA					1.69		172	Vertical	12.94	63.20
901	LI	DX	EF		SEA					5.87		111	Inclined	16.44	59.75
902	LI	DX	EF		SEA					2.45		83	Hz	9.20	67.00
903	LI	DX	EF		SEA					1.96		8	Vertical	13.56	62.65
904	LI	CO	VS		RCO	CRE				0.76		89	Hz	22.36	53.86
905	LI	DX	EF		SEA					2.92		98	Hz	14.24	61.99
906	LI	DX	EF		SEA					1.66		26	Inclined	15.07	61.18
907	LI	DX	EF		SEA					1.47		72	Inclined	7.87	68.38
908	LI	DX	EF		RCO					3.60		172	Vertical	6.09	70.17
909	LI	DX	EF		SEA					4.02		117	Inclined	15.23	61.11
910	LI	DX	EF		SEA					1.55		79	Hz	6.12	70.23
911	LI	DX	EF		SEA					0.97		110	Inclined	8.77	67.58
912	LI	DX	EF		SEA					3.36		95	Hz	7.10	69.26
913	LI	DX	EF		RCO					2.00		179	Vertical	31.09	45.28
914	LI	DX	EF		SEA					0.97		73	Inclined	7.38	69.01
915	LI	DX	EF		RCO					2.06		11	Vertical	16.27	60.19
916	LI	DX	EF		SEA					1.16		85	Hz	7.92	68.55
917	LI	DX	EF		RCO					3.60		3	Vertical	11.89	64.59
918	LI	DX	EF		SEA					2.09		83	Hz	7.33	69.16
919	LI	DX	EF		SEA					4.93		89	Hz	8.66	67.83
920	LI	DX	EF		SEA					0.95		95	Hz	9.77	66.72
921	LI	DX	EF		SEA					2.95		109	Inclined	7.13	69.41
922	LI	DX	EF		SEA					5.88		91	Hz	16.26	60.29
923	LI	DX	EF		SEA					1.89		72	Inclined	9.26	67.31
924	LI	DX	EF		RCO					2.37		0	Vertical	30.77	45.80
925	LI	DX	EF		SEA					3.09		92	Hz	6.75	69.83
926	LI	DX	EF		SEA					2.96		109	Inclined	15.17	61.41
927	LI	DX	EF		SEA					2.05		83	Hz	11.12	65.48
928	LI	DX	EF		SEA					1.53		87	Hz	11.09	65.51
929	LI	DX	EF		SEA					1.82		94	Hz	12.94	63.67
930	LI	DX	EF		SEA					1.38		93	Hz	6.68	69.95
931	LI	DX	EF		RCO					10.15		161	Inclined	28.33	48.33
932	LI	DX	EF		SEA					3.16		107	Inclined	16.90	59.79
933	LI	DX	EF		SEA					1.31		81	Hz	11.92	64.77
934	LI	DX	EF		SEA					1.22		64	Inclined	11.06	65.68
935	LI	DX	EF		SEA					1.58		90	Hz	9.79	66.97
936	LI	DX	EF		RCO					4.68		164	Inclined	30.12	46.64
937	LI	DX	EF		SEA					3.14		82	Hz	8.80	67.98
938	LI	DX	EF		SEA					9.27		90	Hz	15.63	61.16
939	LI	DX	EF		SEA					5.47		166	Vertical	6.11	70.69
940	LI	DX	EF		SEA					1.73		87	Hz	14.25	62.55
941	LI	DX	EF		SEA					4.27		97	Hz	12.57	64.24

942	SF	CA			SEA						3.05			32.68	44.18
943	LI	DX	EF		SEA					3.40		92	Hz	15.18	61.68
944	LI	DX	EF		SEA					3.89		86	Hz	10.49	66.43
945	LI	DX	EF		SEA					1.09		118	Inclined	7.94	68.99
946	PT	DX	EF		RCO	CRE								38.47	68.28
947	LI	DX	EF		RCO					6.02		170	Vertical	16.93	60.07
948	LI	DX	EF		RCO					10.14		164	Inclined	23.41	53.60
949	LI	DX	EF		SEA					0.82		92	Hz	7.09	69.93
950	LI	DX	EF		SEA					2.09		79	Hz	6.79	70.25
951	LI	DX	EF		SEA					2.41		11	Vertical	15.80	61.25
952	LI	DX	EF		SEA					0.98		123	Inclined	9.73	67.32
953	PT	DX	EF		RCO	CRE								38.53	57.65
954	LI	DX	EF		SEA					1.30		120	Inclined	7.96	69.10
955	LI	DX	EF		SEA					1.56		86	Hz	12.57	64.50
956	LI	DX	EF		RCO	CRE				1.41		91	Hz	27.51	49.59
957	LI	DX	EF		SEA					3.73		81	Hz	7.88	69.23
958	LI	DX	EF		SEA					1.86		164	Inclined	7.86	69.31
959	LI	US			RCO	CRE				0.87		91	Hz	20.07	57.11
960	LI	DX	EF		SEA					2.51		119	Inclined	16.84	60.35
961	LI	DX	EF		SEA					3.63		106	Inclined	11.86	65.34
962	LI	DX	EF		SEA					3.94		72	Inclined	15.79	61.42
963	LI	DX	EF		RCO	CRE				1.41		177	Vertical	10.55	66.66
964	LI	DX	EF		SEA					0.62		92	Hz	8.80	68.41
965	LI	DX	EF		RCO					9.86		77	Hz	31.58	45.63
966	LI	DX	EF		SEA					1.47		177	Vertical	9.85	67.36
967	LI	DX	EF		SEA					3.12		116	Inclined	15.28	61.94
968	LI	DX	EF		SEA					4.58		84	Hz	13.56	63.67
969	LI	DX	EF		SEA					1.29		173	Vertical	9.60	67.65
970	LI	CO	VS		RCO					0.97		151	Inclined	30.84	46.42
971	LI	DX	EF		SEA					1.89		9	Vertical	15.75	61.51
972	LI	DX	EF		SEA					1.95		110	Inclined	15.06	62.22
973	LI	DX	EF		SEA					4.21		76	Hz	17.56	59.77
974	LI	DX	EF		SEA					1.42		86	Hz	11.85	65.48
975	LI	DX	EF		SEA					1.89		15	Vertical	17.48	59.86
976	LI	DX	EF		SEA					2.52		97	Hz	9.56	67.81
977	LI	DX	EF		SEA					1.59		90	Hz	8.70	68.69
978	LI	DX	EF		SEA					4.37		98	Hz	13.21	64.20
979	LI	DX	EF		SEA					1.87		162	Inclined	15.11	62.30
980	LI	CO	VS		RCO					0.63		150	Inclined	31.00	46.42
981	LI	DX	EF		SEA					2.17		99	Hz	15.75	61.68
982	LI	DX	EF		SEA					2.16		102	Hz	10.46	66.98
983	LI	DX	EF		SEA					4.68		103	Hz	13.50	63.95
984	LI	DX	EF		RCO	CRE				2.11		91	Hz	6.45	71.00
985	LI	DX	EF		SEA					4.97		167	Vertical	6.87	70.59
986	LI	DX	EF		SEA					3.95		115	Inclined	16.30	61.16
987	LI	DX	EF		SEA					1.35		126	Inclined	7.53	69.95
988	LI	DX	EF		SEA					4.67		93	Hz	15.00	62.48
989	LI	DX	EF		SEA					4.94		168	Vertical	13.62	63.89
990	LI	DX	EF		SEA					4.28		88	Hz	11.10	66.42
991	LI	DX	EF		SEA					1.11		95	Hz	6.80	70.72
992	LI	DX	EF		SEA					1.78		172	Vertical	9.62	67.90
993	LI	DX	EF		SEA					3.64		25	Inclined	13.17	64.36
994	LI	DX	EF		RCO	CRE				2.69		90	Hz	9.07	68.48
995	LI	DX	EF		RCO					2.25		179	Vertical	32.12	45.47
996	LI	DX	EF		SEA					1.80		3	Vertical	11.12	66.51
997	LI	DX	EF		SEA					2.29		172	Vertical	15.05	62.59
998	LI	DX	EF		SEA					2.51		89	Hz	7.53	70.11
999	LI	DX	EF		RCO	CRE				1.26		89	Hz	11.40	66.24
1000	LI	DX	EF		SEA					5.08		87	Hz	15.77	61.91
1001	LI	DX	EF		RCO	CRE				1.70		89	Hz	8.68	69.05
1002	LI	DX	EF		SEA					3.74		169	Vertical	7.51	70.27
1003	LI	DX	EF		SEA					1.61		167	Vertical	12.39	65.40
1004	LI	DX	EF		SEA					2.42		75	Hz	12.51	65.30

1005	LI	DX	EF		SEA					3.43		112	Inclined	13.25	64.56
1006	LI	DX	EF		SEA					2.47		102	Hz	10.23	67.58
1007	LI	DX	EF		SEA					4.16		99	Hz	16.40	61.42
1008	LI	DX	EF		SEA					1.66		87	Hz	12.35	65.47
1009	LI	DX	EF		SEA					2.99		93	Hz	14.19	63.67
1010	PT	DX	EF		RCO	CRE								38.94	69.28
1011	LI	DX	EF		RCO					4.08		169	Vertical	10.55	67.35
1012	LI	DX	EF		SEA					3.16		87	Hz	17.58	60.34
1013	PT	DX	EF		RCO	CRE								38.97	57.11
1014	LI	DX	EF		SEA					6.36		89	Hz	15.73	62.22
1015	LI	DX	EF		SEA					2.87		5	Vertical	13.18	64.78
1016	LI	DX	EF		RCO					2.43		25	Inclined	11.93	66.07
1017	LI	DX	EF		SEA					2.29		95	Hz	13.23	64.78
1018	LI	DX	EF		SEA					3.54		91	Hz	13.88	64.20
1019	LI	DX	EF		SEA					2.32		93	Hz	15.26	62.83
1020	LI	DX	EF		RCO					1.78		174	Vertical	17.03	61.06
1021	LI	DX	EF		SEA					2.48		90	Hz	16.44	61.66
1022	LI	DX	EF		RCO					8.57		168	Vertical	32.53	45.58
1023	LI	DX	EF		RCO					3.72		162	Inclined	8.45	69.66
1024	LI	DX	EF		SEA					3.08		91	Hz	11.19	66.92
1025	LI	DX	EF		SEA					2.28		91	Hz	9.45	68.71
1026	LI	DX	EF		SEA					1.22		67	Inclined	15.73	62.45
1027	LI	DX	EF		SEA					1.89		89	Hz	14.25	63.95
1028	LI	DX	EF		SEA					1.56		92	Hz	17.06	61.14
1029	LI	DX	EF		SEA					1.88		170	Vertical	7.51	70.73
1030	LI	DX	EF		SEA					1.99		82	Hz	12.05	66.20
1031	LI	DX	EF		SEA					1.27		167	Vertical	15.60	62.65
1032	LI	DX	EF		RCO					6.66		162	Inclined	29.71	48.55
1033	LI	DX	EF		RCO	CRE				1.97		92	Hz	8.95	69.32
1034	LI	DX	EF		SEA					3.40		64	Inclined	7.64	70.65
1035	LI	DX	EF		RCO					1.37		174	Vertical	16.38	61.92
1036	LI	DX	EF		SEA					1.97		58	Inclined	10.48	67.83
1037	LI	DX	EF		SEA					3.40		85	Hz	16.32	61.99
1038	LI	DX	EF		SEA					2.84		89	Hz	9.92	68.40
1039	LI	DX	EF		SEA					3.20		76	Hz	7.54	70.81
1040	LI	DX	EF		SEA					2.98		84	Hz	11.90	66.46
1041	LI	DX	EF		RCO					1.27		174	Vertical	13.92	64.45
1042	SF	CA			SEA						0.78			34.29	44.13
1043	LI	DX	EF		SEA					2.83		95	Hz	13.90	64.51
1044	LI	DX	EF		RCO					0.88		5	Vertical	10.35	68.07
1045	LI	DX	EF		SEA					1.42		52	Inclined	16.17	62.26
1046	LI	DX	EF		SEA					2.69		5	Vertical	16.36	62.10
1047	LI	DX	EF		RCO	CRE				1.54		90	Hz	9.45	69.04
1048	LI	DX	EF		SEA					8.63		90	Hz	17.10	61.41
1049	LI	DX	EF		SEA					1.28		22	Inclined	13.63	64.88
1050	LI	DX	EF		SEA					3.31		94	Hz	8.73	69.80
1051	LI	DX	EF		SEA					2.69		92	Hz	13.77	64.77
1052	LI	DX	EF		SEA					2.42		173	Vertical	17.05	61.53
1053	LI	DX	EF		SEA					3.93		82	Hz	14.38	64.22
1054	LI	DX	EF		SEA					1.58		71	Inclined	9.98	68.63
1055	LI	DX	EF		RCO					3.56		114	Inclined	32.81	45.80
1056	LI	DX	EF		SEA					3.78		84	Hz	8.12	70.49
1057	LI	DX	EF		SEA					1.78		8	Vertical	13.77	64.85
1058	LI	DX	EF		SEA					3.15		92	Hz	13.32	65.31
1059	LI	DX	EF		RCO	CRE				2.34		90	Hz	11.84	66.79
1060	LI	DX	EF		SEA					1.19		95	Hz	13.74	64.93
1061	LI	DX	EF		SEA					1.74		177	Vertical	13.27	65.40
1062	LI	DX	EF		RCO					4.77		171	Vertical	11.29	67.40
1063	LI	DX	EF		RCO					3.31		18	Inclined	26.07	52.63
1064	LI	DX	EF		SEA					1.81		92	Hz	13.22	65.48
1065	LI	DX	EF		SEA					3.23		105	Inclined	17.02	61.72
1066	LI	DX	EF		SEA					3.59		85	Hz	11.16	67.59
1067	LI	DX	EF		SEA					1.15		89	Hz	9.96	68.80

1068	LI	DX	EF		RCO	CRE				1.36		92	Hz	9.20	69.59
1069	LI	DX	EF		SEA					1.71		76	Hz	17.68	61.14
1070	LI	DX	EF		SEA					4.06		77	Hz	11.00	67.83
1071	LI	DX	EF		SEA					6.29		172	Vertical	11.93	66.93
1072	LI	DX	EF		SEA					1.88		88	Hz	12.69	66.18
1073	LI	DX	EF		SEA					2.64		83	Hz	16.33	62.55
1074	LI	DX	EF		SEA					0.56		82	Hz	12.13	66.76
1075	LI	DX	EF		SEA					4.70		162	Inclined	17.07	61.85
1076	LI	DX	EF		SEA					3.67		85	Hz	8.84	70.09
1077	LI	DX	EF		SEA					1.49		68	Inclined	13.87	65.07
1078	LI	DX	EF		SEA					1.52		89	Hz	8.18	70.79
1079	LI	DX	EF		SEA					1.93		102	Hz	11.98	66.99
1080	LI	DX	EF		SEA					2.68		105	Inclined	14.53	64.48
1081	LI	DX	EF		RCO	CRE				1.77		90	Hz	22.46	56.56
1082	LI	DX	EF		SEA					1.93		86	Hz	12.65	66.46
1083	LI	DX	EF		SEA					4.84		89	Hz	17.12	62.00
1084	LI	DX	EF		SEA					1.53		167	Vertical	14.57	64.56
1085	LI	DX	EF		SEA					3.59		81	Hz	13.87	65.29
1086	LI	DX	EF		SEA					1.33		127	Inclined	16.91	62.27
1087	LI	DX	EF		SEA					0.94		10	Vertical	13.82	65.38
1088	LI	DX	EF		SEA					1.69		90	Hz	15.55	63.68
1089	LI	CO	VS		RCO					0.43		132	Inclined	32.56	46.68
1090	LI	DX	EF		SEA					0.90		144	Inclined	17.78	61.48
1091	LI	DX	EF		SEA					2.19		116	Inclined	12.69	66.59
1092	LI	DX	EF		SEA					3.62		93	Hz	12.56	66.74
1093	LI	DX	EF		SEA					1.45		92	Hz	12.00	67.31
1094	LI	DX	EF		SEA					2.36		93	Hz	11.68	67.63
1095	LI	DX	EF		SEA					1.90		97	Hz	10.71	68.61
1096	LI	DX	EF		SEA					3.57		95	Hz	11.19	68.13
1097	LI	DX	EF		SEA					2.62		93	Hz	15.10	64.22
1098	LI	DX	EF		SEA					1.73		175	Vertical	10.27	69.05
1099	LI	DX	EF		SEA					1.83		90	Hz	9.85	69.54
1100	LI	DX	EF		SEA					0.62		23	Inclined	11.72	67.68
1101	LI	DX	EF		SEA					1.39		168	Vertical	11.22	68.19
1102	LI	DX	EF		SEA					1.67		79	Hz	17.72	61.69
1103	LI	DX	EF		SEA					2.01		88	Hz	13.31	66.13
1104	LI	DX	EF		SEA					0.53		23	Inclined	11.82	67.67
1105	LI	DX	EF		SEA					1.00		163	Inclined	11.32	68.20
1106	SF	CA			SEA						9.27			35.40	44.15
1107	LI	DX	EF		SEA					1.77		91	Hz	9.87	69.68
1108	LI	DX	EF		SEA					2.06		95	Hz	10.73	68.82
1109	LI	CO	VS		RCO					0.71		52	Inclined	32.95	46.62
1110	LI	DX	EF		SEA					1.06		169	Vertical	13.33	66.25
1111	LI	DX	EF		SEA					1.35		93	Hz	15.61	63.98
1112	LI	DX	EF		SEA					2.85		89	Hz	12.60	67.00
1113	LI	DX	EF		SEA					2.36		89	Hz	9.51	70.10
1114	LI	DX	EF		SEA					1.82		174	Vertical	17.01	62.63
1115	LI	DX	EF		SEA					1.61		12	Vertical	12.61	67.08
1116	LI	DX	EF		SEA					2.79		68	Inclined	16.91	62.81
1117	LI	DX	EF		RCO	CRE				1.01		90	Hz	8.44	71.28
1118	LI	DX	EF		SEA					2.52		103	Hz	17.74	61.99
1119	LI	DX	EF		SEA					2.93		77	Hz	11.92	67.84
1120	LI	DX	EF		RCO	CRE				2.05		91	Hz	15.22	64.57
1121	LI	DX	EF		SEA					3.54		91	Hz	9.48	70.33
1122	LI	DX	EF		SEA					1.71		3	Vertical	11.88	67.92
1123	LI	DX	EF		RCO					2.60		177	Vertical	33.98	45.83
1124	LI	DX	EF		SEA					2.74		68	Inclined	10.86	68.97
1125	LI	DX	EF		SEA					2.88		96	Hz	11.44	68.40
1126	LI	DX	EF		SEA					2.87		93	Hz	14.53	65.33
1127	LI	DX	EF		SEA					2.30		84	Hz	11.19	68.69
1128	LI	CO	VS		RCO					1.36		141	Inclined	33.24	46.67
1129	LI	DX	EF		SEA					1.56		94	Hz	17.67	62.24
1130	LI	DX	EF		RCO	CRE				11.59		167	Vertical	26.05	53.87

1131	LI	DX	EF		SEA					1.11		22	Inclined	12.53	67.40
1132	LI	DX	EF		SEA					2.08		88	Hz	10.09	69.86
1133	LI	DX	EF		RCO	CRE				1.40		86	Hz	18.46	61.50
1134	LI	DX	EF		SEA					1.56		2	Vertical	13.17	66.81
1135	LI	DX	EF		SEA					3.63		97	Hz	13.27	66.72
1136	LI	DX	EF		SEA					1.53		14	Vertical	12.62	67.38
1137	LI	DX	EF		SEA					1.91		91	Hz	11.88	68.14
1138	LI	DX	EF		SEA					2.59		92	Hz	12.48	67.55
1139	LI	DX	EF		RCO					5.02		175	Vertical	34.32	45.76
1140	LI	DX	EF		SEA					1.25		4	Vertical	12.47	67.62
1141	LI	DX	EF		SEA					0.90		59	Inclined	12.77	67.33
1142	LI	DX	EF		SEA					1.37		93	Hz	15.32	64.78
1143	LI	DX	EF		RCO	CRE				0.75		93	Hz	9.41	70.72
1144	LI	DX	EF		SEA					2.85		4	Vertical	10.56	69.57
1145	LI	DX	EF		RCO					3.61		160	Inclined	33.85	46.29
1146	LI	DX	EF		SEA					1.54		165	Vertical	11.98	68.20
1147	LI	DX	EF		SEA					1.34		94	Hz	15.95	64.23
1148	LI	DX	EF		SEA					3.08		84	Hz	14.03	66.15
1149	LI	DX	EF		RCO					1.56		18	Inclined	27.60	52.60
1150	LI	DX	EF		SEA					1.97		86	Hz	16.30	63.94
1151	LI	DX	EF		RCO					1.65		8	Vertical	15.28	64.97
1152	LI	DX	EF		SEA					1.76		124	Inclined	11.29	68.96
1153	LI	DX	EF		SEA					3.70		85	Hz	13.26	66.99
1154	LI	DX	EF		RCO	CRE				1.79		91	Hz	33.34	46.95
1155	LI	DX	EF		SEA					1.82		157	Inclined	14.08	66.27
1156	LI	DX	EF		SEA					1.70		177	Vertical	13.28	67.08
1157	LI	DX	EF		SEA					1.29		94	Hz	12.51	67.85
1158	LI	DX	EF		RCO					2.17		11	Vertical	34.56	45.84
1159	LI	DX	EF		SEA					3.07		64	Inclined	10.32	70.09
1160	LI	DX	EF		SEA					2.60		86	Hz	14.05	66.36
1161	LI	DX	EF		SEA					7.78		80	Hz	12.85	67.59
1162	LI	DX	EF		SEA					1.38		173	Vertical	10.24	70.20
1163	LI	DX	EF		SEA					1.92		80	Hz	14.04	66.42
1164	LI	CO	VS		RCO					0.73		35	Inclined	33.79	46.67
1165	LI	CO	VS		RCO					1.41		151	Inclined	33.80	46.67
1166	LI	DX	EF		SEA					1.47		15	Vertical	11.99	68.49
1167	LI	DX	EF		SEA					1.34		178	Vertical	13.41	67.09
1168	LI	DX	EF		RCO	CRE				0.83		86	Hz	22.33	58.18
1169	LI	DX	EF		SEA					2.50		94	Hz	13.25	67.27
1170	LI	DX	EF		SEA					1.75		38	Inclined	15.12	65.46
1171	LI	DX	EF		SEA					0.94		12	Vertical	14.03	66.55
1172	LI	DX	EF		SEA					1.55		179	Vertical	13.27	67.35
1173	LI	DX	EF		SEA					2.81		99	Hz	15.29	65.33
1174	LI	DX	EF		SEA					3.01		101	Hz	12.10	68.55
1175	LI	DX	EF		SEA					1.43		171	Vertical	12.18	68.47
1176	LI	DX	EF		SEA					3.89		91	Hz	12.06	68.66
1177	LI	DX	EF		SEA					1.54		90	Hz	12.61	68.12
1178	LI	DX	EF		SEA					0.88		85	Hz	15.98	64.77
1179	LI	DX	EF		SEA					1.85		6	Vertical	13.98	66.81
1180	LI	DX	EF		SEA					1.51		101	Hz	10.72	70.10
1181	LI	DX	EF		RCO					1.07		171	Vertical	13.29	67.54
1182	LI	DX	EF		SEA					1.60		79	Hz	14.11	66.71
1183	PT	DX	EF		RCO	CRE								40.43	58.19
1184	LI	DX	EF		RCO	CRE				5.95		173	Vertical	10.18	70.72
1185	LI	DX	EF		RCO	CRE				0.68		87	Hz	23.00	57.91
1186	LI	DX	EF		SEA					3.76		95	Hz	16.69	64.22
1187	LI	DX	EF		RCO	CRE				1.55		92	Hz	9.92	70.99
1188	LI	DX	EF		SEA					3.15		157	Inclined	16.02	64.94
1189	LI	CO	VS		RCO					0.45		153	Inclined	32.35	48.63
1190	LI	US			RCO					0.72		155	Inclined	32.33	48.68
1191	PT	CO	VS		RCO									40.52	59.45
1192	PT	DX	EF		RCO	CRE								40.52	56.84
1193	LI	DX	EF		RCO					2.93		179	Vertical	35.69	45.36

1194	LI	DX	EF		SEA					1.76		166	Vertical	16.76	64.29
1195	LI	DX	EF		SEA					1.32		71	Inclined	13.78	67.27
1196	LI	DX	EF		RCO	CRE				3.14		5	Vertical	12.06	69.00
1197	LI	DX	EF		SEA					1.90		172	Vertical	10.69	70.39
1198	LI	DX	EF		SEA					1.82		57	Inclined	12.47	68.68
1199	LI	DX	EF		SEA					2.84		83	Hz	12.69	68.54
1200	LI	CO	VS		RCO					0.84		148	Inclined	34.54	46.70
1201	LI	DX	EF		SEA					1.63		178	Vertical	13.90	67.36
1202	LI	DX	EF		RCO					4.68		170	Vertical	35.52	45.75
1203	LI	DX	EF		SEA					3.95		91	Hz	15.93	65.34
1204	LI	DX	EF		SEA					1.78		8	Vertical	15.91	65.42
1205	LI	DX	EF		SEA					2.19		107	Inclined	13.49	67.85
1206	LI	DX	EF		SEA					1.82		60	Inclined	14.07	67.28
1207	LI	DX	EF		RCO	CRE				1.17		92	Hz	14.56	66.80
1208	LI	DX	EF		RCO					9.47		16	Inclined	27.62	53.75
1209	LI	DX	EF		SEA					2.96		92	Hz	16.63	64.75
1210	LI	DX	EF		SEA					1.16		178	Vertical	14.01	67.38
1211	LI	DX	EF		SEA					4.53		71	Inclined	13.32	68.10
1212	LI	DX	EF		RCO	CRE				0.88		92	Hz	31.90	49.59
1213	LI	DX	EF		SEA					2.07		18	Inclined	16.63	64.86
1214	LI	DX	EF		RCO	CRE				4.59		174	Vertical	11.89	69.64
1215	LI	DX	EF		SEA					2.19		96	Hz	15.42	66.13
1216	LI	DX	EF		SEA					1.41		90	Hz	13.85	67.71
1217	LI	CR	EF		RCO				0.0315	4.64		168	Vertical	35.77	45.79
1218	LI	DX	EF		SEA					2.58		110	Inclined	12.91	68.66
1219	LI	DX	EF		SEA					2.88		91	Hz	14.61	66.99
1220	LI	DX	EF		RCO	CRE				2.63		92	Hz	10.34	71.27
1221	LI	DX	EF		RCO					4.37		162	Inclined	15.97	65.66
1222	LI	DX	EF		SEA					2.03		17	Inclined	16.83	64.84
1223	LI	DX	EF		SEA					1.74		97	Hz	16.66	65.07
1224	LI	CO	VS		RCO					0.63		36	Inclined	35.02	46.71
1225	LI	DX	EF		SEA					1.42		138	Inclined	12.73	69.00
1226	LI	DX	EF		SEA					1.42		88	Hz	11.65	70.11
1227	LI	DX	EF		RCO	CRE				3.20		172	Vertical	11.50	70.28
1228	LI	DX	EF		SEA					2.18		86	Hz	13.92	67.86
1229	LI	CR	EF		RCO	CRE			0.0315	6.65		179	Vertical	36.18	45.70
1230	LI	DX	EF		SEA					3.03		168	Vertical	13.37	68.53
1231	PT	DX	EF		RCO	CRE								40.95	58.20
1232	LI	DX	EF		SEA					1.80		97	Hz	15.43	66.50
1233	LI	DX	EF		SEA					1.77		106	Inclined	15.36	66.61
1234	LI	CO	VS		RCO					0.41		146	Inclined	35.51	46.46
1235	LI	US			RCO	CRE				1.23		90	Hz	31.34	50.65
1236	LI	DX	EF		SEA					0.89		178	Vertical	14.64	67.35
1237	LI	DX	EF		RCO	CRE				1.05		91	Hz	22.70	59.29
1238	LI	CO	VS		RCO					0.85		36	Inclined	35.85	46.15
1239	LI	DX	EF		SEA					2.97		104	Hz	14.45	67.55
1240	LI	DX	EF		RCO					3.10		172	Vertical	17.38	64.63
1241	LI	DX	EF		SEA					5.75		102	Hz	16.12	65.92
1242	LI	DX	EF		SEA					2.64		86	Hz	14.73	67.32
1243	LI	DX	EF		SEA					1.38		26	Inclined	14.41	67.66
1244	LI	DX	EF		SEA					1.72		5	Vertical	14.44	67.64
1245	LI	DX	EF		SEA					2.06		88	Hz	17.37	64.77
1246	LI	DX	EF		SEA					3.76		86	Hz	13.48	68.66
1247	LI	DX	EF		SEA					1.70		12	Vertical	16.74	65.43
1248	LI	CO	VS		RCO					0.45		44	Inclined	35.55	46.62
1249	LI	DX	EF		RCO					5.53		15	Inclined	29.63	52.54
1250	LI	DX	EF		RCO					3.79		167	Vertical	15.42	66.78
1251	LI	DX	EF		SEA					3.06		86	Hz	16.10	66.14
1252	LI	DX	EF		SEA					3.71		98	Hz	14.13	68.16
1253	LI	DX	EF		RCO					2.30		173	Vertical	36.46	45.84
1254	LI	CO	VS		RCO					0.51		146	Inclined	35.07	47.25
1255	LI	DX	EF		SEA					4.83		5	Vertical	13.44	68.91
1256	LI	DX	EF		RCO					6.74		172	Vertical	36.69	45.68

1257	PT	CO	VS		RCO									41.20	46.24
1258	PT	DX	EF		RCO									41.20	66.92
1259	LI	DX	EF		SEA					3.23		92	Hz	15.41	67.00
1260	LI	DX	EF		RCO	CRE				6.97		164	Inclined	32.85	49.57
1261	LI	DX	EF		SEA					0.98		13	Vertical	15.40	67.05
1262	LI	DX	EF		SEA					7.00		173	Vertical	17.38	65.08
1263	LI	DX	EF		SEA					2.82		96	Hz	17.40	65.07
1264	LI	DX	EF		SEA					3.25		101	Hz	12.37	70.10
1265	LI	DX	EF		RCO	CRE				1.16		89	Hz	32.37	50.12
1266	LI	DX	EF		SEA					0.99		143	Inclined	14.90	67.60
1267	PT	CO	VS		RCO	CRE								41.25	70.70
1268	LI	DX	EF		SEA					2.84		94	Hz	12.04	70.47
1269	LI	DX	EF		RCO					4.92		164	Inclined	27.71	54.83
1270	LI	DX	EF		SEA					5.54		98	Hz	15.31	67.29
1271	LI	DX	EF		SEA					3.12		58	Inclined	15.88	66.73
1272	LI	DX	EF		RCO	CRE				1.15		91	Hz	22.80	59.84
1273	LI	DX	EF		SEA					3.64		94	Hz	17.32	65.33
1274	LI	DX	EF		SEA					1.20		27	Inclined	13.66	69.00
1275	LI	DX	EF		SEA					1.35		86	Hz	12.06	70.63
1276	LI	DX	EF		SEA					1.78		18	Inclined	15.34	67.38
1277	LI	DX	EF		SEA					8.07		98	Hz	16.25	66.51
1278	LI	DX	EF		SEA					4.10		87	Hz	14.12	68.65
1279	LI	DX	EF		SEA					4.05		120	Inclined	16.67	66.11
1280	LI	US			RCO					1.01		30	Inclined	36.41	46.41
1281	LI	DX	EF		RCO					7.02		174	Vertical	37.14	45.68
1282	LI	DX	EF		RCO					4.37		169	Vertical	37.03	45.79
1283	SF	CA			SEA						2.36			38.68	44.16
1284	LI	DX	EF		SEA					1.73		4	Vertical	14.13	68.74
1285	LI	CO	VS		RCO					1.27		140	Inclined	36.46	46.42
1286	LI	US			RCO					0.53		154	Inclined	36.50	46.41
1287	LI	DX	EF		SEA					1.12		24	Inclined	14.96	67.96
1288	PT	DX	EF		RCO	CRE								41.49	60.95
1289	LI	DX	EF		SEA					1.46		36	Inclined	15.40	67.58
1290	LI	DX	EF		SEA					4.05		92	Hz	15.19	67.82
1291	LI	DX	EF		SEA					1.78		136	Inclined	15.78	67.29
1292	LI	DX	EF		RCO	CRE				6.96		180	Vertical	37.53	45.56
1293	LI	DX	EF		RCO					17.77		160	Inclined	33.78	49.34
1294	LI	DX	EF		RCO					4.68		178	Vertical	37.38	45.74
1295	LI	DX	EF		SEA					2.06		95	Hz	12.89	70.23
1296	PT	DX	EF		RCO	CRE								41.57	58.18
1297	LI	DX	EF		SEA					2.32		98	Hz	16.75	66.46
1298	LI	CO	VS		RCO					0.35		39	Inclined	36.72	46.49
1299	LI	US			RCO		FR			0.44		42	Inclined	36.74	46.52
1300	PT	CO	VS		RCO									41.63	46.42
1301	LI	DX	EF		SEA					4.41		168	Vertical	15.23	68.05
1302	LI	DX	EF		SEA					1.74		2	Vertical	16.49	66.80
1303	LI	DX	EF		RCO	CRE				5.79		90	Hz	12.02	71.27
1304	LI	DX	EF		SEA					1.83		91	Hz	15.72	67.58
1305	LI	DX	EF		SEA					2.08		83	Hz	17.41	65.90
1306	LI	DX	EF		SEA					1.81		144	Inclined	14.31	69.01
1307	LI	DX	EF		SEA					1.54		66	Inclined	12.66	70.66
1308	LI	DX	EF		SEA					1.71		176	Vertical	15.45	67.91
1309	LI	DX	EF		SEA					1.44		78	Hz	12.62	70.77
1310	LI	CR	EF		RCO				0.0315	0.51		177	Vertical	38.06	45.37
1311	LI	DX	EF		SEA	CRE				2.71		90	Hz	12.46	70.98
1312	LI	DX	EF		RCO					2.42		173	Vertical	13.81	69.68
1313	LI	DX	EF		RCO					5.14		175	Vertical	37.79	45.71
1314	LI	DX	EF		SEA					1.87		176	Vertical	15.59	67.93
1315	LI	DX	EF		SEA					2.27		95	Hz	16.83	66.70
1316	PT	CO	RT		RCO									41.78	59.45
1317	LI	DX	EF		SEA					1.45		161	Inclined	17.35	66.25
1318	LI	DX	EF		SEA					3.61		53	Inclined	16.23	67.42
1319	LI	US			RCO		FR			1.37		90	Hz	36.70	46.97

1320	LI	DX	EF		SEA					2.94		86	Hz	14.47	69.23
1321	LI	DX	EF		RCO					9.51		165	Vertical	27.76	55.95
1322	LI	DX	EF		SEA					1.77		1	Vertical	15.84	67.92
1323	LI	DX	EF		RCO					1.85		176	Vertical	37.94	45.84
1324	LI	DX	EF		SEA					1.12		59	Inclined	13.09	70.79
1325	LI	DX	EF		SEA					2.80		48	Inclined	15.47	68.43
1326	SF	CA			SEA						2.48			39.80	44.14
1327	LI	DX	EF		SEA					5.89		85	Hz	16.67	67.30
1328	LI	DX	EF		RCO					3.15		19	Inclined	34.24	49.73
1329	LI	DX	EF		SEA					1.15		170	Vertical	16.01	67.96
1330	LI	DX	EF		SEA					1.57		24	Inclined	15.82	68.15
1331	LI	DX	EF		RCO					1.55		174	Vertical	13.44	70.54
1332	LI	DX	EF		RCO					0.78		171	Vertical	15.93	68.06
1333	LI	DX	EF		RCO					4.26		179	Vertical	38.28	45.73
1334	LI	DX	EF		SEA					5.69		96	Hz	15.34	68.68
1335	LI	DX	EF		SEA					5.30		65	Inclined	16.31	67.71
1336	LI	DX	EF		SEA					1.46		179	Vertical	16.66	67.37
1337	LI	DX	EF		RCO					1.98		160	Inclined	38.13	45.90
1338	LI	DX	EF		SEA					1.83		174	Vertical	16.42	67.63
1339	LI	DX	EF		SEA					7.40		169	Vertical	17.52	66.54
1340	LI	US			RCO					1.04		99	Hz	36.30	47.78
1341	LI	DX	EF		SEA					3.36		159	Inclined	15.44	68.71
1342	LI	DX	EF		RCO	CRE				2.93		91	Hz	13.20	70.98
1343	LI	DX	EF		SEA					1.73		166	Vertical	16.81	67.38
1344	LI	DX	EF		SEA					3.82		60	Inclined	17.20	67.00
1345	LI	DX	EF		SEA					3.39		106	Inclined	14.54	69.66
1346	LI	DX	EF		SEA					2.06		104	Hz	13.57	70.65
1347	LI	DX	EF		RCO					3.79		16	Inclined	24.04	60.23
1348	LI	DX	EF		SEA					1.87		88	Hz	15.08	69.20
1349	LI	DX	EF		SEA					0.50		175	Vertical	16.57	67.71
1350	LI	DX	EF		RCO					3.45		159	Inclined	35.89	48.41
1351	LI	DX	EF		SEA					2.30		8	Vertical	16.69	67.63
1352	LI	DX	EF		SEA					0.75		174	Vertical	16.61	67.70
1353	LI	DX	EF		RCO					2.60		169	Vertical	38.52	45.81
1354	LI	DX	EF		SEA					3.03		81	Hz	13.99	70.35
1355	LI	DX	EF		RCO	CRE				2.02		89	Hz	35.81	48.55
1356	LI	DX	EF		SEA					1.22		168	Vertical	13.94	70.42
1357	LI	DX	EF		SEA					3.54		24	Inclined	16.13	68.24
1358	LI	DX	EF		SEA					1.70		3	Vertical	16.44	67.93
1359	LI	DX	EF		RCO					2.73		165	Vertical	32.50	51.89
1360	LI	CR	EF		RCO	CRE			0.0315	5.32		180	Vertical	38.88	45.65
1361	LI	DX	EF		RCO	CRE				7.83		90	Hz	13.28	71.26
1362	LI	DX	EF		SEA					3.08		55	Inclined	16.52	68.12
1363	LI	DX	EF		SEA					3.71		84	Hz	14.09	70.61
1364	LI	DX	EF		SEA					1.47		177	Vertical	17.08	67.64
1365	PT	DX	EF		RCO									42.38	58.08
1366	LI	DX	EF		SEA					1.92		169	Vertical	14.05	70.71
1367	LI	CO	VS		RCO	CRE				1.13		90	Hz	13.54	71.27
1368	LI	DX	EF		SEA					1.96		11	Vertical	17.45	67.38
1369	LI	DX	EF		SEA					1.99		44	Inclined	15.38	69.54
1370	LI	DX	EF		RCO					1.96		167	Vertical	39.15	45.81
1371	LI	DX	EF		RCO	CRE				1.37		90	Hz	24.57	60.39
1372	LI	DX	EF		SEA					1.27		24	Inclined	16.75	68.26
1373	LI	DX	EF		SEA					2.57		9	Vertical	16.23	68.83
1374	LI	DX	EF		RCO					0.85		3	Vertical	39.22	45.86
1375	LI	DX	EF		RCO	CRE				0.89		90	Hz	38.36	46.73
1376	LI	DX	EF		SEA					1.79		166	Vertical	17.47	67.64
1377	LI	DX	EF		SEA					1.11		44	Inclined	16.83	68.27
1378	LI	CO	VS		RCO					0.40		168	Vertical	27.77	57.39
1379	LI	DX	EF		SEA					1.28		22	Inclined	16.08	69.09
1380	LI	DX	EF		RCO	CRE				1.65		176	Vertical	17.34	67.84
1381	LI	DX	EF		SEA					2.79		132	Inclined	15.30	69.92
1382	LI	DX	EF		RCO					4.10		173	Vertical	39.45	45.77

1383	LI	DX	EF		RCO					7.71		17	Inclined	31.31	53.94
1384	LI	DX	EF		RCO	CRE				1.40		89	Hz	14.84	70.44
1385	LI	DX	EF		SEA					1.91		7	Vertical	16.30	69.05
1386	LI	DX	EF		RCO					6.23		164	Inclined	29.50	55.98
1387	LI	DX	EF		RCO	CRE				1.08		92	Hz	38.78	46.71
1388	LI	DX	EF		SEA					3.31		91	Hz	16.04	69.52
1389	LI	DX	EF		RCO					2.37		171	Vertical	40.22	45.34
1390	LI	DX	EF		RCO	CRE				1.72		172	Vertical	14.82	70.77
1391	LI	DX	EF		SEA					2.14		100	Hz	15.53	70.08
1392	LI	DX	EF		RCO					2.24		163	Inclined	39.78	45.84
1393	LI	CO	VS		RCO	CRE				0.63		170	Vertical	14.81	70.82
1394	LI	DX	EF		SEA					1.86		6	Vertical	16.86	68.77
1395	LI	DX	EF		SEA					2.51		47	Inclined	17.56	68.10
1396	LI	DX	EF		RCO					0.91		152	Inclined	39.92	45.81
1397	LI	DX	EF		SEA					1.79		6	Vertical	17.02	68.76
1398	LI	DX	EF		SEA					2.16		136	Inclined	15.88	69.91
1399	LI	DX	EF		SEA					1.66		166	Vertical	16.22	69.59
1400	LI	DX	EF		SEA					1.46		87	Hz	17.52	68.41
1401	PT	DX	EF		RCO									42.97	66.91
1402	LI	DX	EF		RCO					6.79		165	Inclined	30.03	55.96
1403	LI	DX	EF		SEA					1.65		88	Hz	17.53	68.53
1404	LI	DX	EF		RCO	CRE				1.44		91	Hz	15.10	70.99
1405	PT	CO	RT		RCO									43.05	48.62
1406	LI	DX	EF		RCO	CRE				2.06		90	Hz	14.86	71.27
1407	LI	CR			RCO	CRE			0.0315	2.54		179	Vertical	40.24	45.90
1408	SF	CA			SEA						0.35			42.02	44.13
1409	LI	DX	EF		SEA					3.85		114	Inclined	16.28	69.87
1410	PT	US			RCO									43.08	46.44
1411	LI	DX	EF		SEA					1.89		89	Hz	17.51	68.67
1412	LI	DX	EF		SEA					2.26		164	Inclined	17.13	69.07
1413	LI	DX	EF		RCO					5.44		16	Inclined	31.58	54.70
1414	LI	DX	EF		RCO					6.75		160	Inclined	34.47	51.83
1415	LI	DX	EF		RCO					2.92		169	Vertical	40.55	45.79
1416	LI	DX	EF		RCO	CRE				8.27		90	Hz	15.64	70.72
1417	LI	DX	EF		SEA					2.00		165	Vertical	17.33	69.05
1418	LI	CO	VS		RCO					0.54		152	Inclined	40.00	46.41
1419	LI	DX	EF		SEA					2.06		166	Vertical	17.43	69.04
1420	LI	DX	EF		SEA					1.35		172	Vertical	16.87	69.60
1421	LI	DX	EF		SEA					5.09		165	Vertical	17.61	68.89
1422	LI	DX	EF		RCO	CRE				1.03		91	Hz	28.98	57.64
1423	LI	DX	EF		RCO					6.61		175	Vertical	41.03	45.72
1424	LI	CO	RT		RCO					0.61		84	Hz	27.73	59.05
1425	LI	DX	EF		SEA					2.73		63	Inclined	17.57	69.22
1426	LI	DX	EF		SEA					1.82		116	Inclined	16.96	69.93
1427	LI	DX	EF		RCO					10.90		169	Vertical	16.17	70.75
1428	LI	DX	EF		RCO					5.37		167	Vertical	41.27	45.66
1429	LI	US			RCO					1.00		152	Inclined	40.51	46.42
1430	PT	DX	EF		RCO									43.49	66.94
1431	LI	DX	EF		SEA					2.57		43	Inclined	17.41	69.83
1432	LI	DX	EF		RCO					5.09		164	Inclined	31.23	56.04
1433	LI	DX	EF		RCO					1.61		169	Vertical	16.93	70.36
1434	LI	CR	EF		RCO	CRE			0.0315	6.80		179	Vertical	41.60	45.70
1435	LI	DX	EF		RCO					1.50		179	Vertical	41.43	45.92
1436	PT	CO	VS		RCO									43.75	46.41
1437	LI	DX	EF		RCO	CRE				1.58		91	Hz	16.25	71.27
1438	PT	CO	VS		RCO									43.77	46.37
1439	LI	DX	EF		RCO					4.84		169	Vertical	29.11	58.43
1440	LI	DX	EF		RCO					10.42		164	Inclined	36.02	51.68
1441	LI	CO	VS		RCO					0.56		151	Inclined	33.52	54.21
1442	LI	DX	EF		RCO					2.28		178	Vertical	41.96	45.84
1443	PT	CO	VS		RCO	CRE								43.91	70.70
1444	LI	DX	EF		RCO	CRE				1.23		91	Hz	39.83	48.04
1445	LI	DX	EF		RCO	CRE				2.19		90	Hz	39.36	48.56

1446	LI	DX	EF		RCO	CRE				4.97		14	Vertical	34.45	53.56
1447	LI	DX	EF		RCO					6.26		169	Vertical	42.37	45.72
1448	LI	DX	EF		RCO					3.27		19	Inclined	32.37	55.90
1449	LI	DX	EF		RCO					1.40		157	Inclined	39.35	49.02
1450	LI	DX	EF		RCO					1.54		173	Vertical	42.73	45.77
1451	LI	DX	EF		RCO					5.08		161	Inclined	37.06	51.44
1452	SF	DX	CS	EF	RCO						0.30			42.08	46.44
1453	LI	CO	VS		RCO					0.42		35	Inclined	42.07	46.45
1454	PT	CO	RT		RCO									44.27	70.42
1455	LI	CR	EF		RCO	CRE			0.0315	7.49		179	Vertical	42.96	45.67
1456	LI	US			RCO	CRE				0.97		89	Hz	38.06	50.67
1457	LI	DX	EF		RCO					0.96		155	Inclined	38.11	50.63
1458	LI	CR			RCO				0.0315	2.43		20	Inclined	42.44	46.33
1459	LI	CO	VS		RCO					0.38		90	Hz	31.33	57.45
1460	LI	DX	EF		RCO					2.60		165	Vertical	32.89	55.97
1461	LI	DX	EF		RCO					0.76		2	Vertical	43.40	45.55
1462	LI	DX	EF		RCO					2.86		164	Inclined	38.58	50.55
1463	LI	DX	EF		RCO					2.95		174	Vertical	43.32	45.81
1464	PT	DX	CS	EF	RCO	CRE								44.60	60.12
1465	LI	DX	EF		RCO					3.10		20	Inclined	33.48	55.75
1466	LI	DX	EF		RCO					6.11		171	Vertical	29.19	60.14
1467	LI	DX	EF		RCO	CRE				6.67		167	Vertical	34.30	55.05
1468	LI	DX	EF		RCO					1.15		4	Vertical	43.97	45.42
1469	LI	DX	EF		RCO					4.17		172	Vertical	43.72	45.70
1470	LI	DX	EF		RCO					1.35		1	Vertical	44.05	45.42
1471	LI	DX	EF		RCO					1.84		170	Vertical	43.97	45.74
1472	LI	CO	VS		RCO					0.80		147	Inclined	43.31	46.44
1473	PT	CO	VS		RCO									44.98	46.36
1474	LI	CR	EF		RCO				0.0315	8.28		165	Inclined	31.46	58.61
1475	LI	DX	EF		RCO					6.23		22	Inclined	40.67	49.45
1476	LI	US			RCO		FR			0.66		144	Inclined	43.73	46.44
1477	PT	CO	RT		RCO									45.11	57.52
1478	LI	DX	EF		RCO					5.95		17	Inclined	41.10	49.37
1479	LI	DX	EF		RCO	CRE				0.58		91	Hz	31.51	59.02
1480	LI	CO	VS		RCO					0.37		164	Inclined	40.03	50.50
1481	PT	DX	EF		RCO	CRE								45.27	58.20
1482	LI	DX	EF		RCO	CRE				1.33		88	Hz	31.52	59.31
1483	LI	DX	EF		RCO	CRE				1.53		89	Hz	21.02	69.89
1484	PT	CO	VS		RCO									45.47	71.38
1485	LI	DX	EF		RCO					2.41		18	Inclined	41.60	49.41
1486	LI	DX	EF		RCO	CRE				1.38		179	Vertical	45.68	45.44
1487	LI	DX	EF		RCO					2.40		175	Vertical	45.34	45.83
1488	PT	CO	VS		RCO									45.58	46.78
1489	LI	DX	EF		RCO	CRE				0.45		89	Hz	44.53	46.71
1490	PT	CO	VS		RCO									45.66	46.63
1491	PT	CO	VS		RCO									45.68	46.66
1492	LI	DX	EF		RCO					5.00		164	Inclined	40.02	51.53
1493	LI	DX	EF		RCO	CRE				11.10		14	Vertical	37.70	53.90
1494	LI	DX	EF		RCO	CRE				0.79		91	Hz	44.92	46.71
1495	PT	DX	EF		RCO	CRE								46.02	52.54
1496	LI	DX	EF		RCO					8.28		162	Inclined	40.53	51.55
1497	LI	DX	EF		RCO					7.34		179	Vertical	46.40	45.68
1498	LI	DX	EF		RCO	CRE				0.81		90	Hz	31.73	60.40
1499	LI	CR			RCO				0.0315	2.44		171	Vertical	31.73	60.52
1500	LI	DX	EF		RCO	CRE				1.93		90	Hz	44.38	48.04
1501	LI	DX	EF		SEA					1.47		90	Hz	31.00	61.43
1502	LI	CO	VS		RCO					0.89		129	Inclined	20.85	71.62
1503	LI	DX	EF		RCO					2.25		176	Vertical	46.62	45.92
1504	LI	CO	VS		RCO					1.73		13	Vertical	45.70	46.86
1505	LI	DX	EF		RCO					8.51		168	Vertical	31.71	61.03
1506	LI	DX	EF		RCO	CRE				2.46		90	Hz	44.75	48.04
1507	LI	DX	EF		RCO					3.74		32	Inclined	38.67	54.19
1508	LI	DX	EF		RCO					0.94		11	Vertical	47.42	45.44

1509	LI	CO	VS		RCO					3.12		28	Inclined	46.58	46.30
1510	PT	CO	RT		RCO									46.50	61.12
1511	LI	DX	EF		RCO					14.24		165	Inclined	41.49	51.61
1512	PT	DX	EF		RCO	CRE								46.56	57.65
1513	PT	CO	VS		RCO									46.56	46.46
1514	LI	DX	EF		RCO					4.64		118	Inclined	47.37	45.76
1515	LI	DX	EF		RCO	CRE				1.45		92	Hz	45.10	48.05
1516	PT	DX	EF		RCO	CRE								46.58	47.78
1517	LI	DX	EF		RCO					0.69		173	Vertical	47.78	45.64
1518	LI	DX	EF		RCO					0.70		178	Vertical	47.88	45.56
1519	LI	DX	EF		RCO					2.19		167	Vertical	39.77	53.71
1520	LI	DX	EF		RCO	CRE				0.50		92	Hz	33.65	59.85
1521	LI	CO	VS		RCO					0.45		150	Inclined	49.32	44.23
1522	PT	DX	EF		RCO	CRE								46.79	61.21
1523	PT	CO	VS		RCO									46.80	71.51
1524	LI	DX	EF		RCO					0.80		178	Vertical	47.79	45.88
1525	PT	CO	RT		SEA									46.90	67.04
1526	LI	CR	EF		RCO				0.0315	10.61		107	Inclined	48.10	45.71
1527	LI	DX	EF		RCO	CRE				0.43		89	Hz	40.33	53.60
1528	LI	CR	EF		RCO				0.0315	10.22		106	Inclined	48.26	45.74
1529	LI	CR	EF		RCO				0.0315	7.27		163	Inclined	37.14	56.90
1530	LI	DX	EF		RCO	CRE				0.41		92	Hz	31.73	62.33
1531	PT	DX	EF		RCO									47.03	45.42
1532	LI	DX	EF		RCO	CRE				0.76		92	Hz	33.70	60.39
1533	LI	CR	EF		RCO				0.0315	10.19		114	Inclined	48.60	45.71
1534	LI	DX	EF		RCO	CRE				0.50		87	Hz	35.33	59.02
1535	LI	CO	VS		RCO					0.41		146	Inclined	47.79	46.60
1536	LI	DX	EF		RCO	CRE				0.62		92	Hz	31.80	62.61
1537	LI	DX	EF		RCO					3.60		129	Inclined	48.65	45.79
1538	LI	US			RCO		FR			1.44		90	Hz	23.56	71.00
1539	LI	DX	EF		RCO					8.56		175	Vertical	31.93	62.69
1540	LI	CO	VS		RCO					0.85		148	Inclined	48.24	46.44
1541	LI	DX	EF		RCO	CRE				0.87		93	Hz	32.47	62.33
1542	LI	DX	EF		RCO	CRE				1.09		89	Hz	35.01	59.84
1543	PT	CO	VS		RCO									47.43	46.84
1544	LI	DX	EF		RCO	CRE				7.91		164	Inclined	41.41	53.51
1545	LI	DX	EF		RCO	CRE				0.52		89	Hz	40.39	54.67
1546	LI	US			RCO		FR			9.16		90	Hz	49.23	45.99
1547	LI	CO	VS		RCO					1.16		162	Inclined	49.15	46.28
1548	LI	DX	EF		RCO	CRE				1.40		92	Hz	32.04	63.45
1549	LI	DX	EF		SEA					1.39		43	Inclined	32.03	63.65
1550	LI	CO	VS		RCO					1.03		166	Vertical	37.30	58.41
1551	LI	DX	EF		RCO	CRE				1.02		90	Hz	38.05	57.92
1552	LI	CR			RCO				0.0315	3.79		21	Inclined	49.24	46.80
1553	PT	DX	EF		RCO	CRE								48.06	59.35
1554	LI	DX	EF		SEA					1.18		94	Hz	31.81	64.45
1555	LI	CR	EF		RCO				0.0315	7.58		161	Inclined	37.21	59.07
1556	LI	DX	EF		SEA					1.99		91	Hz	33.27	63.08
1557	LI	DX	EF		RCO					11.30		166	Vertical	41.44	54.98
1558	LI	DX	EF		SEA					1.84		89	Hz	31.86	64.73
1559	LI	DX	EF		RCO	CRE				1.47		91	Hz	33.34	63.44
1560	LI	DX	EF		RCO					23.17		163	Inclined	44.49	52.30
1561	LI	DX	EF		RCO	CRE				0.96		89	Hz	37.87	59.02
1562	LI	DX	EF		RCO	CRE				1.71		89	Hz	34.57	62.33
1563	LI	CR	EF		RCO				0.03937	5.69		167	Vertical	36.91	60.12
1564	LI	US			RCO		FR			0.89		172	Vertical	36.90	60.15
1565	LI	DX	EF		RCO	CRE				0.95		90	Hz	35.62	61.48
1566	LI	DX	EF		SEA					2.40		84	Hz	34.05	63.09
1567	LI	DX	EF		RCO	CRE				1.20		93	Hz	44.99	52.27
1568	PT	DX	EF		RCO	CRE								48.64	50.95
1569	LI	DX	EF		SEA					3.26		88	Hz	32.00	65.30
1570	LI	DX	EF		SEA					1.54		92	Hz	32.60	64.75
1571	LI	DX	EF		RCO					5.20		16	Inclined	41.49	55.89

1572	LI	US			SEA					1.30		10	Vertical	36.93	60.45
1573	PT	DX	EF		RCO	CRE								48.70	59.29
1574	LI	DX	EF		SEA					1.01		136	Inclined	33.92	63.60
1575	LI	DX	EF		RCO					2.46		169	Vertical	39.14	58.39
1576	LI	DX	EF		SEA					1.38		90	Hz	33.16	64.46
1577	LI	DX	EF		SEA					1.00		92	Hz	31.14	66.51
1578	LI	DX	EF		RCO					2.24		168	Vertical	51.91	45.92
1579	LI	DX	EF		SEA					2.77		166	Vertical	34.17	63.67
1580	LI	DX	EF		SEA					2.10		90	Hz	32.61	65.26
1581	LI	DX	EF		RCO					1.92		178	Vertical	52.57	45.30
1582	LI	DX	EF		SEA					1.74		89	Hz	34.65	63.31
1583	LI	DX	EF		SEA					1.30		92	Hz	33.25	64.73
1584	LI	DX	EF		RCO					4.43		170	Vertical	52.08	45.91
1585	LI	DX	EF		RCO	CRE				0.63		91	Hz	34.07	64.00
1586	LI	DX	EF		RCO					4.53		15	Inclined	44.53	53.60
1587	LI	DX	EF		SEA					3.81		108	Inclined	33.99	64.18
1588	PT	DX	CS	EF	RCO									49.10	65.63
1589	LI	DX	EF		RCO	CRE				0.42		89	Hz	39.75	58.48
1590	LI	DX	EF		SEA					1.80		150	Inclined	33.09	65.36
1591	LI	DX	EF		RCO					4.81		166	Vertical	36.92	61.55
1592	LI	DX	EF		SEA					2.06		84	Hz	33.21	65.30
1593	LI	DX	EF		RCO	CRE				0.84		93	Hz	35.35	63.16
1594	LI	DX	EF		RCO					1.21		89	Hz	53.08	45.47
1595	LI	DX	EF		RCO	CRE				0.85		93	Hz	32.38	66.23
1596	LI	DX	EF		RCO	CRE				0.56		88	Hz	38.26	60.38
1597	LI	DX	EF		RCO	CRE				0.54		90	Hz	43.17	55.48
1598	PT	US			RCO									49.33	44.25
1599	LI	DX	EF		RCO	CRE				0.59		88	Hz	36.92	61.77
1600	LI	DX	EF		SEA					2.00		178	Vertical	30.58	68.19
1601	LI	DX	EF		RCO	CRE				0.79		90	Hz	34.79	63.99
1602	LI	DX	EF		RCO					5.03		166	Vertical	37.60	61.17
1603	LI	DX	EF		SEA					5.73		91	Hz	34.06	64.74
1604	LI	DX	EF		RCO	CRE				0.82		91	Hz	40.98	57.92
1605	LI	DX	EF		RCO	CRE				0.89		91	Hz	43.17	55.76
1606	LI	DX	EF		RCO	CRE				2.26		88	Hz	33.54	65.39
1607	LI	DX	EF		SEA					3.13		93	Hz	32.56	66.41
1608	LI	DX	EF		SEA					1.42		1	Vertical	30.50	68.47
1609	LI	DX	EF		SEA					5.00		104	Hz	37.62	61.43
1610	LI	DX	EF		SEA					2.15		180	Vertical	32.54	66.54
1611	LI	DX	EF		SEA					1.19		57	Inclined	35.50	63.60
1612	LI	DX	EF		RCO	CRE				0.98		92	Hz	33.47	65.67
1613	LI	DX	EF		SEA					0.41		83	Hz	33.90	65.29
1614	PT	DX	EF		RCO	CRE								49.60	48.82
1615	LI	DX	EF		RCO					10.97		165	Vertical	44.23	55.00
1616	LI	DX	EF		RCO	CRE				1.05		89	Hz	30.77	68.47
1617	PT	DX	EF		RCO	CRE								49.63	48.57
1618	LI	DX	EF		SEA					2.98		123	Inclined	37.34	61.96
1619	PT	CO	VS		RCO									49.66	68.40
1620	LI	DX	EF		SEA					0.80		141	Inclined	32.69	66.63
1621	LI	DX	EF		RCO					6.30		12	Vertical	43.17	56.18
1622	PT	DX	EF		RCO									49.69	45.39
1623	LI	DX	EF		SEA					4.22		69	Inclined	37.67	61.75
1624	LI	DX	EF		SEA					3.25		104	Hz	31.85	67.57
1625	LI	DX	EF		RCO	CRE				0.57		86	Hz	32.63	66.80
1626	LI	DX	EF		SEA					1.89		7	Vertical	34.06	65.39
1627	LI	DX	EF		RCO	CRE				2.08		91	Hz	36.15	63.43
1628	LI	DX	EF		SEA					1.99		91	Hz	33.15	66.44
1629	LI	CR	EF		RCO				0.0315	5.14		169	Vertical	37.26	62.35
1630	LI	DX	EF		SEA					3.51		101	Hz	38.22	61.42
1631	LI	US			RCO					4.16		97	Hz	54.14	45.51
1632	LI	DX	EF		SEA					1.55		180	Vertical	33.16	66.52
1633	LI	CR	EF		RCO				0.03937	9.12		169	Vertical	40.52	59.22
1634	LI	DX	EF		SEA					6.13		101	Hz	37.77	62.04

1635	LI	DX	EF		RCO	CRE				2.43		90	Hz	41.10	58.74
1636	LI	CO	VS		RCO					0.57		166	Vertical	48.56	51.29
1637	LI	DX	EF		RCO	CRE				1.41		89	Hz	35.31	64.55
1638	LI	DX	EF		SEA					3.39		88	Hz	38.22	61.68
1639	LI	DX	EF		SEA					1.88		91	Hz	35.22	64.68
1640	LI	DX	EF		RCO	CRE				1.77		90	Hz	31.48	68.47
1641	LI	DX	EF		RCO					2.91		4	Vertical	37.26	62.74
1642	LI	DX	EF		SEA					3.61		92	Hz	34.76	65.30
1643	LI	DX	EF		RCO	CRE				3.33		92	Hz	32.50	67.63
1644	LI	DX	EF		RCO	CRE				1.39		92	Hz	37.27	62.88
1645	LI	DX	EF		SEA					2.87		60	Inclined	36.82	63.35
1646	LI	DX	EF		RCO	CRE				0.89		88	Hz	38.96	61.22
1647	LI	DX	EF		SEA					1.15		80	Hz	35.17	65.03
1648	LI	DX	EF		SEA					3.84		91	Hz	34.77	65.51
1649	LI	CO	VS	EF	RCO	CRE				0.50		90	Hz	46.68	53.61
1650	LI	DX	EF		RCO	CRE				6.94		90	Hz	34.11	66.23
1651	LI	DX	EF		RCO	CRE				0.50		88	Hz	40.23	60.11
1652	LI	DX	EF		RCO	CRE				1.68		90	Hz	38.91	61.49
1653	LI	DX	EF		RCO	CRE				1.88		90	Hz	41.16	59.29
1654	LI	DX	EF		RCO					10.27		166	Vertical	44.26	56.23
1655	LI	DX	EF		RCO	CRE				0.95		90	Hz	32.58	67.91
1656	LI	DX	EF		RCO	CRE				1.26		90	Hz	41.83	58.74
1657	LI	DX	EF		RCO					2.79		9	Vertical	39.57	61.02
1658	PT	CO	VS		RCO									50.30	61.26
1659	LI	DX	EF		RCO	CRE				2.06		3	Vertical	33.20	67.46
1660	LI	DX	EF		RCO	CRE				1.79		91	Hz	31.10	69.60
1661	LI	DX	EF		RCO	CRE				2.54		89	Hz	36.73	63.99
1662	LI	DX	EF		SEA					1.99		88	Hz	32.07	68.66
1663	PT	DX	EF		RCO									50.37	49.61
1664	LI	DX	EF		SEA					4.89		89	Hz	39.60	61.16
1665	LI	DX	EF		SEA					1.65		157	Inclined	35.94	64.83
1666	LI	DX	EF		SEA					0.84		158	Inclined	33.12	67.69
1667	LI	DX	EF		RCO	CRE				0.41		92	Hz	37.68	63.15
1668	LI	DX	EF		SEA					5.97		54	Inclined	39.35	61.47
1669	LI	DX	EF		SEA					5.56		112	Inclined	38.76	62.06
1670	LI	DX	EF		RCO	CRE				0.79		91	Hz	37.97	62.87
1671	LI	DX	EF		SEA					1.34		171	Vertical	31.59	69.30
1672	LI	DX	EF		SEA					3.37		118	Inclined	35.97	64.93
1673	LI	DX	EF		RCO	CRE				0.68		89	Hz	40.83	60.11
1674	LI	DX	EF		SEA					3.41		39	Inclined	37.51	63.43
1675	LI	DX	EF		RCO	CRE				1.01		90	Hz	36.77	64.26
1676	LI	DX	EF		SEA					1.51		91	Hz	33.00	68.10
1677	LI	DX	EF		RCO	CRE				2.22		90	Hz	38.51	62.60
1678	LI	DX	EF		RCO	CRE				0.76		88	Hz	41.82	59.29
1679	LI	DX	EF		SEA					2.21		82	Hz	39.50	61.61
1680	LI	DX	EF		RCO	CRE				1.47		91	Hz	42.39	58.74
1681	LI	DX	EF		SEA					2.07		175	Vertical	31.31	69.85
1682	LI	DX	EF		SEA					1.44		176	Vertical	31.93	69.29
1683	LI	DX	EF		SEA					1.32		93	Hz	38.20	63.08
1684	LI	CO	VS		RCO					0.76		170	Vertical	31.15	70.17
1685	LI	DX	EF		RCO	CRE				14.05		90	Hz	32.89	68.47
1686	LI	DX	EF		SEA					4.30		113	Inclined	36.04	65.32
1687	LI	DX	EF		RCO	CRE				1.66		91	Hz	38.54	62.88
1688	LI	DX	EF		SEA					1.39		86	Hz	37.51	63.92
1689	LI	DX	EF		RCO	CRE				2.90		180	Vertical	35.34	66.10
1690	LI	DX	EF		RCO	CRE				4.42		90	Hz	33.55	67.90
1691	LI	DX	EF		RCO	CRE				2.38		91	Hz	34.72	66.78
1692	LI	DX	EF		RCO	CRE				2.62		91	Hz	31.08	70.44
1693	LI	DX	EF		RCO	CRE				3.12		91	Hz	32.54	69.02
1694	LI	DX	EF		SEA					5.66		73	Inclined	40.08	61.48
1695	LI	DX	EF		SEA					1.80		92	Hz	32.36	69.22
1696	LI	DX	EF		SEA					8.54		95	Hz	39.57	62.14
1697	LI	DX	EF		RCO	CRE				2.10		89	Hz	42.97	58.74

1698	LI	DX	EF		SEA					1.73		89	Hz	38.67	63.06
1699	LI	DX	EF		RCO	CRE				2.02		91	Hz	35.83	65.95
1700	SF	DX	CS	EF	RCO						0.59			30.81	71.00
1701	LI	DX	EF		RCO					6.42		166	Vertical	43.46	58.37
1702	LI	DX	EF		RCO	CRE				1.36		90	Hz	35.33	66.51
1703	LI	DX	EF		RCO	CRE				2.09		89	Hz	38.16	63.71
1704	LI	DX	EF		SEA					1.46		89	Hz	37.51	64.47
1705	LI	DX	EF		SEA					2.25		90	Hz	36.72	65.27
1706	LI	DX	EF		SEA					2.12		64	Inclined	38.08	63.91
1707	LI	DX	EF		RCO	CRE				1.47		91	Hz	33.83	68.19
1708	LI	DX	EF		RCO	CRE				1.50		92	Hz	32.73	69.30
1709	LI	CR	EF		RCO				0.04724	5.73		9	Vertical	40.87	61.22
1710	LI	DX	EF		SEA					2.36		98	Hz	40.06	62.03
1711	LI	DX	EF		SEA					2.15		6	Vertical	40.06	62.05
1712	LI	DX	EF		RCO					3.39		8	Vertical	40.23	61.89
1713	LI	DX	EF		SEA					1.24		92	Hz	37.41	64.72
1714	LI	DX	EF		RCO	CRE				2.88		89	Hz	36.00	66.22
1715	LI	DX	EF		RCO	CRE				0.82		92	Hz	39.34	62.88
1716	LI	DX	EF		SEA					2.05		107	Inclined	40.10	62.16
1717	LI	DX	EF		SEA					0.82		85	Hz	35.56	66.71
1718	LI	DX	EF		RCO	CRE				2.10		91	Hz	31.86	70.44
1719	LI	DX	EF		RCO					7.58		167	Vertical	43.03	59.27
1720	LI	DX	EF		SEA					1.77		90	Hz	33.10	69.23
1721	LI	DX	EF		RCO	CRE				5.57		90	Hz	33.33	69.03
1722	LI	DX	EF		RCO	CRE				2.18		90	Hz	40.88	61.48
1723	LI	DX	EF		RCO	CRE				1.90		92	Hz	38.12	64.27
1724	LI	DX	EF		SEA					2.10		175	Vertical	32.53	69.87
1725	LI	DX	EF		SEA					1.72		87	Hz	39.43	63.06
1726	LI	DX	EF		RCO	CRE				2.06		93	Hz	35.99	66.51
1727	LI	DX	EF		RCO	CRE				1.06		91	Hz	43.76	58.75
1728	LI	DX	EF		SEA					0.85		66	Inclined	38.05	64.46
1729	LI	CR	EF		RCO				0.0315	4.13		163	Inclined	40.88	61.68
1730	LI	DX	EF		RCO	CRE				1.02		92	Hz	36.92	65.66
1731	LI	DX	EF		SEA					2.88		106	Inclined	34.56	68.07
1732	LI	DX	EF		RCO	CRE				2.85		90	Hz	35.85	66.78
1733	LI	DX	EF		RCO	CRE				1.70		93	Hz	36.69	65.95
1734	LI	DX	EF		SEA					6.76		111	Inclined	40.08	62.61
1735	LI	DX	EF		RCO	CRE				1.97		91	Hz	40.69	62.04
1736	LI	DX	EF		RCO	CRE				3.80		89	Hz	38.81	63.99
1737	LI	DX	EF		RCO	CRE				0.67		90	Hz	39.66	63.16
1738	PT	DX	EF		RCO	CRE								51.43	61.77
1739	PT	DX	EF		RCO	CRE								51.43	60.95
1740	LI	DX	EF		RCO	CRE				8.70		90	Hz	34.96	67.90
1741	PT	CO	VS		RCO	CRE								51.44	60.95
1742	LI	DX	EF		SEA					1.63		13	Vertical	37.53	65.36
1743	LI	DX	EF		SEA					4.09		106	Inclined	37.63	65.29
1744	LI	DX	EF		SEA					1.74		84	Hz	38.86	64.18
1745	LI	DX	EF		RCO					3.12		160	Inclined	49.34	53.73
1746	LI	DX	EF		RCO	CRE				2.34		90	Hz	34.60	68.47
1747	LI	DX	EF		RCO					7.78		169	Vertical	43.76	59.32
1748	LI	DX	EF		SEA					2.40		82	Hz	38.10	65.01
1749	LI	DX	EF		RCO					1.69		13	Vertical	38.19	64.92
1750	LI	DX	EF		SEA					4.04		174	Vertical	33.15	69.96
1751	LI	DX	EF		RCO	CRE				0.65		90	Hz	47.09	56.04
1752	LI	DX	EF		RCO	CRE				1.72		94	Hz	32.13	71.00
1753	LI	DX	EF		SEA					2.04		87	Hz	36.73	66.40
1754	LI	DX	EF		SEA					1.91		63	Inclined	37.68	65.46
1755	LI	DX	EF		SEA					1.90		88	Hz	40.14	63.06
1756	LI	DX	EF		SEA					1.77		92	Hz	33.91	69.30
1757	LI	DX	EF		SEA					2.01		94	Hz	35.26	68.08
1758	LI	DX	EF		RCO	CRE				3.38		91	Hz	34.32	69.02
1759	LI	DX	EF		SEA					1.75		91	Hz	36.73	66.62
1760	LI	DX	EF		SEA					3.13		16	Inclined	40.15	63.21

1761	LI	DX	EF		RCO	CRE				2.17		91	Hz	38.56	64.83
1762	LI	DX	EF		RCO	CRE				1.24		91	Hz	33.81	69.59
1763	LI	DX	EF		RCO	CRE				0.74		91	Hz	42.19	61.21
1764	LI	DX	EF		RCO					5.80		168	Vertical	47.10	56.30
1765	LI	DX	EF		RCO	CRE				0.76		89	Hz	38.90	64.54
1766	LI	DX	EF		RCO	CRE				1.46		90	Hz	37.25	66.22
1767	LI	DX	EF		SEA					1.31		148	Inclined	38.07	65.41
1768	LI	DX	EF		RCO	CRE				0.80		92	Hz	39.57	63.99
1769	LI	DX	EF		SEA					2.13		91	Hz	34.26	69.31
1770	LI	DX	EF		SEA					2.03		95	Hz	36.05	67.53
1771	LI	DX	EF		SEA					1.28		126	Inclined	35.32	68.26
1772	LI	DX	EF		RCO	CRE				0.64		92	Hz	44.32	59.30
1773	LI	DX	EF		RCO	CRE				1.66		91	Hz	36.58	67.06
1774	LI	DX	EF		SEA					1.73		94	Hz	40.30	63.35
1775	LI	DX	EF		SEA					2.21		86	Hz	38.31	65.36
1776	LI	DX	EF		SEA					1.42		3	Vertical	38.25	65.43
1777	LI	DX	EF		RCO	CRE				1.13		89	Hz	42.20	61.49
1778	LI	DX	EF		RCO	CRE				1.47		90	Hz	38.61	65.10
1779	LI	DX	EF		SEA					1.29		137	Inclined	38.43	65.32
1780	LI	DX	EF		RCO	CRE				1.52		93	Hz	45.02	58.74
1781	LI	DX	EF		SEA					1.50		87	Hz	36.81	67.00
1782	LI	DX	EF		SEA					1.96		85	Hz	36.03	67.80
1783	LI	DX	EF		SEA					1.26		96	Hz	34.94	68.89
1784	LI	DX	EF		SEA					0.67		92	Hz	38.89	64.99
1785	LI	DX	EF		RCO	CRE				0.61		93	Hz	37.40	66.50
1786	LI	DX	EF		RCO	CRE				1.79		90	Hz	41.34	62.60
1787	LI	DX	EF		SEA					2.89		82	Hz	40.13	63.86
1788	LI	DX	EF		SEA					0.98		88	Hz	38.75	65.27
1789	LI	DX	EF		SEA					2.12		82	Hz	39.62	64.43
1790	LI	DX	EF		RCO	CRE				3.88		89	Hz	37.88	66.22
1791	LI	DX	EF		RCO	CRE				1.11		89	Hz	45.95	58.20
1792	PT	CO	VS		RCO									52.08	46.45
1793	LI	DX	EF		RCO	CRE				0.95		88	Hz	39.39	64.83
1794	LI	DX	EF		SEA					2.60		143	Inclined	39.19	65.06
1795	LI	DX	EF		SEA					2.19		98	Hz	40.20	64.07
1796	LI	DX	EF		RCO	CRE				2.38		89	Hz	37.50	66.78
1797	LI	DX	EF		RCO	CRE				3.79		170	Vertical	45.01	59.27
1798	LI	DX	EF		RCO	CRE				0.85		90	Hz	45.00	59.29
1799	LI	DX	EF		RCO	CRE				0.51		88	Hz	45.59	58.74
1800	LI	DX	EF		RCO	CRE				1.01		89	Hz	40.91	63.43
1801	LI	DX	EF		SEA					1.89		86	Hz	35.15	69.20
1802	LI	DX	EF		SEA					1.42		9	Vertical	38.98	65.39
1803	LI	DX	EF		RCO	CRE				0.74		89	Hz	42.89	61.49
1804	LI	DX	EF		SEA					1.74		94	Hz	40.22	64.19
1805	LI	DX	EF		SEA					0.93		100	Hz	39.31	65.13
1806	LI	DX	EF		RCO	CRE				1.40		91	Hz	36.55	67.89
1807	LI	DX	EF		SEA					12.55		159	Inclined	40.33	64.12
1808	LI	DX	EF		SEA					2.37		80	Hz	38.14	66.40
1809	LI	DX	EF		RCO	CRE				2.14		90	Hz	42.82	61.76
1810	LI	DX	EF		RCO	CRE				1.89		89	Hz	40.88	63.70
1811	LI	DX	EF		RCO	CRE				1.78		91	Hz	41.99	62.60
1812	LI	DX	EF		SEA					2.43		92	Hz	36.54	68.08
1813	LI	DX	EF		SEA					2.04		83	Hz	40.26	64.40
1814	LI	DX	EF		RCO	CRE				1.20		92	Hz	46.51	58.20
1815	LI	DX	EF		RCO	CRE				2.23		88	Hz	37.40	67.34
1816	LI	DX	EF		SEA					3.45		171	Vertical	38.13	66.62
1817	LI	DX	EF		SEA					1.79		89	Hz	35.54	69.21
1818	LI	DX	EF		RCO	CRE				0.73		91	Hz	33.50	71.28
1819	LI	DX	EF		RCO	CRE				2.92		92	Hz	35.79	69.02
1820	LI	DX	EF		RCO	CRE				1.20		90	Hz	40.84	63.98
1821	LI	DX	EF		SEA					1.26		13	Vertical	36.71	68.13
1822	LI	DX	EF		SEA					4.01		103	Hz	39.59	65.26
1823	PT	DX	EF		RCO	CRE								52.44	50.41

1824	LI	DX	EF		RCO	CRE				0.76		94	Hz	42.06	62.87
1825	PT	DX	EF		RCO	CRE								52.48	56.58
1826	LI	DX	EF		RCO	CRE				2.23		90	Hz	37.35	67.62
1827	LI	DX	EF		SEA					2.25		176	Vertical	39.61	65.37
1828	LI	DX	EF		RCO					1.23		96	Hz	36.09	68.92
1829	LI	DX	EF		RCO	CRE				2.01		91	Hz	37.98	67.07
1830	LI	DX	EF		RCO					2.52		170	Vertical	38.17	66.90
1831	LI	DX	EF		RCO	CRE				2.33		90	Hz	38.86	66.22
1832	LI	DX	EF		RCO	CRE				0.67		88	Hz	40.02	65.10
1833	LI	DX	EF		SEA					0.52		95	Hz	38.74	66.42
1834	LI	DX	EF		RCO					3.15		166	Vertical	51.47	53.75
1835	LI	DX	EF		SEA					7.16		10	Vertical	40.11	65.16
1836	LI	DX	EF		SEA					2.04		73	Inclined	40.24	65.04
1837	LI	DX	EF		RCO	CRE				0.96		91	Hz	43.25	62.04
1838	LI	DX	EF		SEA					0.75		73	Inclined	40.30	65.01
1839	LI	DX	EF		RCO	CRE				0.40		87	Hz	43.57	61.76
1840	LI	CO	VS		RCO					0.67		175	Vertical	45.62	59.72
1841	LI	DX	EF		SEA					0.64		95	Hz	38.94	66.41
1842	LI	DX	EF		RCO	CRE				2.37		91	Hz	37.19	68.17
1843	LI	DX	EF		RCO	CRE				1.96		90	Hz	37.48	67.89
1844	LI	DX	EF		RCO	CRE				1.32		90	Hz	40.88	64.54
1845	LI	DX	EF		RCO					3.58		161	Inclined	38.07	67.36
1846	PT	DX	EF		RCO	CRE								52.73	49.62
1847	LI	DX	EF		RCO	CRE				3.66		90	Hz	42.32	63.15
1848	PT	DX	EF		RCO	CRE								52.74	62.05
1849	LI	DX	EF		RCO	CRE				0.76		91	Hz	35.15	70.42
1850	LI	DX	EF		RCO	CRE				2.54		91	Hz	36.57	69.02
1851	LI	DX	EF		RCO	CRE				1.92		90	Hz	42.24	63.42
1852	LI	DX	EF		RCO	CRE				1.39		92	Hz	41.68	63.99
1853	LI	DX	EF		RCO	CRE				1.02		89	Hz	38.90	66.78
1854	LI	DX	EF		SEA					2.52		87	Hz	37.90	67.80
1855	LI	DX	EF		RCO	CRE				0.80		92	Hz	44.22	61.49
1856	LI	DX	EF		RCO	CRE				0.99		91	Hz	37.26	68.46
1857	LI	DX	EF		SEA					2.06		178	Vertical	38.10	67.63
1858	LI	DX	EF		RCO	CRE				2.21		90	Hz	43.42	62.32
1859	PT	DX	EF		RCO									52.88	45.41
1860	LI	DX	EF		RCO	CRE				0.86		90	Hz	38.76	67.06
1861	LI	DX	EF		RCO					2.95		165	Inclined	38.91	66.93
1862	LI	DX	EF		SEA					8.06		93	Hz	40.48	65.37
1863	LI	DX	EF		RCO	CRE				0.89		91	Hz	40.76	65.10
1864	LI	DX	EF		SEA					1.71		91	Hz	39.53	66.41
1865	LI	DX	EF		SEA					3.76		92	Hz	37.85	68.12
1866	LI	DX	EF		RCO	CRE				6.96		170	Vertical	46.90	59.08
1867	LI	DX	EF		RCO	CRE				1.39		91	Hz	42.86	63.16
1868	LI	DX	EF		RCO	CRE				2.59		91	Hz	40.08	65.94
1869	SF	US			RCO	CRE					1.42			43.98	62.07
1870	LI	DX	EF		RCO	CRE				1.40		89	Hz	43.45	62.60
1871	LI	DX	EF		RCO	CRE				1.95		91	Hz	41.52	64.54
1872	LI	DX	EF		RCO	CRE				1.76		90	Hz	38.16	67.90
1873	LI	DX	EF		RCO	CRE				0.63		90	Hz	40.41	65.65
1874	LI	DX	EF		SEA					1.95		20	Inclined	37.85	68.25
1875	LI	DX	EF		RCO	CRE				0.73		92	Hz	39.33	66.78
1876	LI	DX	EF		RCO	CRE				2.97		91	Hz	35.42	70.70
1877	LI	DX	EF		RCO	CRE				1.79		91	Hz	42.22	63.99
1878	LI	DX	EF		SEA					2.16		2	Vertical	38.93	67.33
1879	LI	DX	EF		RCO	CRE				3.38		90	Hz	40.09	66.22
1880	LI	DX	EF		RCO	CRE				1.28		90	Hz	41.50	64.83
1881	LI	DX	EF		RCO	CRE				1.43		90	Hz	39.30	67.06
1882	LI	DX	EF		RCO	CRE				0.83		92	Hz	37.12	69.29
1883	LI	DX	EF		RCO	CRE				4.30		89	Hz	41.09	65.37
1884	PT	DX	EF		RCO	CRE								53.24	58.75
1885	LI	DX	EF		SEA					1.83		176	Vertical	39.41	67.06
1886	LI	DX	EF		SEA					1.07		102	Hz	38.68	67.81

1887	LI	DX	EF		SEA					1.86		93	Hz	39.54	66.95
1888	LI	DX	EF		RCO	CRE				0.43		92	Hz	40.57	65.94
1889	LI	DX	EF		SEA					3.38		26	Inclined	38.91	67.64
1890	LI	DX	EF		SEA					2.81		90	Hz	49.01	57.59
1891	LI	DX	EF		SEA					1.73		86	Hz	40.23	66.41
1892	LI	DX	EF		RCO	CRE				1.58		89	Hz	42.95	63.70
1893	LI	DX	EF		RCO	CRE				3.47		89	Hz	37.74	69.01
1894	LI	DX	EF		RCO	CRE				1.08		89	Hz	45.55	61.22
1895	LI	DX	EF		RCO	CRE				1.06		86	Hz	41.11	65.66
1896	LI	DX	EF		RCO	CRE				2.23		89	Hz	38.60	68.18
1897	LI	DX	EF		RCO	CRE				0.91		87	Hz	39.45	67.33
1898	LI	DX	EF		RCO	CRE				1.43		89	Hz	47.51	59.30
1899	LI	DX	EF		RCO	CRE				2.26		92	Hz	38.17	68.74
1900	LI	DX	EF		RCO					1.86		175	Vertical	38.64	68.28
1901	LI	DX	EF		RCO	CRE				3.24		89	Hz	42.11	64.82
1902	PT	DX	EF		RCO									53.50	45.44
1903	LI	DX	EF		SEA					1.57		89	Hz	38.66	68.36
1904	LI	DX	EF		SEA					3.00		111	Inclined	40.08	66.98
1905	LI	DX	EF		RCO	CRE				1.06		90	Hz	37.80	69.29
1906	LI	DX	EF		RCO	CRE				1.94		89	Hz	43.70	63.43
1907	LI	DX	EF		RCO	CRE				3.70		89	Hz	44.83	62.32
1908	LI	DX	EF		RCO	CRE				0.64		92	Hz	51.11	56.03
1909	LI	DX	EF		RCO	CRE				1.90		90	Hz	41.77	65.38
1910	LI	DX	EF		RCO	CRE				1.42		91	Hz	44.59	62.60
1911	LI	DX	EF		RCO	CRE				1.68		88	Hz	42.93	64.27
1912	LI	DX	EF		RCO	CRE				6.08		90	Hz	40.99	66.21
1913	LI	DX	EF		RCO	CRE				1.76		91	Hz	42.11	65.10
1914	PT	CO	VS		RCO	CRE								53.63	60.40
1915	LI	DX	EF		SEA					1.40		88	Hz	38.38	68.92
1916	LI	DX	EF		SEA					1.23		84	Hz	39.18	68.12
1917	LI	DX	EF		SEA					3.76		28	Inclined	39.46	67.87
1918	LI	CO	VS		RCO					0.61		166	Vertical	53.63	53.72
1919	LI	DX	EF		RCO	CRE				1.93		90	Hz	41.69	65.66
1920	LI	DX	EF		RCO	CRE				2.62		89	Hz	40.09	67.34
1921	LI	DX	EF		SEA					2.22		69	Inclined	50.06	57.40
1922	PT	DX	EF		RCO									53.74	45.44
1923	LI	DX	EF		SEA					1.67		75	Inclined	39.13	68.37
1924	LI	DX	EF		RCO	CRE				1.83		91	Hz	42.68	64.83
1925	LI	DX	EF		RCO					2.09		16	Inclined	40.09	67.44
1926	LI	DX	EF		RCO	CRE				2.57		89	Hz	40.76	66.77
1927	LI	DX	EF		RCO	CRE				0.78		91	Hz	44.38	63.16
1928	PT	CO	VS		RCO									53.78	46.45
1929	PT	CO	VS		RCO									53.78	46.58
1930	LI	DX	EF		RCO	CRE				1.62		91	Hz	47.19	60.39
1931	LI	DX	EF		RCO	CRE				1.79		88	Hz	38.85	68.73
1932	LI	DX	EF		RCO					1.17		7	Vertical	41.00	66.61
1933	LI	DX	EF		SEA					3.42		89	Hz	41.50	66.12
1934	LI	DX	EF		RCO	CRE				1.46		91	Hz	43.09	64.54
1935	PT	CO	VS		RCO									53.82	70.71
1936	LI	DX	EF		RCO	CRE				0.86		90	Hz	43.66	63.99
1937	LI	DX	EF		SEA					2.20		40	Inclined	40.04	67.67
1938	LI	DX	EF		SEA					1.45		91	Hz	39.17	68.54
1939	LI	DX	EF		SEA					2.60		114	Inclined	38.54	69.20
1940	LI	DX	EF		RCO	CRE				0.65		88	Hz	45.42	62.32
1941	LI	DX	EF		RCO	CRE				3.19		91	Hz	40.73	67.05
1942	LI	DX	EF		RCO	CRE				2.37		91	Hz	44.36	63.43
1943	LI	DX	EF		RCO	CRE				3.85		89	Hz	42.43	65.38
1944	LI	DX	EF		RCO					1.11		4	Vertical	39.32	68.55
1945	LI	DX	EF		RCO	CRE				0.96		92	Hz	42.79	65.10
1946	LI	DX	EF		RCO	CRE				1.39		92	Hz	43.64	64.27
1947	LI	DX	EF		SEA					3.34		125	Inclined	39.90	68.10
1948	LI	DX	EF		RCO	CRE				1.86		91	Hz	42.12	65.94
1949	LI	DX	EF		SEA					5.02		86	Hz	49.39	58.68

1950	LI	DX	EF		SEA					2.51		86	Hz	39.50	68.61
1951	LI	DX	EF		RCO	CRE				0.87		89	Hz	42.45	65.66
1952	LI	CO	VS		RCO					0.65		172	Vertical	37.10	71.01
1953	LI	DX	EF		RCO	CRE				1.47		89	Hz	44.99	63.15
1954	LI	DX	EF		RCO	CRE				1.76		89	Hz	44.44	63.71
1955	LI	DX	EF		RCO					3.96		165	Inclined	40.83	67.34
1956	LI	DX	EF		SEA					0.99		77	Hz	40.68	67.53
1957	LI	DX	EF		SEA					1.24		5	Vertical	38.44	69.80
1958	LI	DX	EF		RCO	CRE				1.02		91	Hz	45.41	62.88
1959	LI	DX	EF		SEA					2.01		90	Hz	38.43	69.86
1960	LI	DX	EF		SEA					1.63		88	Hz	42.21	66.12
1961	LI	DX	EF		RCO	CRE				5.36		90	Hz	40.48	67.89
1962	LI	DX	EF		RCO	CRE				0.70		90	Hz	44.38	63.99
1963	LI	DX	EF		SEA					1.93		91	Hz	41.72	66.67
1964	LI	DX	EF		SEA					1.29		93	Hz	41.28	67.13
1965	LI	DX	EF		RCO	CRE				1.13		93	Hz	43.05	65.38
1966	LI	DX	EF		SEA					5.08		101	Hz	50.29	58.15
1967	LI	DX	EF		RCO	CRE				0.42		94	Hz	43.62	64.82
1968	LI	DX	EF		RCO	CRE				0.81		88	Hz	39.71	68.73
1969	LI	DX	EF		RCO	CRE				1.06		90	Hz	45.09	63.43
1970	LI	DX	EF		SEA					1.96		75	Hz	40.45	68.08
1971	LI	DX	EF		SEA					2.04		16	Inclined	39.27	69.29
1972	LI	DX	EF		SEA					6.07		94	Hz	49.81	58.78
1973	LI	DX	EF		RCO	CRE				1.32		90	Hz	43.51	65.11
1974	LI	DX	EF		RCO	CRE				2.96		177	Vertical	40.95	67.76
1975	LI	DX	EF		RCO	CRE				0.98		92	Hz	45.08	63.71
1976	LI	DX	EF		RCO	CRE				2.33		91	Hz	45.64	63.15
1977	LI	DX	EF		SEA					2.95		88	Hz	40.21	68.65
1978	LI	DX	EF		RCO	CRE				1.82		92	Hz	40.71	68.17
1979	LI	DX	EF		RCO	CRE				1.07		91	Hz	47.42	61.50
1980	LI	DX	EF		RCO	CRE				2.60		90	Hz	44.09	64.83
1981	LI	DX	EF		SEA					4.41		64	Inclined	41.40	67.52
1982	LI	DX	EF		RCO	CRE				0.78		90	Hz	44.38	64.54
1983	LI	DX	EF		SEA					1.47		86	Hz	42.82	66.11
1984	LI	DX	EF		SEA					1.22		88	Hz	39.78	69.21
1985	LI	DX	EF		RCO					3.93		11	Vertical	49.98	59.03
1986	LI	DX	EF		SEA					0.77		123	Inclined	42.12	66.95
1987	LI	DX	EF		RCO	CRE				1.36		89	Hz	46.75	62.32
1988	LI	DX	EF		RCO	CRE				1.38		87	Hz	42.30	66.77
1989	LI	DX	EF		RCO	CRE				3.42		91	Hz	38.38	70.70
1990	LI	DX	EF		SEA					4.31		90	Hz	50.80	58.29
1991	LI	DX	EF		RCO	CRE				2.29		91	Hz	40.08	69.01
1992	LI	DX	EF		RCO	CRE				1.77		90	Hz	43.71	65.38
1993	LI	DX	EF		RCO	CRE				2.20		90	Hz	45.73	63.43
1994	LI	DX	EF		RCO	CRE				0.92		93	Hz	40.46	68.74
1995	LI	DX	EF		RCO	CRE				1.59		92	Hz	40.78	68.45
1996	LI	DX	EF		RCO	CRE				3.78		90	Hz	44.15	65.10
1997	LI	DX	EF		SEA					2.51		91	Hz	41.23	68.09
1998	LI	DX	EF		RCO	CRE				1.60		92	Hz	46.76	62.59
1999	LI	DX	EF		RCO	CRE				1.31		93	Hz	45.65	63.71
2000	LI	DX	EF		RCO	CRE				2.15		90	Hz	39.82	69.58
2001	LI	DX	EF		SEA					2.06		88	Hz	42.19	67.24
2002	LI	DX	EF		RCO	CRE				1.51		89	Hz	41.57	67.89
2003	LI	DX	EF		SEA					7.75		92	Hz	50.09	59.39
2004	LI	DX	EF		SEA					2.33		89	Hz	43.08	66.40
2005	LI	DX	EF		RCO					2.86		10	Vertical	43.55	65.98
2006	LI	DX	EF		SEA					5.99		91	Hz	51.96	57.60
2007	LI	DX	EF		RCO	CRE				1.98		90	Hz	40.84	68.73
2008	LI	DX	EF		RCO	CRE				1.28		92	Hz	44.77	64.82
2009	LI	DX	EF		RCO	CRE				0.71		89	Hz	47.27	62.32
2010	LI	DX	EF		RCO	CRE				0.70		90	Hz	48.12	61.50
2011	LI	DX	EF		RCO	CRE				0.69		90	Hz	46.75	62.88
2012	LI	DX	EF		SEA					2.53		114	Inclined	43.64	66.12

2013	LI	DX	EF		RCO	CRE				0.99		92	Hz	44.39	65.38
2014	LI	DX	EF		RCO	CRE				0.63		90	Hz	48.85	60.95
2015	LI	DX	EF		SEA					2.79		87	Hz	42.28	67.52
2016	LI	DX	EF		RCO	CRE				0.60		96	Hz	46.42	63.44
2017	LI	DX	EF		SEA					4.62		90	Hz	50.61	59.24
2018	LI	DX	EF		SEA					1.18		1	Vertical	42.28	67.58
2019	LI	DX	EF		RCO	CRE				1.10		85	Hz	39.20	70.70
2020	LI	DX	EF		RCO	CRE				2.63		92	Hz	44.86	65.10
2021	LI	DX	EF		SEA					1.88		174	Vertical	41.37	68.66
2022	LI	DX	EF		SEA					1.93		164	Inclined	42.93	67.16
2023	LI	DX	EF		RCO	CRE				0.80		90	Hz	44.47	65.66
2024	LI	DX	EF		SEA					2.57		91	Hz	42.31	67.89
2025	LI	DX	EF		RCO	CRE				0.88		91	Hz	46.52	63.71
2026	LI	DX	EF		RCO	CRE				3.50		89	Hz	43.74	66.49
2027	LI	DX	EF		RCO	CRE				2.09		91	Hz	39.89	70.42
2028	LI	DX	EF		RCO	CRE				1.34		90	Hz	43.53	66.78
2029	LI	DX	EF		SEA					1.24		87	Hz	42.22	68.08
2030	LI	DX	EF		SEA					5.36		90	Hz	49.43	60.88
2031	LI	DX	EF		RCO	CRE				1.02		90	Hz	48.01	62.31
2032	LI	DX	EF		SEA					1.98		173	Vertical	41.70	68.66
2033	LI	DX	EF		SEA					3.93		88	Hz	41.62	68.76
2034	LI	DX	EF		SEA					1.41		89	Hz	43.73	66.67
2035	LI	DX	EF		SEA					1.01		173	Vertical	41.78	68.62
2036	LI	DX	EF		SEA					1.50		94	Hz	41.80	68.67
2037	LI	DX	EF		RCO	CRE				0.96		89	Hz	46.48	63.99
2038	LI	CR	EF		RCO				0.0315	3.80		162	Inclined	48.76	61.79
2039	LI	DX	EF		RCO	CRE				1.50		93	Hz	42.15	68.45
2040	LI	DX	EF		RCO	CRE				2.95		90	Hz	45.29	65.38
2041	LI	DX	EF		SEA					1.69		88	Hz	42.06	68.61
2042	LI	DX	EF		SEA					3.79		88	Hz	42.96	67.77
2043	LI	DX	EF		RCO	CRE				1.42		89	Hz	39.52	71.26
2044	LI	DX	EF		RCO	CRE				2.76		90	Hz	47.08	63.71
2045	LI	DX	EF		RCO	CRE				1.54		89	Hz	47.65	63.15
2046	LI	DX	EF		RCO	CRE				2.90		89	Hz	44.37	66.50
2047	LI	DX	EF		SEA					0.49		84	Hz	43.64	67.24
2048	LI	DX	EF		RCO	CRE				0.50		91	Hz	52.69	58.21
2049	LI	DX	EF		RCO	CRE				0.81		92	Hz	49.44	61.50
2050	LI	DX	EF		SEA					3.30		88	Hz	41.73	69.21
2051	LI	DX	EF		SEA					1.60		174	Vertical	42.93	68.03
2052	LI	DX	EF		RCO	CRE				1.97		91	Hz	47.03	63.99
2053	LI	DX	EF		SEA					3.14		91	Hz	41.31	69.72
2054	LI	DX	EF		SEA					2.48		151	Inclined	43.62	67.45
2055	LI	DX	EF		RCO	CRE				0.66		91	Hz	46.54	64.54
2056	LI	DX	EF		RCO	CRE				3.02		90	Hz	42.38	68.73
2057	LI	DX	EF		SEA					1.96		8	Vertical	41.30	69.82
2058	LI	DX	EF		RCO	CRE				0.59		89	Hz	44.35	66.78
2059	LI	DX	EF		RCO	CRE				3.52		170	Vertical	51.94	59.19
2060	LI	DX	EF		RCO	CRE				1.51		90	Hz	44.92	66.22
2061	LI	DX	EF		RCO	CRE				2.95		90	Hz	44.12	67.06
2062	LI	DX	EF		SEA					3.80		90	Hz	42.30	68.89
2063	LI	DX	EF		SEA					5.00		120	Inclined	42.85	68.38
2064	LI	DX	EF		SEA					1.69		177	Vertical	43.68	67.61
2065	LI	DX	EF		RCO	CRE				1.19		89	Hz	48.72	62.60
2066	LI	DX	EF		RCO	CRE				1.30		89	Hz	41.77	69.57
2067	LI	DX	EF		SEA					2.92		89	Hz	44.15	67.23
2068	LI	DX	EF		SEA					0.95		94	Hz	42.85	68.55
2069	LI	DX	EF		RCO	CRE				2.29		89	Hz	46.02	65.38
2070	LI	DX	EF		RCO	CRE				0.88		92	Hz	46.35	65.11
2071	LI	DX	EF		SEA					5.17		133	Inclined	41.79	69.68
2072	LI	DX	EF		SEA					2.60		5	Vertical	42.74	68.76
2073	LI	DX	EF		RCO	CRE				2.59		90	Hz	45.02	66.50
2074	LI	DX	EF		SEA					4.46		91	Hz	51.11	60.44
2075	LI	DX	EF		RCO	CRE				2.72		90	Hz	47.84	63.71

2076	LI	DX	EF		SEA					5.30		90	Hz	50.67	60.88
2077	LI	DX	EF		SEA					0.75		87	Hz	43.49	68.07
2078	LI	DX	EF		SEA					3.13		90	Hz	43.76	67.81
2079	LI	DX	EF		SEA					1.30		174	Vertical	43.75	67.87
2080	LI	DX	EF		RCO	CRE				1.22		90	Hz	50.13	61.49
2081	LI	DX	EF		SEA					0.72		5	Vertical	42.88	68.74
2082	LI	DX	EF		SEA					2.36		90	Hz	42.43	69.20
2083	LI	DX	EF		RCO	CRE				2.51		90	Hz	46.83	64.82
2084	LI	DX	EF		RCO	CRE				1.55		92	Hz	47.14	64.54
2085	LI	DX	EF		SEA					3.95		89	Hz	43.05	68.64
2086	LI	DX	EF		SEA					1.75		11	Vertical	42.98	68.72
2087	LI	DX	EF		SEA					4.33		68	Inclined	49.96	61.75
2088	LI	DX	EF		SEA					0.99		92	Hz	44.23	67.53
2089	LI	DX	EF		SEA					2.09		51	Inclined	41.90	69.89
2090	LI	DX	EF		RCO					1.66		176	Vertical	42.85	68.96
2091	LI	DX	EF		RCO	CRE				1.64		90	Hz	47.86	63.99
2092	LI	DX	EF		SEA					2.51		9	Vertical	43.11	68.75
2093	LI	DX	EF		RCO	CRE				2.60		91	Hz	45.10	66.77
2094	LI	DX	EF		RCO	CRE				1.97		91	Hz	46.79	65.11
2095	LI	DX	EF		RCO	CRE				1.91		92	Hz	44.84	67.06
2096	LI	DX	EF		SEA					1.49		91	Hz	42.47	69.44
2097	LI	DX	EF		SEA					1.11		86	Hz	42.21	69.73
2098	LI	DX	EF		RCO					5.47		12	Vertical	48.53	63.46
2099	LI	DX	EF		SEA					1.65		91	Hz	43.91	68.10
2100	LI	DX	EF		SEA					2.25		94	Hz	45.64	66.40
2101	LI	DX	EF		SEA					0.79		179	Vertical	43.91	68.14
2102	LI	DX	EF		RCO	CRE				2.91		91	Hz	46.68	65.37
2103	SF	DX	HC		RCO	CRE					1.37			46.68	65.39
2104	LI	DX	EF		RCO	CRE				0.67		94	Hz	46.16	65.94
2105	LI	DX	EF		RCO	CRE				3.12		91	Hz	48.44	63.71
2106	LI	DX	EF		SEA					1.29		91	Hz	43.93	68.28
2107	LI	DX	EF		SEA					1.58		4	Vertical	43.20	69.00
2108	LI	DX	EF		RCO	CRE				1.73		88	Hz	47.49	64.82
2109	LI	DX	EF		RCO	CRE				2.86		90	Hz	49.18	63.16
2110	LI	DX	EF		SEA					1.88		90	Hz	42.66	69.76
2111	LI	DX	EF		RCO	CRE				1.66		91	Hz	43.78	68.73
2112	LI	DX	EF		SEA					11.12		89	Hz	50.28	62.24
2113	LI	DX	EF		RCO	CRE				1.14		91	Hz	45.74	66.78
2114	LI	DX	EF		RCO	CRE				0.95		89	Hz	46.32	66.21
2115	LI	DX	EF		RCO	CRE				1.38		91	Hz	47.47	65.11
2116	LI	DX	EF		SEA					0.35		96	Hz	45.94	66.69
2117	LI	DX	EF		RCO	CRE				2.14		91	Hz	48.42	64.27
2118	LI	DX	EF		SEA					1.72		93	Hz	43.20	69.51
2119	LI	DX	EF		SEA					2.63		88	Hz	43.81	68.91
2120	LI	DX	EF		RCO	CRE				1.01		90	Hz	41.47	71.25
2121	LI	DX	EF		SEA					1.86		92	Hz	50.28	62.45
2122	LI	DX	EF		RCO	CRE				1.33		92	Hz	46.80	65.94
2123	LI	DX	EF		SEA					0.79		120	Inclined	46.08	66.68
2124	LI	DX	EF		RCO	CRE				3.33		90	Hz	47.40	65.38
2125	LI	DX	EF		RCO	CRE				0.88		89	Hz	42.68	70.13
2126	LI	DX	EF		SEA					1.73		89	Hz	49.21	63.65
2127	LI	DX	EF		SEA					3.63		126	Inclined	44.20	68.67
2128	LI	DX	EF		SEA					1.52		90	Hz	50.29	62.59
2129	LI	DX	EF		RCO	CRE				0.96		89	Hz	42.48	70.41
2130	LI	DX	EF		SEA					1.66		77	Hz	50.17	62.81
2131	LI	DX	EF		RCO	CRE				0.80		89	Hz	43.75	69.29
2132	LI	DX	EF		SEA					4.44		104	Hz	46.66	66.42
2133	LI	DX	EF		SEA					0.76		102	Hz	44.50	68.59
2134	LI	DX	EF		SEA					2.34		74	Inclined	44.20	68.91
2135	LI	DX	EF		RCO	CRE				1.84		90	Hz	48.34	64.83
2136	LI	DX	EF		SEA					2.03		97	Hz	50.97	62.24
2137	LI	CO	VS		RCO	CRE				0.53		172	Vertical	42.51	70.70
2138	LI	DX	EF		SEA					1.69		91	Hz	46.53	66.69

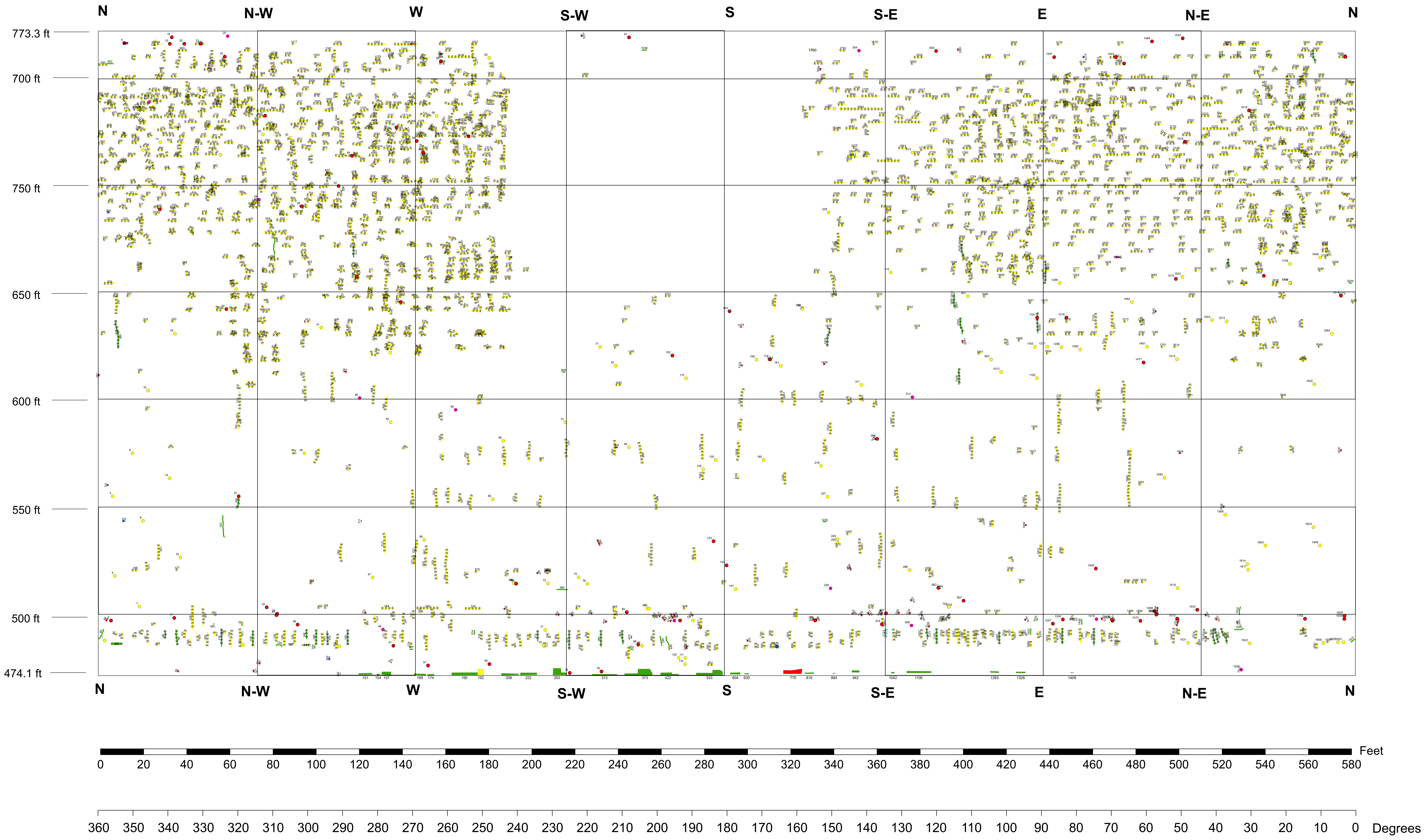
2139	LI	DX	EF		SEA					2.04		5	Vertical	43.37	69.86
2140	LI	DX	EF		SEA					2.33		90	Hz	46.27	66.98
2141	LI	DX	EF		RCO	CRE				1.53		90	Hz	47.07	66.22
2142	LI	DX	EF		RCO					1.43		45	Inclined	45.93	67.39
2143	LI	DX	EF		SEA					3.09		89	Hz	43.40	69.96
2144	LI	DX	EF		RCO	CRE				2.09		90	Hz	48.27	65.10
2145	LI	DX	EF		RCO	CRE				1.57		89	Hz	48.03	65.38
2146	LI	DX	EF		SEA					1.19		174	Vertical	43.60	69.82
2147	LI	DX	EF		SEA					2.52		121	Inclined	43.92	69.55
2148	LI	DX	EF		RCO	CRE				1.54		91	Hz	47.54	65.94
2149	LI	DX	EF		SEA					2.87		70	Inclined	49.32	64.20
2150	LI	DX	EF		SEA					2.64		80	Hz	51.00	62.52
2151	LI	DX	EF		SEA					1.91		89	Hz	45.74	67.81
2152	LI	DX	EF		SEA					1.92		90	Hz	46.31	67.24
2153	LI	DX	EF		RCO	CRE				1.32		90	Hz	43.24	70.42
2154	LI	DX	EF		SEA					1.98		128	Inclined	51.47	62.25
2155	LI	DX	EF		SEA					1.85		171	Vertical	43.88	69.85
2156	LI	DX	EF		SEA					2.58		98	Hz	49.80	63.94
2157	LI	DX	EF		RCO					2.92		173	Vertical	43.23	70.57
2158	LI	DX	EF		SEA					8.54		105	Hz	50.08	63.73
2159	LI	CO	VS		RCO	CRE				0.41		89	Hz	44.54	69.29
2160	LI	DX	EF		RCO	CRE				2.49		90	Hz	45.09	68.74
2161	LI	DX	EF		SEA					1.37		16	Inclined	49.86	64.01
2162	LI	DX	EF		SEA					1.78		90	Hz	49.39	64.48
2163	LI	DX	EF		SEA					2.92		49	Inclined	44.12	69.77
2164	LI	DX	EF		RCO	CRE				1.73		91	Hz	44.60	69.29
2165	LI	DX	EF		SEA					3.05		92	Hz	50.53	63.36
2166	LI	DX	EF		RCO	CRE				2.31		90	Hz	48.83	65.11
2167	LI	DX	EF		SEA					1.99		92	Hz	46.96	66.99
2168	LI	DX	EF		SEA					1.06		28	Inclined	51.58	62.38
2169	LI	DX	EF		RCO	CRE				0.88		91	Hz	45.51	68.46
2170	LI	DX	EF		SEA					1.19		91	Hz	46.38	67.62
2171	SF	DX	HC		RCO	CRE					1.09			48.68	65.39
2172	LI	DX	EF		SEA					1.29		13	Vertical	51.76	62.32
2173	LI	DX	EF		RCO	CRE				0.79		89	Hz	53.68	60.41
2174	LI	DX	EF		SEA					3.82		111	Inclined	49.89	64.20
2175	LI	DX	EF		SEA					1.42		3	Vertical	49.83	64.28
2176	LI	DX	EF		RCO	CRE				1.75		90	Hz	48.21	65.94
2177	LI	DX	EF		SEA					3.13		85	Hz	50.52	63.64
2178	LI	DX	EF		SEA					2.88		175	Vertical	51.67	62.57
2179	LI	DX	EF		SEA					1.99		93	Hz	51.15	63.08
2180	LI	DX	EF		RCO	CRE				0.92		90	Hz	52.76	61.50
2181	LI	DX	EF		RCO	CRE				1.12		88	Hz	48.91	65.38
2182	LI	DX	EF		RCO	CRE				0.84		90	Hz	54.18	60.12
2183	LI	DX	EF		RCO	CRE				2.49		90	Hz	46.98	67.34
2184	LI	DX	EF		SEA					2.65		49	Inclined	51.78	62.60
2185	LI	DX	EF		SEA					1.69		91	Hz	47.99	66.40
2186	LI	DX	EF		RCO	CRE				1.21		91	Hz	45.10	69.29
2187	LI	DX	EF		SEA					3.27		91	Hz	49.66	64.74
2188	LI	DX	EF		RCO	CRE				1.50		91	Hz	48.74	65.66
2189	LI	DX	EF		RCO	CRE				1.52		89	Hz	44.03	70.41
2190	LI	DX	EF		SEA					2.27		90	Hz	47.52	66.95
2191	LI	DX	EF		RCO	CRE				0.45		90	Hz	51.68	62.89
2192	LI	DX	EF		RCO	CRE				3.89		90	Hz	43.92	70.69
2193	LI	DX	EF		SEA					1.41		175	Vertical	50.68	64.00
2194	LI	DX	EF		SEA					3.92		70	Inclined	49.39	65.29
2195	LI	DX	EF		RCO	CRE				1.47		90	Hz	46.23	68.46
2196	LI	DX	EF		RCO	CRE				0.88		89	Hz	49.66	65.11
2197	LI	DX	EF		RCO	CRE				7.10		91	Hz	45.05	69.84
2198	LI	DX	EF		SEA					3.66		111	Inclined	51.28	63.63
2199	LI	DX	EF		RCO	CRE				0.51		92	Hz	52.92	62.05
2200	LI	US			RCO	CRE				0.81		93	Hz	54.03	60.95
2201	LI	DX	EF		SEA					1.91		89	Hz	47.75	67.25

2202	LI	DX	EF		SEA					1.95		89	Hz	47.15	67.89
2203	LI	DX	EF		RCO	CRE				0.66		94	Hz	45.76	69.28
2204	LI	DX	EF		SEA					1.83		169	Vertical	51.37	63.71
2205	LI	DX	EF		SEA					1.62		90	Hz	46.45	68.66
2206	LI	DX	EF		RCO	CRE				2.72		90	Hz	48.61	66.50
2207	LI	DX	EF		SEA					1.75		83	Hz	51.35	63.80
2208	LI	DX	EF		RCO	CRE				0.67		91	Hz	53.38	61.77
2209	LI	DX	EF		SEA					2.85		10	Vertical	47.85	67.38
2210	LI	DX	EF		SEA					1.85		90	Hz	48.27	66.97
2211	LI	DX	EF		SEA					5.81		52	Inclined	51.74	63.50
2212	LI	DX	EF		SEA					3.38		76	Hz	51.33	63.91
2213	LI	DX	EF		RCO	CRE				1.29		91	Hz	52.92	62.33
2214	LI	DX	EF		RCO	CRE				2.27		91	Hz	46.28	69.01
2215	LI	DX	EF		SEA					1.92		9	Vertical	51.31	64.00
2216	LI	DX	EF		RCO	CRE				1.11		91	Hz	44.10	71.25
2217	LI	DX	EF		RCO					5.26		169	Vertical	53.01	62.34
2218	LI	DX	EF		RCO	CRE				1.32		90	Hz	46.65	68.74
2219	LI	DX	EF		SEA					2.99		97	Hz	49.58	65.85
2220	LI	DX	EF		SEA					3.94		91	Hz	50.14	65.32
2221	LI	CO	VS		RCO	CRE				1.04		90	Hz	52.93	62.61
2222	LI	DX	EF		RCO	CRE				1.18		90	Hz	52.94	62.60
2223	LI	DX	EF		SEA					2.77		102	Hz	51.38	64.17
2224	LI	DX	EF		RCO					5.24		4	Vertical	52.03	63.61
2225	LI	DX	EF		SEA					3.61		94	Hz	50.91	64.76
2226	LI	DX	EF		RCO	CRE				0.93		88	Hz	51.96	63.72
2227	LI	DX	EF		RCO	CRE				5.92		91	Hz	48.91	66.78
2228	LI	DX	EF		SEA					1.66		168	Vertical	50.88	64.84
2229	LI	DX	EF		RCO	CRE				8.32		90	Hz	48.18	67.62
2230	LI	DX	EF		RCO	CRE				1.61		91	Hz	45.13	70.70
2231	LI	DX	EF		SEA					1.73		92	Hz	46.07	69.77
2232	LI	DX	EF		RCO	CRE				2.37		91	Hz	47.77	68.17
2233	LI	DX	EF		SEA					3.33		172	Vertical	51.99	64.02
2234	LI	DX	EF		SEA					2.71		69	Inclined	47.15	68.91
2235	LI	DX	EF		SEA					1.56		84	Hz	46.59	69.48
2236	LI	DX	EF		SEA					5.66		68	Inclined	52.12	63.96
2237	LI	DX	EF		SEA					3.19		90	Hz	50.86	65.30
2238	LI	DX	EF		SEA					1.70		107	Inclined	50.33	65.87
2239	LI	DX	EF		RCO	CRE				3.15		90	Hz	49.00	67.34
2240	LI	DX	EF		RCO	CRE				0.94		93	Hz	48.55	67.90
2241	LI	DX	EF		SEA					2.36		91	Hz	47.84	68.63
2242	LI	DX	EF		RCO					2.40		6	Vertical	50.36	66.13
2243	LI	DX	EF		RCO					4.82		156	Inclined	51.92	64.59
2244	LI	DX	EF		SEA					4.18		128	Inclined	47.08	69.47
2245	LI	DX	EF		SEA					1.60		3	Vertical	48.42	68.22
2246	LI	DX	EF		SEA					7.68		126	Inclined	50.21	66.43
2247	LI	DX	EF		RCO	CRE				0.93		86	Hz	52.65	64.00
2248	LI	DX	EF		SEA					1.72		9	Vertical	51.27	65.39
2249	LI	DX	EF		SEA					5.03		92	Hz	49.68	66.98
2250	LI	DX	EF		SEA					1.60		0	Vertical	50.04	66.65
2251	LI	DX	EF		RCO					2.06		163	Inclined	51.70	65.02
2252	LI	DX	EF		SEA					3.63		91	Hz	47.80	68.93
2253	LI	DX	EF		SEA					2.79		103	Hz	50.98	65.87
2254	LI	DX	EF		SEA					1.32		177	Vertical	50.09	66.81
2255	LI	DX	EF		SEA					1.89		54	Inclined	49.35	67.56
2256	LI	DX	EF		RCO	CRE				0.90		92	Hz	52.64	64.29
2257	LI	DX	EF		SEA					0.93		92	Hz	52.22	64.74
2258	LI	DX	EF		SEA					1.12		23	Inclined	51.61	65.35
2259	LI	DX	EF		RCO	CRE				1.57		93	Hz	53.26	63.71
2260	LI	DX	EF		RCO	CRE				2.76		90	Hz	49.12	67.90
2261	LI	DX	EF		RCO	CRE				3.02		89	Hz	48.38	68.74
2262	LI	DX	EF		RCO	CRE				1.37		91	Hz	47.30	69.85
2263	LI	DX	EF		SEA					3.36		101	Hz	49.21	68.06
2264	LI	DX	EF		RCO	CRE				2.14		90	Hz	46.57	70.69

2265	LI	DX	EF		RCO	CRE				0.98		94	Hz	50.53	66.78
2266	LI	DX	EF		SEA					2.47		71	Inclined	54.07	63.36
2267	LI	DX	EF		SEA					1.76		25	Inclined	49.88	67.62
2268	LI	DX	EF		SEA					1.03		3	Vertical	52.14	65.38
2269	LI	DX	EF		SEA					2.12		97	Hz	50.46	67.12
2270	LI	DX	EF		SEA					1.30		16	Inclined	50.81	66.81
2271	LI	DX	EF		SEA					3.32		95	Hz	54.01	63.62
2272	LI	DX	EF		SEA					0.89		117	Inclined	51.80	65.88
2273	LI	DX	EF		SEA					0.53		100	Hz	51.52	66.17
2274	LI	DX	EF		SEA					2.10		79	Hz	49.86	67.82
2275	LI	DX	EF		SEA					1.00		9	Vertical	51.20	66.56
2276	LI	DX	EF		SEA					1.66		87	Hz	52.37	65.40
2277	LI	DX	EF		SEA					3.02		114	Inclined	53.61	64.17
2278	LI	DX	EF		RCO	CRE				0.84		92	Hz	47.14	70.69
2279	LI	DX	EF		RCO	CRE				3.15		89	Hz	53.00	64.84
2280	LI	DX	EF		RCO	CRE				1.10		90	Hz	48.58	69.30
2281	LI	DX	EF		SEA					1.02		57	Inclined	51.47	66.41
2282	LI	DX	EF		SEA					2.90		88	Hz	49.84	68.10
2283	LI	DX	EF		SEA					0.54		75	Hz	51.85	66.16
2284	LI	DX	EF		SEA					1.83		177	Vertical	49.83	68.20
2285	LI	DX	EF		SEA					2.04		118	Inclined	50.48	67.56
2286	LI	DX	EF		SEA					2.25		97	Hz	51.08	66.96
2287	LI	DX	EF		SEA					2.48		13	Vertical	51.08	67.08
2288	LI	DX	EF		SEA					2.02		110	Inclined	52.28	65.87
2289	LI	DX	EF		SEA					1.79		90	Hz	49.85	68.35
2290	LI	DX	EF		SEA					1.29		15	Vertical	51.24	67.03
2291	LI	DX	EF		RCO	CRE				1.51		91	Hz	53.17	65.12
2292	LI	DX	EF		SEA					2.16		92	Hz	54.09	64.20
2293	LI	DX	EF		SEA					5.95		93	Hz	51.63	66.66
2294	LI	DX	EF		RCO	CRE				3.43		91	Hz	52.93	65.40
2295	LI	DX	EF		SEA					2.11		90	Hz	50.62	67.78
2296	LI	DX	EF		SEA					1.53		76	Hz	49.25	69.18
2297	LI	DX	EF		SEA					2.54		139	Inclined	52.42	66.02
2298	LI	DX	EF		SEA					1.82		64	Inclined	52.33	66.15
2299	LI	DX	EF		SEA					3.06		112	Inclined	53.79	64.74
2300	LI	DX	EF		RCO	CRE				2.08		90	Hz	48.69	69.86
2301	LI	DX	EF		RCO	CRE				0.87		93	Hz	47.87	70.69
2302	LI	DX	EF		SEA					1.75		8	Vertical	52.06	66.50
2303	LI	DX	EF		SEA					1.50		87	Hz	50.44	68.13
2304	LI	DX	EF		SEA					0.94		77	Hz	54.08	64.49
2305	LI	DX	EF		RCO	CRE				4.07		90	Hz	50.96	67.63
2306	LI	DX	EF		SEA					2.22		79	Hz	52.06	66.59
2307	LI	DX	EF		SEA					0.87		3	Vertical	52.13	66.55
2308	LI	DX	EF		SEA					0.77		85	Hz	52.26	66.42
2309	LI	DX	EF		SEA					3.28		15	Vertical	51.95	66.83
2310	LI	DX	EF		SEA					1.57		18	Inclined	50.09	68.76
2311	LI	DX	EF		SEA					1.55		86	Hz	51.35	67.55
2312	LI	DX	EF		RCO	CRE				1.72		90	Hz	53.57	65.40
2313	LI	DX	EF		SEA					2.10		122	Inclined	50.05	68.94
2314	LI	DX	EF		SEA					1.43		94	Hz	53.12	65.88
2315	LI	DX	EF		SEA					1.71		60	Inclined	52.32	66.73
2316	LI	DX	EF		SEA					1.40		147	Inclined	49.97	69.16
2317	LI	DX	EF		RCO	CRE				1.88		89	Hz	52.65	66.51
2318	LI	DX	EF		RCO	CRE				0.94		88	Hz	48.48	70.69
2319	LI	DX	EF		SEA					2.63		100	Hz	53.13	66.15
2320	LI	CR			RCO				0.0315	2.84		171	Vertical	48.51	70.83
2321	LI	DX	EF		SEA					3.35		95	Hz	51.33	68.07
2322	LI	DX	EF		RCO	CRE				2.11		90	Hz	52.34	67.07
2323	LI	DX	EF		SEA					2.70		31	Inclined	50.74	68.76
2324	LI	DX	EF		SEA					1.01		74	Inclined	50.54	68.96
2325	LI	DX	EF		SEA					1.15		158	Inclined	50.50	69.02
2326	LI	DX	EF		SEA					3.75		99	Hz	51.94	67.58
2327	LI	DX	EF		RCO	CRE				0.02		180	Vertical	54.18	65.39

2328	LI	DX	EF		SEA					1.05		4	Vertical	50.61	69.03
2329	LI	DX	EF		SEA					0.86		175	Vertical	51.31	68.34
2330	LI	DX	EF		RCO	CRE				1.29		91	Hz	52.34	67.35
2331	LI	DX	EF		SEA					2.94		53	Inclined	51.17	68.54
2332	LI	DX	EF		SEA					1.33		127	Inclined	50.46	69.27
2333	LI	DX	EF		RCO	CRE				3.55		90	Hz	49.09	70.70
2334	LI	DX	EF		SEA					1.65		176	Vertical	50.28	69.54
2335	LI	DX	EF		RCO	CRE				1.64		91	Hz	53.36	66.51
2336	LI	DX	EF		RCO	CRE				5.15		91	Hz	53.11	66.79
2337	LI	DX	EF		SEA					1.45		96	Hz	50.54	69.38
2338	LI	DX	EF		SEA					1.81		92	Hz	53.78	66.16
2339	LI	DX	EF		SEA					2.90		87	Hz	51.90	68.06
2340	LI	DX	EF		SEA					3.44		115	Inclined	51.30	68.68
2341	LI	CO	VS		RCO	CRE				0.78		89	Hz	48.72	71.26
2342	LI	CR			RCO				0.0315	2.43		173	Vertical	49.17	70.82
2343	LI	DX	EF		RCO	CRE				2.87		89	Hz	48.76	71.25
2344	LI	DX	EF		SEA					1.32		89	Hz	49.99	70.02
2345	LI	DX	EF		RCO	CRE				0.85		89	Hz	50.17	69.85
2346	LI	DX	EF		SEA					1.91		109	Inclined	53.62	66.45
2347	LI	DX	EF		SEA					2.12		33	Inclined	51.99	68.16
2348	LI	DX	EF		SEA					2.37		75	Hz	51.75	68.53
2349	LI	DX	EF		RCO	CRE				2.75		90	Hz	52.66	67.63
2350	LI	DX	EF		SEA					1.10		85	Hz	50.19	70.19
2351	LI	DX	EF		SEA					1.47		89	Hz	51.43	68.96
2352	LI	DX	EF		SEA					1.91		55	Inclined	51.93	68.49
2353	LI	DX	EF		SEA					3.87		150	Inclined	53.67	66.76
2354	LI	DX	EF		SEA					1.54		106	Inclined	54.10	66.42
2355	LI	DX	EF		SEA					1.50		91	Hz	51.92	68.61
2356	LI	DX	EF		RCO	CRE				1.66		87	Hz	49.85	70.70
2357	LI	CO	VS		RCO	CRE				0.88		92	Hz	49.33	71.27
2358	LI	DX	EF		RCO	CRE				2.22		91	Hz	49.37	71.25
2359	LI	DX	EF		SEA					1.93		90	Hz	51.95	68.68
2360	LI	DX	EF		SEA					1.77		89	Hz	53.28	67.36
2361	LI	DX	EF		SEA					1.88		171	Vertical	54.22	66.50
2362	LI	DX	EF		RCO	CRE				2.80		90	Hz	52.56	68.18
2363	LI	DX	EF		SEA					7.99		170	Vertical	51.30	69.48
2364	LI	US			RCO	CRE				1.74		90	Hz	49.83	70.99
2365	LI	CR			SEA				0.0315	2.28		90	Hz	51.95	68.89
2366	LI	DX	EF		SEA					1.32		172	Vertical	51.56	69.31
2367	LI	DX	EF		SEA					2.65		91	Hz	53.36	67.57
2368	LI	DX	EF		SEA					1.28		155	Inclined	50.81	70.14
2369	LI	DX	EF		SEA					1.77		89	Hz	51.98	68.99
2370	LI	DX	EF		SEA					6.27		91	Hz	53.94	67.04
2371	LI	DX	EF		SEA					4.76		103	Hz	53.75	67.26
2372	LI	DX	EF		RCO	CRE				1.42		89	Hz	52.58	68.47
2373	LI	DX	EF		SEA					1.28		29	Inclined	53.77	67.34
2374	LI	DX	EF		SEA					2.83		69	Inclined	53.33	67.81
2375	LI	DX	EF		RCO	CRE				2.20		90	Hz	49.95	71.25
2376	LI	DX	EF		RCO	CRE				0.92		91	Hz	50.53	70.71
2377	LI	DX	EF		RCO	CRE				2.34		90	Hz	51.44	69.86
2378	LI	DX	EF		RCO	CRE				2.79		172	Vertical	50.52	70.83
2379	LI	DX	EF		SEA					1.37		87	Hz	53.27	68.12
2380	LI	DX	EF		RCO	CRE				2.37		90	Hz	52.72	68.75
2381	LI	DX	EF		SEA					4.86		174	Vertical	51.86	69.64
2382	LI	DX	EF		SEA					0.90		83	Hz	51.92	69.64
2383	LI	DX	EF		SEA					1.29		174	Vertical	52.03	69.58
2384	LI	DX	EF		SEA					3.12		164	Inclined	53.36	68.38
2385	LI	DX	EF		SEA					2.54		174	Vertical	51.98	69.77
2386	LI	DX	EF		SEA					1.55		92	Hz	54.02	67.85
2387	LI	DX	EF		RCO	CRE				3.47		90	Hz	52.86	69.03
2388	LI	DX	EF		SEA					1.85		95	Hz	51.68	70.24
2389	LI	DX	EF		SEA					1.28		85	Hz	53.26	68.69
2390	LI	DX	EF		RCO	CRE				1.65		89	Hz	52.09	69.86

2391	LI	DX	EF		RCO	CRE				1.26		92	Hz	52.64	69.31
2392	LI	DX	EF		SEA					1.82		9	Vertical	52.04	70.10
2393	LI	DX	EF		SEA					0.88		95	Hz	52.60	69.60
2394	LI	DX	EF		SEA					2.60		92	Hz	53.60	68.68
2395	LI	DX	EF		SEA					0.60		90	Hz	53.50	68.80
2396	LI	DX	EF		SEA					1.54		89	Hz	52.14	70.19
2397	LI	DX	EF		SEA					2.09		106	Inclined	54.06	68.40
2398	LI	DX	EF		RCO	CRE				1.94		87	Hz	51.88	70.71
2399	LI	DX	EF		SEA					2.89		78	Hz	53.93	68.67
2400	LI	DX	EF		RCO	CRE				1.18		90	Hz	52.78	69.87
2401	LI	DX	EF		RCO	CRE				2.08		91	Hz	54.01	69.03
2402	LI	DX	EF		RCO	CRE				2.34		91	Hz	52.08	70.99
2403	LI	CR	EF		RCO				0.0315	6.02		166	Vertical	52.43	70.70
2404	LI	DX	EF		RCO	CRE				1.10		90	Hz	52.15	71.27
2405	LI	DX	EF		RCO	CRE				2.00		89	Hz	52.56	70.99
2406	LI	DX	EF		SEA					0.85		170	Vertical	53.94	69.62
2407	LI	DX	EF		SEA					3.07		118	Inclined	54.15	69.58
2408	LI	DX	EF		RCO	CRE				2.11		91	Hz	52.70	71.27
2409	LI	DX	EF		RCO	CRE				2.40		91	Hz	53.71	70.71



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69570 DARDILLY (FRANCE)
Tel : (+33) (0)4 78 33 80 00

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Visual inspection of the shell

Appendix 2 - Map of defects

Cylindrical unwrap R= 92.719 ft (28.261 m)

LEGEND

Type of defect	Abbreviation	Symbol
Family		
Crack	CR	
Corrosion	CO	
Seepage	SE	
Unsticking	US	
Miscellaneous	DX	
Secondary features :		
Efflorescence	EF	E
Seepage	SE	S
Rust trace	RT	T

Geometry of the defects:
- Points
- Lines
- Surfaces

Update			
Inspection number	Date	Sign	
		Execution	Control
0	20/04/2020		

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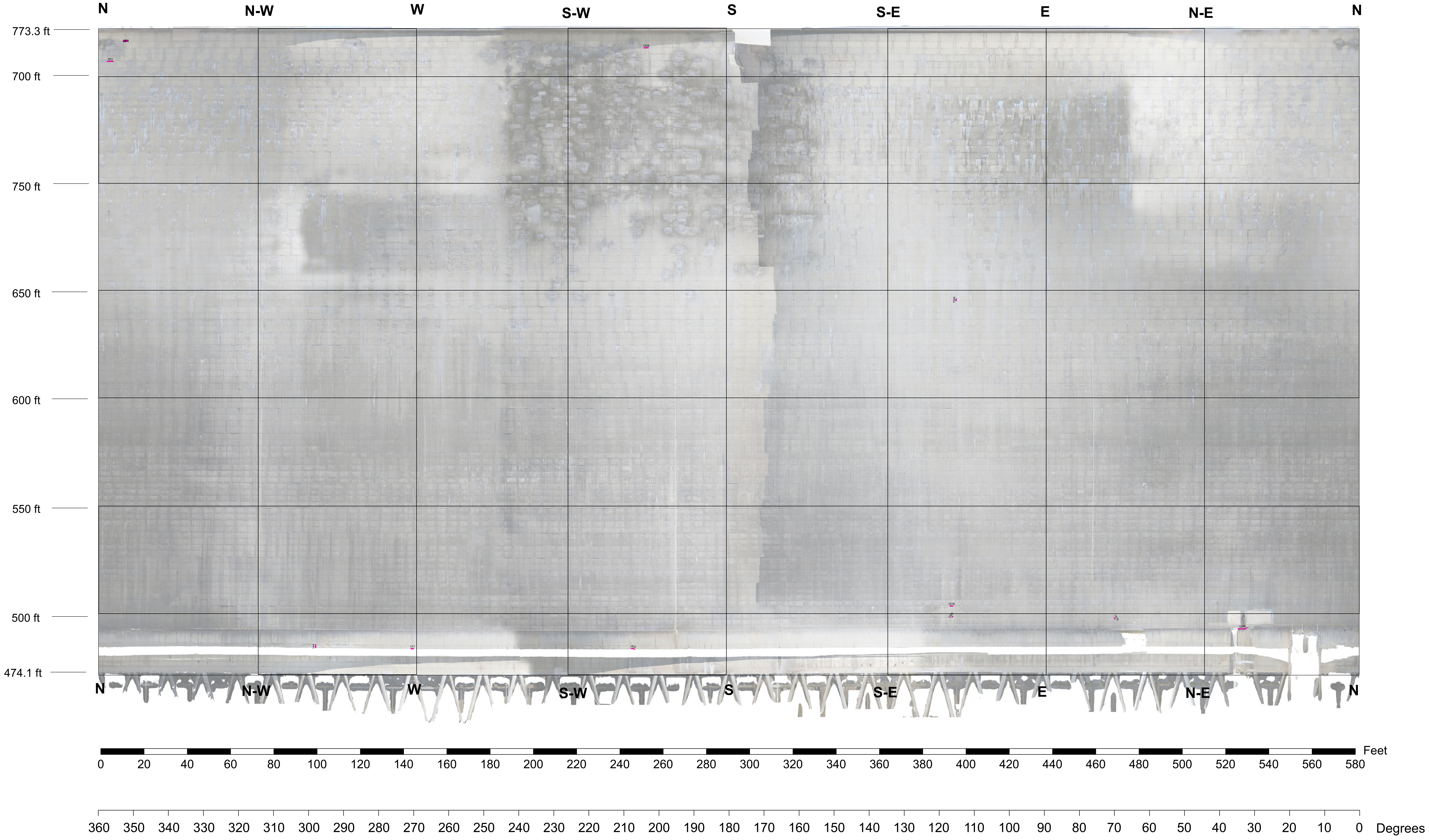

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Visual inspection of the shell

Appendix 3 - Map of defects with falling risks

Cylindrical unwrap R= 92.719 ft (28.261 m)

LEGEND

Type of defect	Abbreviation	Symbol
Family		
Crack	CR	green point / line / surface
Corrosion	CO	red point / line / surface
Seepage	SE	blue point / line / surface
Unsticking	US	purple point / line / surface
Miscellaneous	DX	yellow point / line / surface
Secondary features :		
Efflorescence	EF	E
Seepage	SE	S
Rust trace	RT	T

Geometry of the defects:
- Points
- Lines
- Surfaces

Update			
Inspection number	Date	Sign: Execution	Sign: Control
0	20/04/2020		

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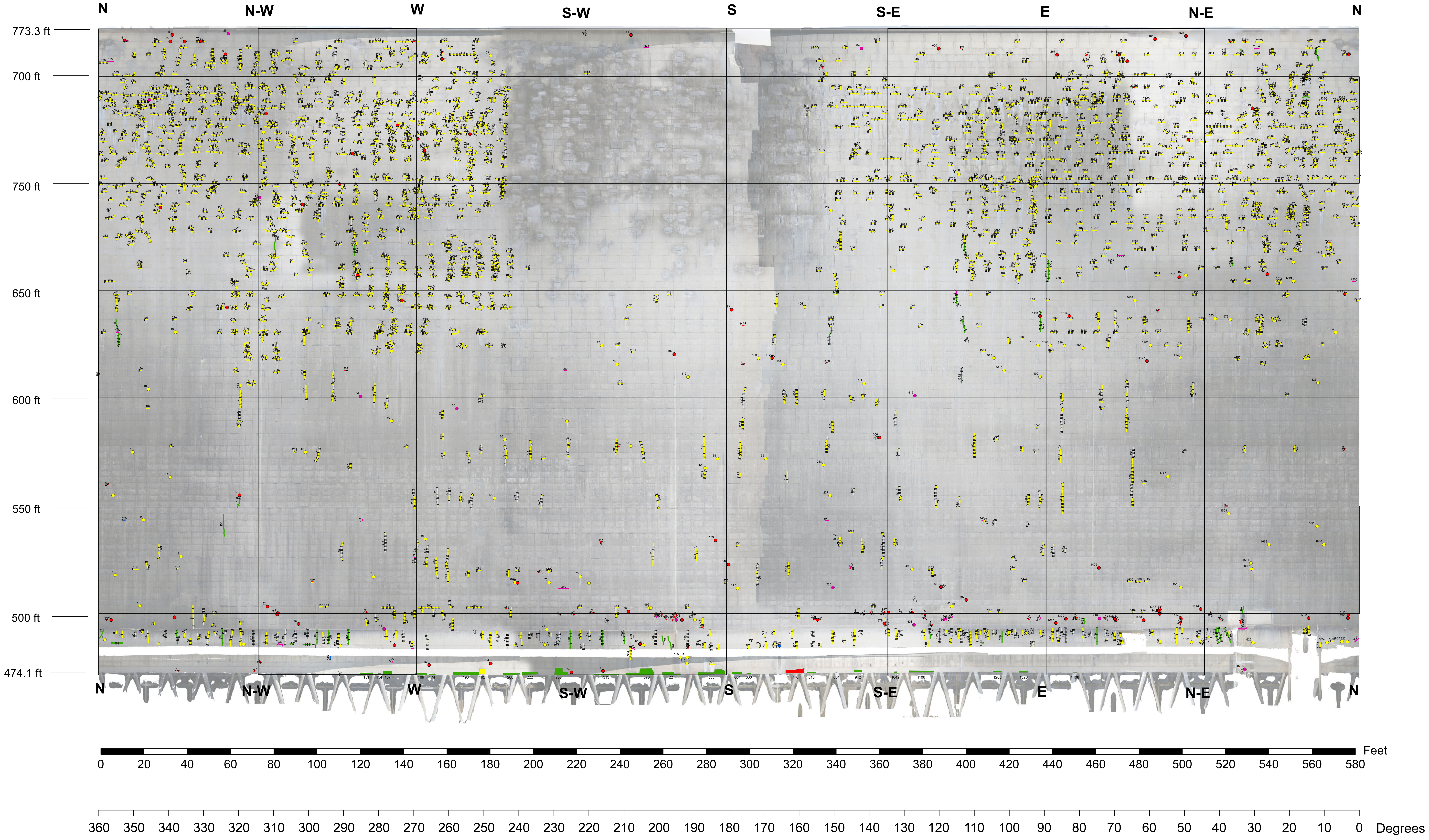
SCALE : 1:200



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Visual inspection of the shell
Appendix 4 - Map of defects overlaying the orthophotography
Cylindrical unwrap R= 92.719 ft (28.261 m)

LEGEND

Type of defect	Abbreviation	Symbol
Family		
Crack	CR	green point / line / surface
Corrosion	CO	red point / line / surface
Seepage	SE	blue point / line / surface
Unsticking	US	purple point / line / surface
Miscellaneous	DX	yellow point / line / surface
Secondary features :		
Efflorescence	EF	E
Seepage	SE	S
Rust trace	RT	T

Geometry of the defects:
Points
Lines
Surfaces

Update			
Inspection number	Date	Sign	
		Execution	Control
0	20/04/2020		

Report R 20 LY 1942

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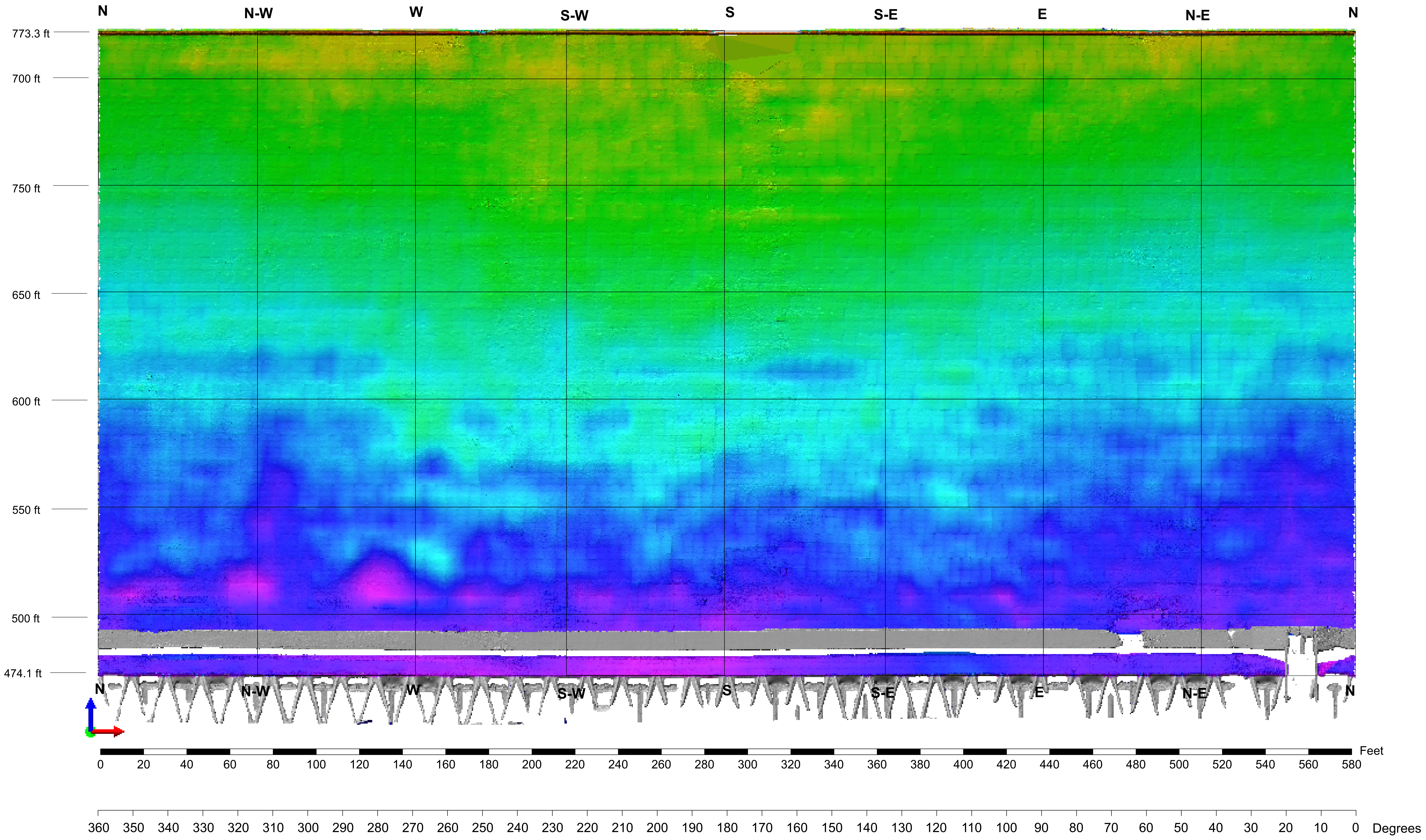

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Visual inspection of the shell

Appendix 5 - Map of distortions

Cylindrical unwrap R= 92.719 ft (28.261 m)

LEGEND

Type of defect	Abbreviation	Symbol
Family		
Crack	CR	
Corrosion	CO	
Seepage	SE	
Unsticking	US	
Miscellaneous	DX	
Secondary features :		
Efflorescence	EF	E
Seepage	SE	S
Rust trace	RT	T

Geometry of the defects:
- Points
- Lines
- Surfaces

Update

Inspection number	Date	Sign: Execution	Sign: Control
0	20/04/2020		

Geometry distortions scale (Meter / Feets)

Outside distortion

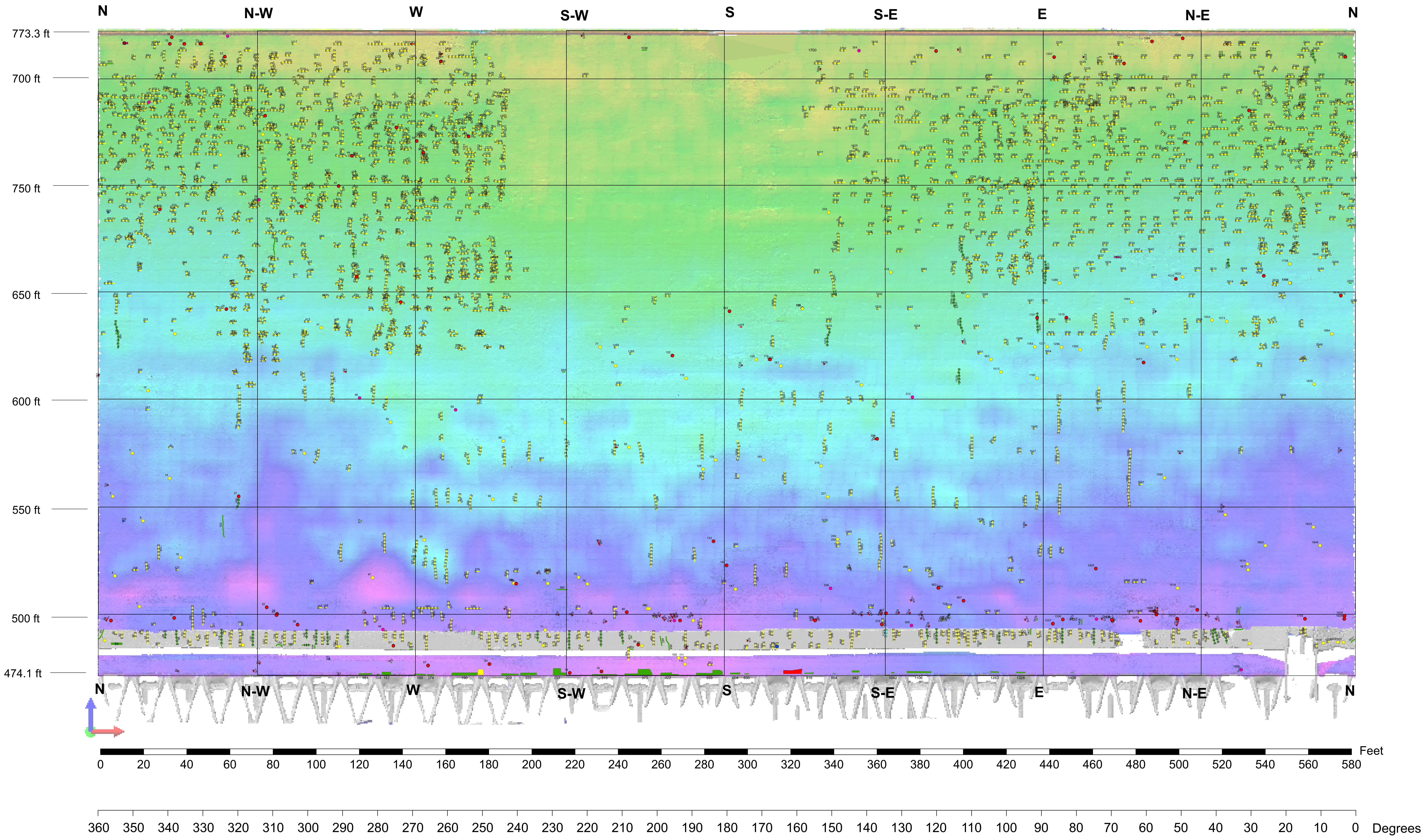
No distortion

Inside distortion

0.98, 0.90, 0.80, 0.70, 0.60, 0.50, 0.40, 0.30, 0.20, 0.10, 0.00, -0.10, -0.20, -0.30, -0.40, -0.50, -0.60, -0.70, -0.80, -0.90, -0.98

Report R 20 LY 1942

SCALE : 1:200



SITES SAS
5 route du Pérollier
69570 DARDILLY (FRANCE)
Tel : (+33) (0)4 78 33 80 00

Big Sandy

Visual inspection of the shell

Appendix 6 - Map of distortions

Cylindrical unwrap R= 92.719 ft (28.261 m)

LEGEND

Type of defect	Abbreviation	Symbol
Family		
Crack	CR	
Corrosion	CO	
Seepage	SE	
Unsticking	US	
Miscellaneous	DX	
Secondary features :		
Efflorescence	EF	E
Seepage	SE	S
Rust trace	RT	T

Geometry of the defects:
Points
Lines
Surfaces

Update			
Inspection number	Date	Sign	
		Execution	Control
0	20/04/2020		

Geometry distortions scale (Meter / Feets)

Outside distortion

0.98, 0.90, 0.80, 0.70, 0.60, 0.50, 0.40, 0.30, 0.20, 0.10, 0.00, -0.10, -0.20, -0.30, -0.40, -0.50, -0.60, -0.70, -0.80, -0.90, -0.98

No distortion

Inside distortion

Report R 20 LY 1942

SCALE : 1:200

DATA REQUEST

KPSC 1_2 Refer to the Wolffram Direct Testimony, page 6, lines 21–23.

a. If the Mitchell Cooling Tower Project (MCTP) is currently scheduled to be completed in 2029 and the new mechanical draft cooling tower is expected to go into service in the second quarter 2028, explain the extent to which Mitchell Unit 2 has been or will be derated in the interim with respect to Kentucky Power's PJM capacity obligation.

b. Explain how Kentucky Power plans to make up for any capacity deficit resulting from the reduced Mitchell Unit 2 capacity until the MCTP is operational.

c. If Kentucky Power is purchasing capacity as a result of the MCTP, provide details including the cost and terms of the capacity purchase.

RESPONSE

a.-c. The Company has not been required to derate Mitchell Unit 2 because of the structural issues with the Unit 2 cooling tower and does not anticipate a derate during the construction of the Mitchell Cooling Tower Project. The expected derate would not take place until the draft cooling tower goes into service. Given the timing and magnitude of the derate, the Company does not expect to have to make any capacity purchases.

Witness: Daniel W. Pizzino

Witness: Tanner S. Wolffram

DATA REQUEST

KPSC 1_3 Refer to the Wolffram Direct Testimony, page 14, lines 1–9.

a. Provide any correspondence or other document from the Department of Energy discussing the grant requested for Kentucky Power or informing Kentucky Power or American Electric Power that Kentucky Power would not receive the grant.

b. Identify the entities and projects that received such grant funds.

c. Explain Kentucky Power's understanding, if any, of why the Department of Energy did not award it a grant.

d. Explain whether there are other opportunities to fund the MCTP with grant funding.

RESPONSE

a. Please see KPCO_R_KPSC_1_3_Attachment1 for the requested information.

b. According to the U.S. Department of Energy, the entities that received grant funding for this program included: Appalachian Power Company, Buckeye Power Inc., Duke Energy Carolinas LLC, Kentucky Utilities Corporation, Monongahela Power Company, and Ohio Valley Electric Corporation.[1]

c. Please see the Company's response to subpart a.

d. It is the Company's understanding that there may be additional grant opportunities for coal-fired generation projects. However, at this point, the Company does not have any specific information about additional opportunities that are currently available. If the Mitchell Cooling Tower Project qualifies for additional grant opportunities in the future, the Company will pursue grants that will reduce rate impacts for customers.

Witness: Tanner S. Wolffram

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[1] U.S. Dep't Energy, *Energy Department Announces $175 Million to Modernize Coal Plants, Keeping Affordable Reliable Power Online for Americans* (Feb. 11, 2026), https://www.energy.gov/articles/energy-department-announces-175-million-modernize-coal-plants-keeping-affordable-reliable.

U.S. DEPARTMENT of ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY
Albany, OR • Morgantown, WV • Pittsburgh, PA

NATIONAL ENERGY TECHNOLOGY LABORATORY

February 12, 2026

SENT VIA ELECTRONIC MAIL

Wheeling Power Company
Scott Osterholt
1 Riverside Plaza
Columbus, OH 43215-2373
ssosterholt@aep.com

SUBJECT: Application No. 3605-1510 titled "Mitchell Mechanical Draft Cooling Tower Modernization Project"

Dear Mr. Osterholt:

Evaluation of your application received in response to Broad Agency Announcement (BAA) number DE-FOA-0003605 titled "Restoring Reliability: Coal Recommissioning and Modernization" has been completed in accordance with the process specified in the "Application Review Information" section of the Broad Agency Announcement.

We regret to inform you that based on this evaluation, your application has not been selected for award. The enclosed document provides a copy of your application's strengths and weaknesses. This information is provided to you as important feedback on the quality of your application and will hopefully be valuable to you in the preparation of future applications. This letter and the enclosed attachment constitute your sole debriefing for this BAA.

On behalf of the Department, I would like to express a sincere appreciation for your interest and participation in this program and solicit your participation in future programs. If you have any questions, please contact Ryan Simmons at ccrm-baa@hq.doe.gov.

Sincerely,

DAVID STAUDT Digitally signed by DAVID STAUDT Date: 2026.02.12 07:44:09 -05'00'

David Staudt
Contracting Officer
Finance and Acquisition Center

Enclosure

cc: BAA File

RECORD OF FEDERAL CONSENSUS STRENGTHS AND WEAKNESSES

Applicant: Wheeling Power Company
Application #:3605-1510

BAA Number/Title: DE-FOA-0003605/Restoring Reliability: Coal Recommissioning and Modernization

Project Title: Mitchell Mechanical Draft Cooling Tower

Description	Consensus Rating
MRC 1: Technical Approach and Impact - 30% • **Project Objectives and Relevance:** Degree to which the project supports Broad Agency Announcement (BAA) objectives by commissioning, recommissioning, modernizing, or upgrading coal-fired generation assets to provide reliable, affordable and secure power. • **Grid Impact:** Extent to which the proposed work addresses regional reliability needs, reduces outage risk, and provides measurable value to the bulk power system. • **Technical Design and Scope:** Quality and clarity of proposed upgrades, retrofits, or system modifications, including demonstration of site control and interconnection feasibility where applicable. • **Project Timeline:** Likelihood that the project can achieve operational milestones within the proposed schedule. • **Environmental Considerations:** Adequacy of environmental compliance planning and discussion of emissions and fuel impacts consistent with statutory authorities. • **Technical Risks and Mitigation:** Strength of risk assessment (engineering, construction, fuel supply, interconnection, regulatory) and credibility of proposed mitigation strategies.	
Strengths **Project Objectives and Relevance** The project is a modernization effort focused on replacing an aging natural draft cooling tower with a modern mechanical draft cooling tower, which is intended to extend the service life of the tower and prevent loss of reliability or capacity. The strategy for demolition and construction to bring the new tower online is well described and is adequately justified as an upgrade over the current unit.	

Project Timeline

The timeline is presented in four phases with a high-level description of work to be completed. The schedule is reasonable and presented in a logical sequence of events with appropriate durations.

Weaknesses

Environmental Considerations

Insufficient information was provided regarding environmental considerations. The Construction Strategy document discussed several "possible required permits" with requirements that are yet to be determined for permits such as the Floodplain Permit and Air Permit, however no further clarity was provided.

Technical Risks and Mitigation

The Applicant's risk assessment is overly broad and could apply to any construction project, and did not consider risks specific to the technical scope of the proposed award.

Description	Consensus Rating
MRC 2: Financial and Market Viability - 30% • **Cost Share and Financing:** Availability and credibility of non-federal cost share, financing commitments, and contingency planning. • **Techno-Economic Analysis (TEA):** Adequacy of cost estimates and economic rationale for constructing, commissioning, recommissioning, or retrofitting versus alternatives. • **Market Competitiveness:** Degree to which the project demonstrates long-term viability, including potential revenue from capacity, energy, or ancillary services. • **Financial Commitment:** Strength of commitments from the applicant and partners to cover total project costs. • **Offtake or Load Agreements:** Evidence of strong offtake arrangements, letters of intent from critical loads, or contracts that support project economics. • **Impact of DOE Funding:** Degree to which DOE support is necessary to advance the project and de-risk private investment.	
Strengths	

Cost Share and Financing

The Applicant has a reliable source of cost share with strong letters of commitment from Wheeling Power Company and Kentucky Power Company, subsidiaries of American Electric Power, which will provide 67.8% cost share through a combination of debt and equity financing, recovered from customers through their electric service rates. Most individual milestones and phases of the project are intended to utilize fairly equal shares of federal and cost share dollars, with the notable exception of major equipment and materials procurement being done purely with cost share.

Market Competitiveness

Federal funding for this project would provide approximately a third less rise in revenue required for the upgrade. This would result in customer prices increasing less than if the project were solely privately funded. Other scenarios without this upgrade could also result in a drop in plant capacity, which would have a more profound impact on customers.

Weaknesses

Techno-Economic Analysis (TEA)

The TEA lacked sufficient detail to determine how the present value revenue requirements (PV RR) were calculated for the four options considered for addressing the aging cooling tower. Specifically, while Option 3 was well-defined, the other three options were not adequately described. The project costs are high-level without a clearly defined basis.

Impact of DOE Funding

Preliminary engineering activities are currently underway, which suggests that this work could proceed without federal funding, potentially reducing the impact or necessity of DOE support.

Description	Consensus Rating
MRC 3: Management and Organization - 25% • **Team Qualifications:** Experience of the applicant and key partners in coal plant operations, EPC, Original Equipment Manufacturer (OEM) integration, and grid interconnection. • **Management Structure:** Clarity of governance, roles, and	

responsibilities across team members. • **Past Performance:** Demonstrated ability to execute large-scale energy projects safely, on time, and within budget. • **Workforce Plan:** Inclusion of retraining or local hiring strategies, with attention to maintaining critical skills in coal-reliant communities. • **Stakeholder Coordination:** Evidence of engagement with ISOs/RTOs, regulators, utilities, and community stakeholders.	
Strengths **Team Qualifications** The proposed team members are sufficiently qualified, possessing experience across all sectors of the plant, including engineering, construction, project management, budget, federal compliance, staffing, inventory management, and maintenance. Key personnel have significant experience with coal-fired power plants, and their resumes provide sufficient evidence of their qualifications and experience. **Management Structure** The project team is clearly organized, with well-defined roles and responsibilities for both the organization and individual team members. **Past Performance** The Applicant has a demonstrated ability to execute large-scale energy projects safely, on time, and within budget. The Applicant provides descriptions of two successful projects of similar scale within the last 5 years.	
Weaknesses **Workforce Plan** The proposal provided minimal details on the local hiring plan and did not include a workforce plan or a detailed discussion regarding workforce impacts.	

Description	Consensus Rating
MRC 4: Workplan and Execution - 15% • **Project Schedule:** Reasonableness of milestones and critical path to commissioning, recommissioning or retrofit completion.	

• **Milestone Definition:** Clarity of performance metrics tied to DOE funding tranches. • **Deliverables:** Quality and measurability of proposed technical and financial deliverables, including grid reliability improvements. • **Execution Risk:** Adequacy of discussion on permitting, supply chain, EPC contracting, and operational risks, and credibility of mitigation strategies.	
Strengths **Project Schedule** The Financing document includes a milestones table with a clear timeline and costs associated with each milestone. Milestones logically represent critical points in the overall process.	
Weaknesses **Execution Risk** The risk mitigation strategies for permitting, supply chain, EPC contracting, and operational risks are not sufficiently detailed. For example, the mitigation strategy for permitting risks in Table 4 is to "Implement a detailed project schedule with phase-specific contingency," which lacks adequate specificity.	

DATA REQUEST

KPSC 1_4 Refer to the Wolffram Direct Testimony, page 13, lines 8–9. Refer also to the Wolffram Direct Testimony, page 15, lines 1–9.

a. Explain why there is a need to defer incremental operation and maintenance (O&M) expense for the proposed project if Kentucky Power does not anticipate there being any incremental increase O&M expense, including whether Kentucky Power anticipates an incremental decrease in O&M expense.

b. Identify the expected incremental O&M expense for Options 1, 3 and 4 in Table NMC-1.

c. Explain any differences in the incremental O&M expense for Options 1, 3, and 4 in Table NMC-1.

RESPONSE

a. The referenced testimony on page 15, lines 1-9, was meant to cover any O&M related to construction of the project, such as the engineering work necessary to construct the new cooling tower and the Worley feasibility report included as part of this filing. However, as stated on page 13, lines 8-9, the Company does not anticipate an incremental ongoing O&M expense (as compared to the O&M for the current cooling tower) related to the operation of the new cooling tower after it is placed in service.

b. and c. There is no incremental O&M expense (as compared to the O&M for the current cooling tower) included for Options 1, 3, and 4.

Witness: Tanner S. Wolffram

Witness: Nicole M. Coon

DATA REQUEST

KPSC 1_5 Refer to the Wolffram Direct Testimony, Public Exhibit TSW-1, page 12 indicating "Initial Capital" for Option 1, 3, and 4. Refer also to the Direct Testimony of Nicole M. Coon (Coon Direct Testimony), Exhibit NMC-1, indicating "Total Capital" for Option 1, 3, and 4. Refer also to the Malone Direct Testimony, Exhibit SPM-2.

a. Provide an itemized breakdown of the "Initial Capital" in Exhibit TSW-1 and the "Total Capital" in Exhibit NMC-1 for each option by year and category of cost in Excel spreadsheet format with all formulas, columns, and rows unprotected and fully accessible.

b. Explain how each item in each itemized breakdown was estimated for Option 1 and 4, and provide any documents relied on to support such estimates, including any correspondence with vendors regarding expected cost.

c. Explain the differences in the costs for each option reflected as "Initial Capital" in Exhibit TSW-1; and "Total Capital" in Exhibit NMC-1;

d. Explain the differences between the costs of Option 3 reflected in Exhibit TSW-1 and Exhibit NMC-1; and costs reflected in Exhibit SPM-2.

RESPONSE

a. It is unclear what is meant by the phrase "cost category" but please see KPCO_R_KPSC_1_5_Attachment1.

b. For Option 1, the cost estimate was prepared by extrapolating International Chimney Corporation Commonwealth's (a contractor utilized by the Company) actual repair rate (both duration and cost) realized on the project to date over the remaining anticipated tower repairs. For Option 4, the cost estimate was developed in direct coordination with International Chimney Corporation Commonwealth, as this is their area of expertise and they were physically present on the tower to understand the complexity of, and structural challenges associated with the tower's existing conditions. The Company is diligently working to compile the requested correspondence and has filed a Motion for Extension of Time to file its response by no later than April 10, 2026.

c. and d. The “Initial Capital” column in Exhibit TSW-1 shows initial capital, which included capital invested before an option was deemed to be in-service. Exhibit NMC-1 shows total capital, which included capital for partial demolition and full demolition, if it occurred after the in-service date of the option. Exhibit TSW-1 and Exhibit NMC-1 used costs estimates available in October 2025 when the economic analysis used to support leadership’s decision on options was performed. Exhibit SPM-2 used more current cost estimates and removed AFUDC from the project cost as well. Please see KPCO_R_KPSC_1_5_Attachment2 for a reconciliation of the numbers.

Witness: Shawn P. Malone

Witness: Tanner S. Wolffram

Witness: Nicole M. Coon

DATA REQUEST

KPSC 1_6 Refer to the Direct Testimony of Shawn P. Malone (Malone Direct Testimony), page, 11 lines 5–6. Explain the extent to which local labor will be employed during the construction project.

RESPONSE

During the contracting and execution phases of the Mitchell Cooling Tower Project, the Company will work with its contractors and the applicable National Labor Agreement bargaining units to identify and prioritize the use of available local union labor, consistent with contractor qualifications, safety requirements, and project needs. The Company's procurement and labor practices are structured to support the engagement of a local workforce where it is feasible while ensuring work is performed in accordance with applicable labor agreements, safety standards, and regulatory requirements.

Witness: Shawn P. Malone

DATA REQUEST

KPSC 1_7 Refer to the Coon Direct Testimony, page 5, lines 6–8, and page 9, lines 10–13 and Exhibit MNC-1.

a. Explain how the estimated energy margins were calculated for Options 1–4.

b. Provide an update to the analysis using the approved rates and weighted average cost of capital (WACC) for Kentucky Power from Case No. 2025-00257. If Wheeling Power has an updated WACC or any other data from that used in the application analyses, identify the updated data and include Wheeling Power's updated data in the updated analyses. Also include the additional commitment of Mitchell Unit 2 in the PJM planning cycle year 2027/2028 referenced in Coon Direct Testimony page 6, footnote 2.

RESPONSE

a. Estimated energy margins are the result of the forecasted LMPs less the forecasted dispatch costs. Dispatch costs are a product of an hourly production cost dispatch model.

b. Please see KPCO_R_KPSC_1_7_Attachment1 for an updated Exhibit NMC-1 using the updated WACCs and gross revenue conversion factors for both Kentucky Power and Wheeling Power. Please also see the supporting workpapers provided as KPCO_R_KPSC_1_7_ConfidentialAttachment2 through KPCO_R_KPSC_1_7_ConfidentialAttachment5.

Witness: Nicole M. Coon

DATA REQUEST

KPSC 1_8 Refer to the Coon Direct Testimony, page 5, lines 20–22. Provide a comparison between Kentucky Power's capital structure and Wheeling Power's capital structure and the average capital structure used in the various analyses. Include in the response the date upon which Wheeling Power's capital structure was approved and the proceeding in which it was approved.

RESPONSE

The two capital structures are included in the cost-of-service workpapers. Please see KPCO_R_KPSC_1_10_ConfidentialAttachment4 on the "Cap Structure" tab. The averages utilized can be found on the "Input" tab in the "Other Inputs Used" section.

The capital structure used for Wheeling Power was Wheeling Power's actual capital structure as of September 30, 2024. This was the capital structure used in Wheeling Power's Case No. 25-0626-E-PC filed with the West Virginia PSC on July 15, 2025.

Witness: Nicole M. Coon

DATA REQUEST

KPSC 1_9 Refer to the Coon Direct Testimony, page 6, lines 15–18. Explain how lost energy margins were calculated. Include the assumptions regarding generation, if any, that were made in order to calculate the lost energy margins.

RESPONSE

First, a net energy margin per installed megawatt was calculated. Next, the associated MW derate was multiplied by net energy margin per installed MW to determine the estimated net energy margin lost. The calculations can be found within KPCO_R_KPSC_1_10_ConfidentialAttachment4 and ConfidentialAttachment5, as those are the two options that contain derates.

Witness: Nicole M. Coon

DATA REQUEST

KPSC 1_10 Refer to the Coon Direct Testimony, page 9, lines 10–13 and Exhibit MNC- 1. Provide the supporting workpapers for Exhibit MNC-1 in Excel format with all formulas and cells intact, visible, and unprotected.

RESPONSE

The Company interprets Exhibit MNC-1 referenced in the question to be Exhibit NMC-1. Please see KPCO_R_KPSC_1_10_Attachment1, which is Exhibit NMC-1. Also see KPCO_R_KPSC _1_10_ConfidentialAttachments 2 through 5 for the cost-of-service workpapers that support the revenue requirements in Exhibit NMC-1.

Witness: Nicole M. Coon

DATA REQUEST

KPSC 1_11 Refer to the Coon Direct Testimony, page 10, lines 9–18, page 11, lines 1–7 and Exhibit NMC-2.

a. Provide Exhibit NMC-2 in Excel spreadsheet format with all formulas, columns, and rows unprotected and fully accessible.

b. Explain how the coincident peak (CP) referenced in Column (4) on the tables listed in Exhibit MNC-2 pages 1–4 is calculated.

c. Provide the bill impacts for the average residential customer using 1206 kWh per month and for the summer and winter peaks (using the most recent actual seasonal peaks) for 2026-2029, based upon the Commission approved rates from Case No. 2025-00257.

d. If not provided in subpart c. above, provide an update to Exhibit NMC-2, in Excel spreadsheet format with all formulas, columns, and rows unprotected and fully accessible, based upon the Commission approved rates from Case No. 2025-00257. If Wheeling Power has an updated WACC or any other data from that used in the application analyses, state and include Wheeling Power's updated data in the updated analyses. Also include the additional commitment of Mitchell Unit 2 in the PJM planning cycle year 2027/2028 referenced in Coon Direct Testimony page 6, footnote 2.

RESPONSE

a. Please see KPCO_R_KPSC_1_11_Attachment1 (Exhibit NMC-2) and KPCO_R_KPS_1_11_Attachment2 (cost-of-service supporting workpaper).

b. These percentages were calculated in the Company's most recent base case (Case No. 2025-00257). They are calculated by dividing the average 12 CP during the test year for the class by the metered kWh.

c. Please see KPCO_R_KPSC_1_11_Attachment1 (Exhibit NMC-2). The bill impact is the same in any month that a customer uses 1,206 kwh.

d. Please see KPCO_R_KPSC_1_11_Attachment3 (Updated Exhibit NMC-2) and KPCO_R_KPSC_1_11_Attachment4 (updated cost-of-service workpaper). Exhibit NMC-2 is not impacted by Wheeling Power’s updated WACC nor the additional commitment of Mitchell Unit 2 in the PJM planning cycle year 2027/2028.

Witness: Nicole M. Coon

DATA REQUEST

KPSC 1_12 Refer to the Malone Direct Testimony, page 5, Table SPM-1 and Exhibit SPM-1, Appendix B, page 1.

a. Explain the difference in the project costs between Exhibit SPM-1, Appendix B, page 1 and the cost estimate in Table SPM-1, option 3.

b. Provide all cost components for each option in Excel spreadsheet format with all formulas, columns, and rows unprotected and fully accessible.

RESPONSE

a. Exhibit SPM-1, Appendix B, page 1, is the estimate prepared by Worley on the Company's behalf and serves as the basis for the Option 3 estimate in Table SPM-1. The $162 million shown as the cost of Option 3 in Table SPM-1 is derived from the Worley estimate and additionally incorporates the Company Contingency, Construction Contingency, and Company Indirect costs.

b. Please see KPCO_R_KPSC_1_12_ConfidentialAttachment1.

Witness: Shawn P. Malone

KPCO_R_KPSC_1_12_ConfidentialAttachment1 is redacted in its entirety.

DATA REQUEST

KPSC 1_13 Refer to the Malone Direct Testimony, page 3, line 14. Explain whether Kentucky Power plans to use One-sided or Two-sided Mechanical Cooling Towers.

RESPONSE

The Company is not familiar with the description of One-sided or Two-sided Mechanical Cooling Towers. The proposed mechanical draft cooling towers will be single cell cross flow cooling towers.

Witness: Daniel W. Pizzino

DATA REQUEST

KPSC 1_14 Refer to the Malone Direct Testimony generally and refer to the Direct Testimony of Daniel W. Pizzino (Pizzino Direct Testimony) generally. Refer also to the Pizzino Direct Testimony, page 5, line 7, stating that Kentucky Power's plant personnel first observed the structural anomalies in April 2016.

a. State whether Kentucky Power completed any of the testing listed in subparts (1) and (2) below for the cooling towers on each of Mitchell Unit 1 and Unit 2, and if so, provide the results of any such testing. If not, explain whether such tests or similar tests were not considered to obtain additional information regarding the integrity of the cooling towers.

(1) Non-Destructive Testing (NDT), including Ground Penetrating Radar (GPR), Pachometer, and Ultrasonic Pulse Velocity (UPV) mapping.

(2) Chemical and Petrographic Analysis regarding carbonation and chloride penetration.

b. Identify all tests and inspections conducted on the cooling towers on each of Mitchell Unit 1 and Unit 2 and provide and explain the results of any such tests or inspections.

RESPONSE

a. (1) Kentucky Power has performed Half-Cell Potential Corrosion tests to determine corrosion potential in areas where corrosion was not observed on the surface, and Ground Penetrating Radar at the Mitchell Unit 2 cooling tower. Ground Penetrating Radar was utilized instead of Pachometer testing during the Half-Cell testing to locate rebars. No other Non-Destructive Testing was performed.

(2) Petrographic analysis and subsequent chloride-content testing was performed on cores taken from the Mitchell Unit 2 cooling tower. These tests were not performed on the Mitchell Unit 1 cooling tower because prior inspections did not identify reasons to do so.

Refer to KPCO_R_KPSC_1_14_Attachment1 for the Hyperbolic Cooling Tower Evaluation and Monitoring report for the results of the Non-Destructive and Destructive Testing performed on the Mitchell Unit 2 cooling tower.

b. Please refer to the Company's response to KPCO_R_KPSC_1_1 for a list of inspections conducted on the Mitchell Unit 1 cooling tower shell, as well as the reports containing the results.

In addition to the tests described in subpart a, the following inspections have been conducted for the Mitchell Unit 2 cooling tower shell:

i. 2016 Shell Inspection
ii. 2016 Lidar Scan Inspection
iii. 2016 Drone Inspection
iv. 2017 Lidar Scan Inspection
v. 2018 Lidar Scan Inspection
vi. 2019 Drone Inspection
vii. 2020 Lidar Scan Inspection
viii. 2021 Lider Scan Inspection
ix. 2022 Lider Scan Inspection
x. 2023 Lidar Scan Inspection
xi. 2024 Lidar Scan Inspection

Refer to KPCO_R_KPSC_1_14_Attachment2 for the reports associated with the inspections conducted on the Mitchell Unit 2 cooling tower shell.

Witness: Daniel W. Pizzino

WALTER P MOORE

August 17, 2018

Mr. Doug Polack
Structural Engineering Section
American Electric Power
1 Riverside Plaza
Columbus, OH 43215

**RE: Unit 2 Hyperbolic Cooling Tower Evaluation and Monitoring
Mitchell Power Plant, Moundsville, WV
Walter P Moore Project No. D03.16093.01**

Dear Doug:

Walter P Moore has completed a field investigation of the Unit 2 cooling tower in general accordance with Walter P Moore proposal 17-0011 rev 2, dated January 24, 2018. This letter summarizes the results of the field investigation portion of the scope of services described in the mentioned proposal letter.

Scope

The field investigation was divided into three components. The scope of each component is detailed below. This report describes the results of each component of the evaluation.

1. Visual Observations: Perform two on-site visits to perform a visual review at selected locations at the northwest and southeast of the cooling tower that are readily accessible from the hot deck level and by aerial access.
2. Non-destructive Testing: Coordinate half-cell potential corrosion testing, select testing locations, and review the test results.
3. Destructive Testing: Develop a concrete materials extraction and testing protocol, including selecting locations for core extraction, and review the test results.

Visual Observations

Representatives of Walter P Moore visited the plant on April 3 through April 5, 2018 to coordinate the testing locations at the northwest of the cooling tower and to perform a limited visual review of the tower from the hot deck level. Walter P Moore representatives made another site visit on April 20, 2018 to coordinate the testing locations at the southeast of the tower and to perform a visual review of the areas that were readily accessible by the aerial access at the southeast of the tower (Photos 1 and 2 in Appendix A).

The following distress conditions were observed at the reviewed areas of the cooling tower. Refer to Appendix A for representative photos.

1. Visually perceptible inward (dimple) and outward (bulge) displacements within the concrete veil (Photo 3) with respect to the undeformed shape;

2. Localized concrete cracking (Photos 4 to 6) with cracks as wide as 1/16 inch;
3. Isolated, minor concrete spalling and areas on unconsolidated concrete (Photos 7 and 8); and
4. Staining, efflorescence, and biological growth typically observed at construction joints (Photos 9 and 10), suggesting active water passage through the joints.

These visual observations were considered to choose the concrete testing locations as described in the following sections.

Non-destructive Testing

Walter P Moore selected six locations to perform half-cell potential corrosion tests to determine corrosion potential in areas where corrosion was not observed on the surface at readily-accessible locations with a suspended basket. The half-cell potential test locations were located on the northwest and southeast outside faces of the cooling-tower veil and are shown in Exhibits EX1 to EX4 of Appendix B. These locations were strategically chosen at areas with visible cracking and efflorescence where corrosion may be expected. The tests were performed by Radarview between April 3, 2018 to April 5, 2018 and between April 25, 2018 to April 28, 2018. The report of the test results is attached as Appendix C. The test results indicate that there is a 90% probability that no corrosion activity is present in the reinforcement inside the concrete at most of the locations tested. At a few locations within the areas tested, the test results cannot determine if there is presence or absence of corrosion activity in the reinforcement inside the concrete.

Destructive Testing

Walter P Moore selected seven locations to excise concrete cores for testing at readily-accessible locations with a suspended basket. The cores were located on the northwest and southeast outside faces of the cooling-tower veil and are shown in Exhibits EX1 and EX5 to EX7 of Appendix B. A contractor hired by American Electric Power (AEP) excised the cores and were sent to a laboratory for testing. Three cores were tested for compressive strength. These cores were taken from the thicker part of the concrete veil to meet the height-to-diameter ratio requirements for testing. A petrographic analysis and subsequent chloride-content testing was performed on four cores. The cores for petrographic analysis were taken at locations with either visible cracking on the veil surface or at construction joints with efflorescence. The report by Radarview of the test results is attached as Appendix D. A summary of the test results follows.

Compressive Strength

The compressive strength of three cores ranged from approximately 4,300 to 8,500 psi. The specified concrete strength at 28 days of the veil is 3,000 psi. The measured compressive strength of the three cores exceeded the specified concrete strength.

Chloride Content

The chloride content by weight of concrete measured in the three one-inch-deep depth increments from the exterior face of the four cores ranged from 20 to 60 ppm, which corresponds approximately to 0.01 to 0.04% of the weight of cement for a typical concrete mix (assuming 600 pounds of cement per cubic yard of concrete and a concrete unit weight equal to 3,900 pcy).

According to the American Concrete Institute Committee 318 (ACI 318): Building Code Requirements for Structural Concrete, the recommended maximum chloride content by weight of cement to minimize the risk of corrosion caused by chlorides in the concrete is 0.15% for reinforced concrete structures exposed to moisture and external sources of chlorides. The measured content of chloride in the four cores are below the threshold value to minimize corrosion risk caused by chlorides in concrete.

Petrographic Analysis

The most relevant finding from the petrographic analysis of the cores is that there is evidence of exterior sulfate attack on the interior surfaces of the cores; most of the air voids are filled with ettringite, the interior surface has exposed coarse aggregates, and the interior surface paste is light-beige colored and is soft and friable. AEP provided water chemistry tests performed by Nalco Water and dated May 16, 2018 that indicate the sulfate level in the cooling tower water of Unit 2 is in the order of approximately 630 ppm. According to ACI 318 this sulfate concentration would correspond to a moderate sulfate exposure (comparable to seawater exposure). Even though there is evidence of sulfate attack, the zone visibly affected by sulfate attack appears to be superficial (Figures 1, 6, 9, and 13 of Appendix D), especially considering the cooling tower has been in service approximately 50 years.

The specified veil thickness is 5.5 inches at the core locations. The measured length (along wall thickness direction) of the four cores ranged from 5.2 to 5.8 inches, and it is approximately within the allowable construction tolerance (+3/8 inches and -1/4 inches) according to American Concrete Institute Committee 117: Specifications for Tolerances for Construction and Materials and Commentary.

Summary and Conclusion

A field investigation, focused mainly on visual observations and concrete material testing, was conducted to help in the on-going investigation of the Unit#2 cooling tower to determine the causes of the current distorted veil shape. The testing included six half-cell potential tests to identify the probability of the presence of corrosion activity of the reinforcement inside the concrete, three concrete compressive strength tests, and concrete chloride content tests and petrographic analysis of four cores. The testing locations were strategically chosen at the areas with visible distress conditions based on a limited visual review of the concrete veil. Based on the test results the following is concluded:

1. No corrosion activity is currently on-going in the concrete veil.
2. Concrete compressive strength of the veil is larger than the minimum specified compressive strength by factor that ranges from 1.4 to 2.8.
3. The chloride content of the concrete veil is below the threshold value to produce corrosion caused by chlorides in concrete.
4. Evidence of sulfate attack on the interior face of the veil was identified. However, the extent of the sulfate attack appears to be superficial and currently does not represent a structural concern.

The results from the field investigation indicate that the current distorted shape of the cooling tower veil is not likely related to concrete material properties or current state of the concrete. The deterioration of the interior concrete surface of the veil due to sulfate attack should be monitored over time to ensure it does not become a structural concern.

Limitations

This report has been prepared to assist AEP in evaluating the condition of the concrete of the Unit 2 cooling tower as part of an on-going investigation to determine the causes of the current distorted veil shape.

Walter P Moore has no direct knowledge of and offers no warranty regarding the condition of concealed construction or subsurface conditions beyond what was revealed in our review. Any comments regarding concealed construction or subsurface conditions are our professional opinion, based on engineering experience and judgment, and derived in accordance with current standard of care and professional practice. Comments in this report are not intended to be comprehensive but are representative of observed conditions.

We have made every effort to reasonably present the various areas of concern identified during our investigation. If there are perceived omissions or misstatements in this report regarding the observations made, we ask that they be brought to our attention as soon as possible so that we have the opportunity to fully address them in a timely manner.

We very much appreciate this opportunity to provide these services to you.

Sincerely,

WALTER P. MOORE AND ASSOCIATES, INC.

MARK ERIK WILLIAMS
REGISTERED
21916
STATE OF
WEST VIRGINIA
PROFESSIONAL ENGINEER

08/17/2018

Enrique Villalobos, Ph.D., P.E. (TX)
Associate
Diagnostics Group

Mark E. Williams, Ph.D., P.E.
Senior Principal | Managing Director
Diagnostics Group

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APPENDIX A

PHOTOGRAPH

Photo 1. Overview of Unit 2 cooling tower

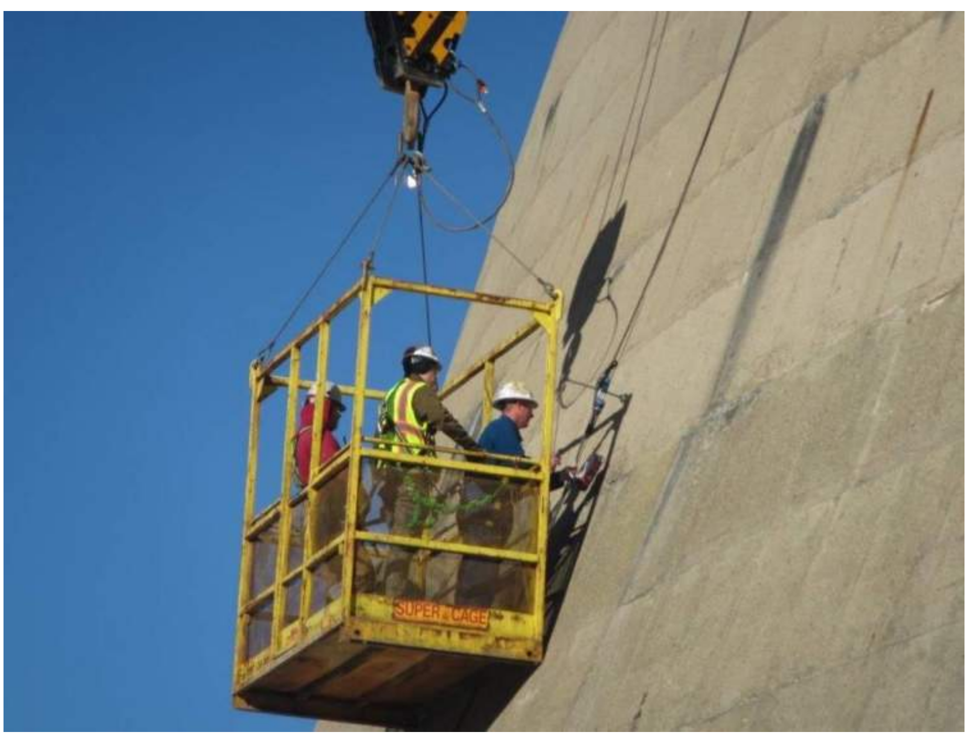

Photo 2. Visual review of the concrete veil

Photo 3. Visible distorted shape of the concrete shape

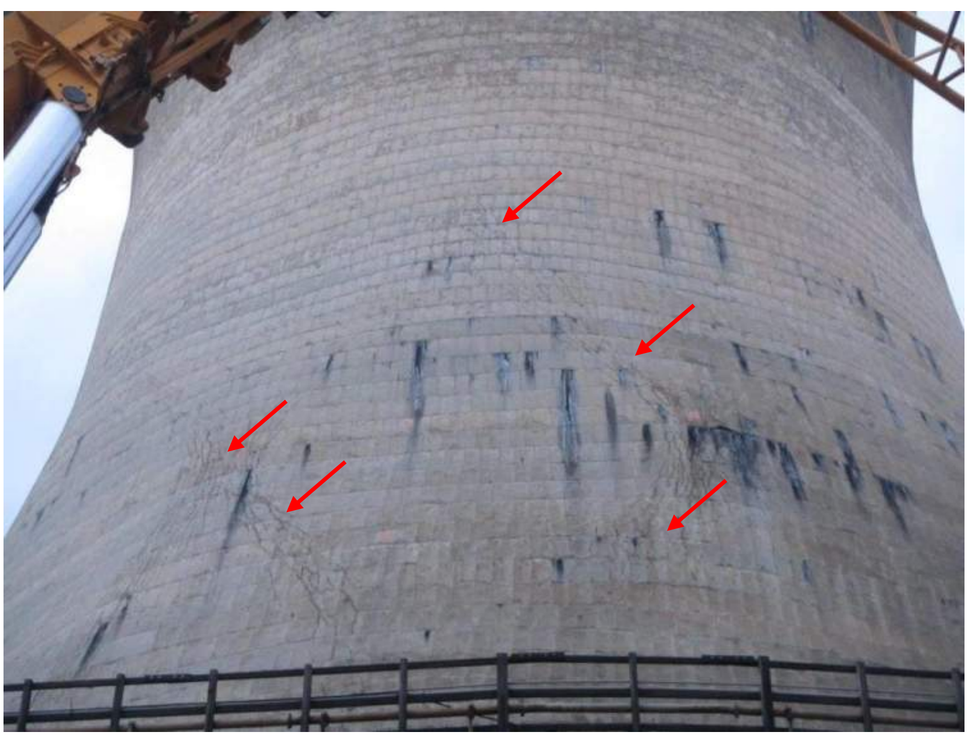

Photo 4. Visible cracking in the concrete veil

Photo 5. Close-up view of a crack in concrete veil


Photo 6. Location marked for a petrography core crossed by a crack

Photo 7. Concrete spall and exposed reinforcement

Photo 7. Unconsolidated concrete at a construction joint

Photo 9. Efflorescence at a construction joint

Photo 10. Location marked for a petrography core at a construction joint

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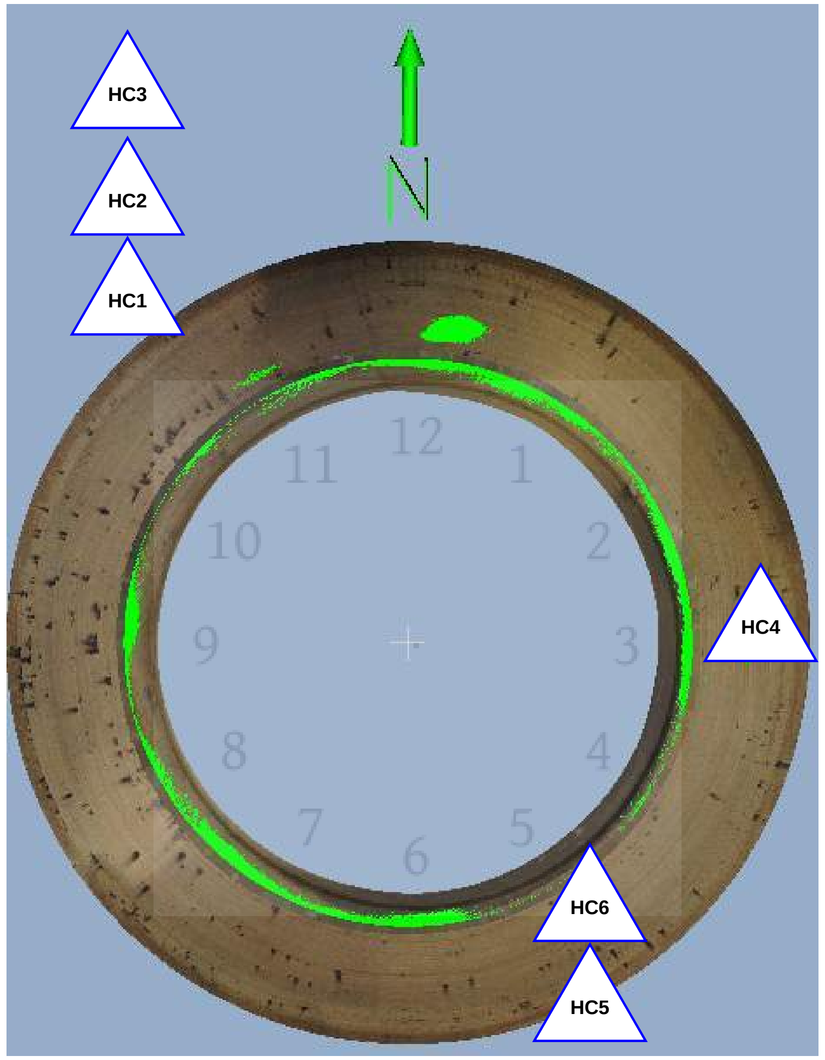
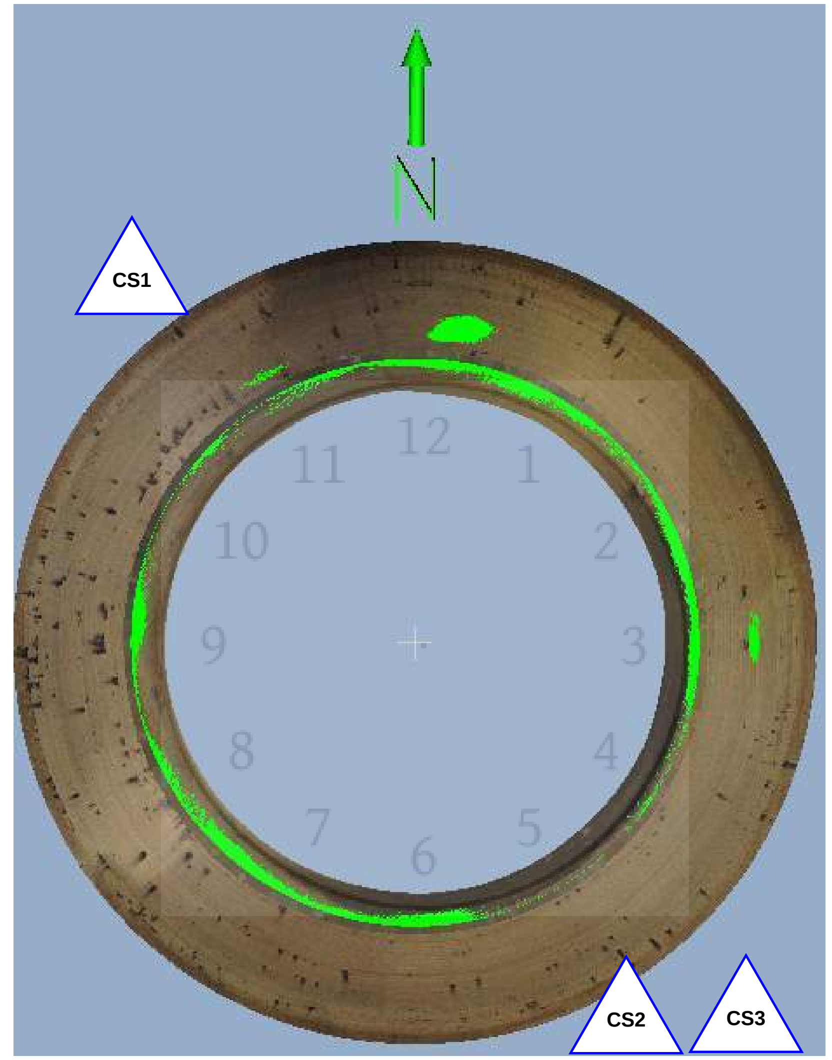
APPENDIX B

EXHIBITS



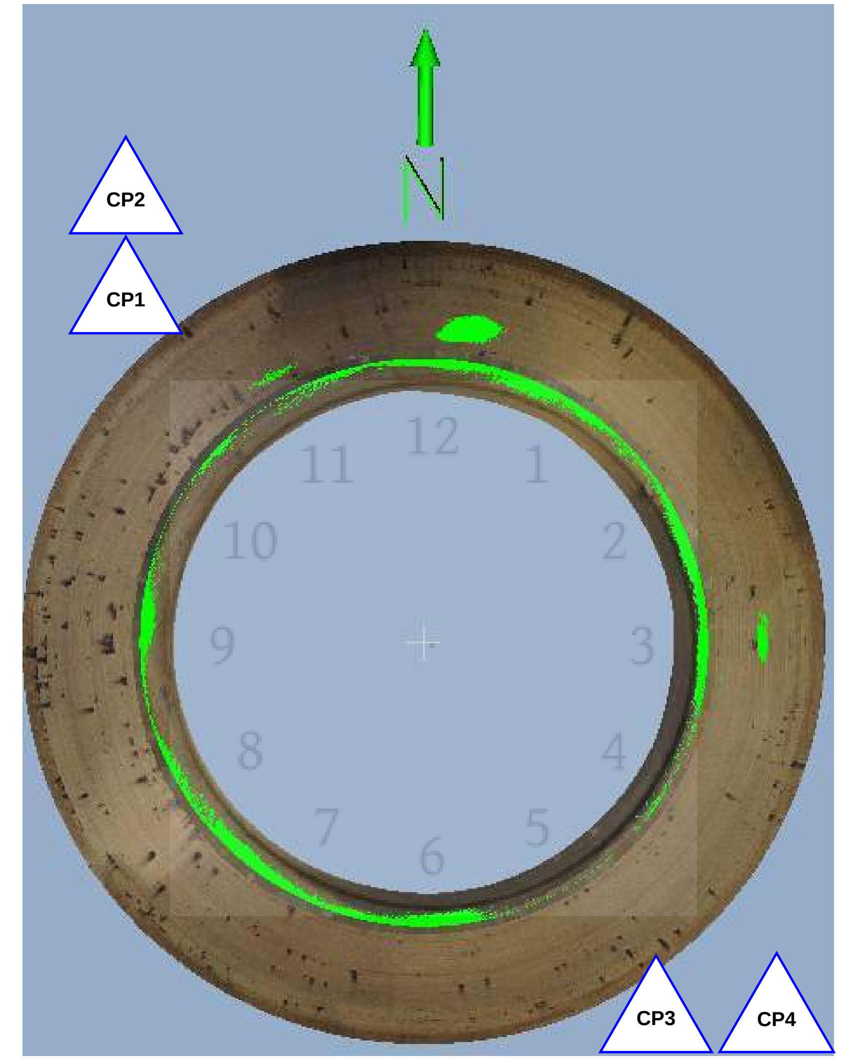
AREA ID	LOCATION
HC1	NW (11:00)
HC2	NW (11:00)
HC3	NW (11:00)
HC4	SE (5:00)
HC5	SE (5:00)
HC6	SE (5:00)

HALF-CELL CORROSION
(REFER TO EX2 TO EX4)



CORE ID	LOCATION
CS1	NW (11:00)
CS2	SE (5:00)
CS3	SE (5:00)

CONCRETE COMPRESSIVE STRENGTH
(REFER TO EX5)



CORE ID	LOCATION
CP1	NW (11:00)
CP2	NW (11:00)
CP3	SE (5:00)
CP4	SE (5:00)

CONCRETE PETROGRAPHY
(REFER TO EX6 AND EX7)

1 PLAN - TEST LOCATIONS

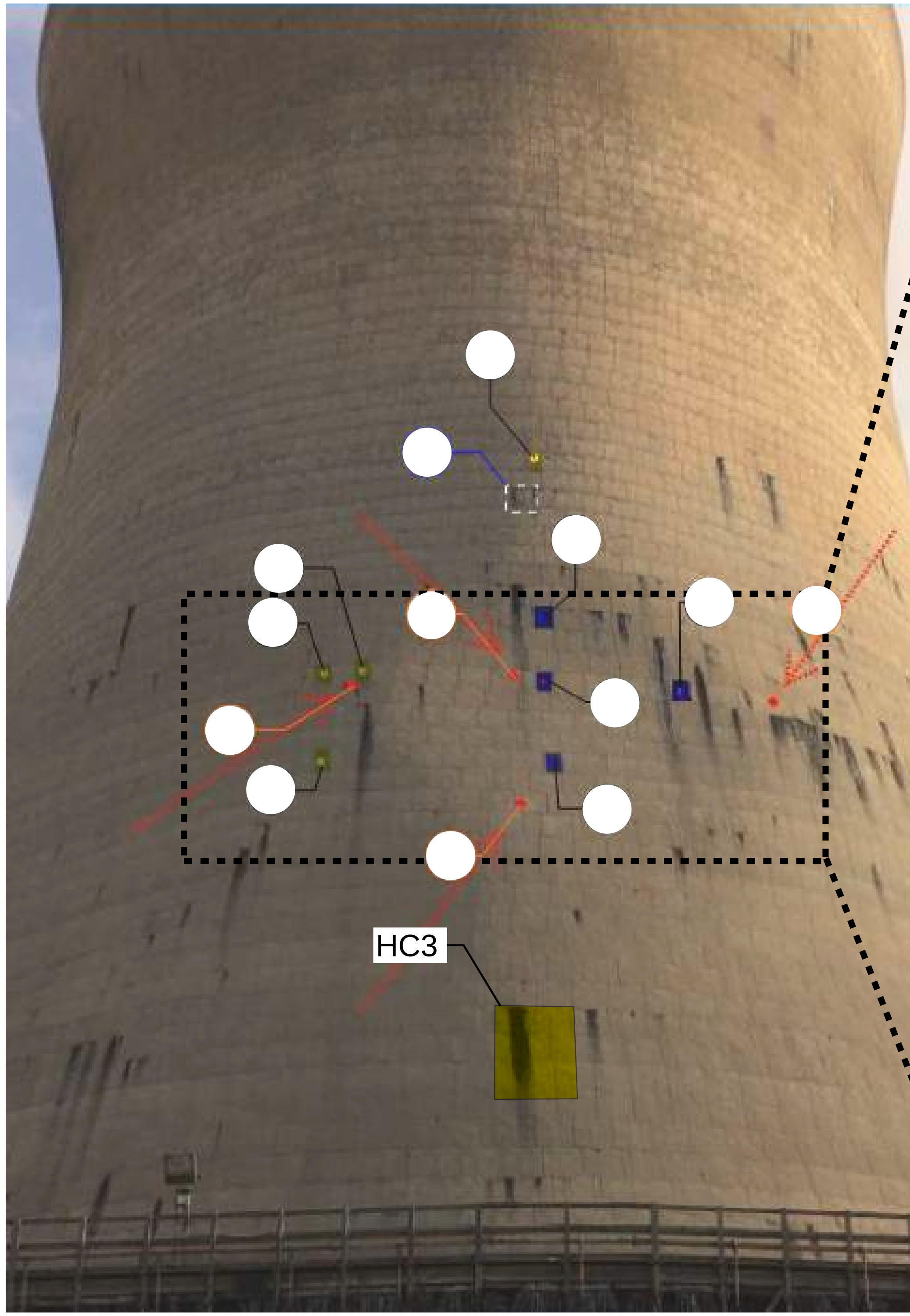
WALTER P MOORE
WALTER P. MOORE AND ASSOCIATES, INC.
1301 McKINNEY, SUITE 1100
HOUSTON, TEXAS 77010
PHONE: 713.630.7300 FAX: 713.630.7396

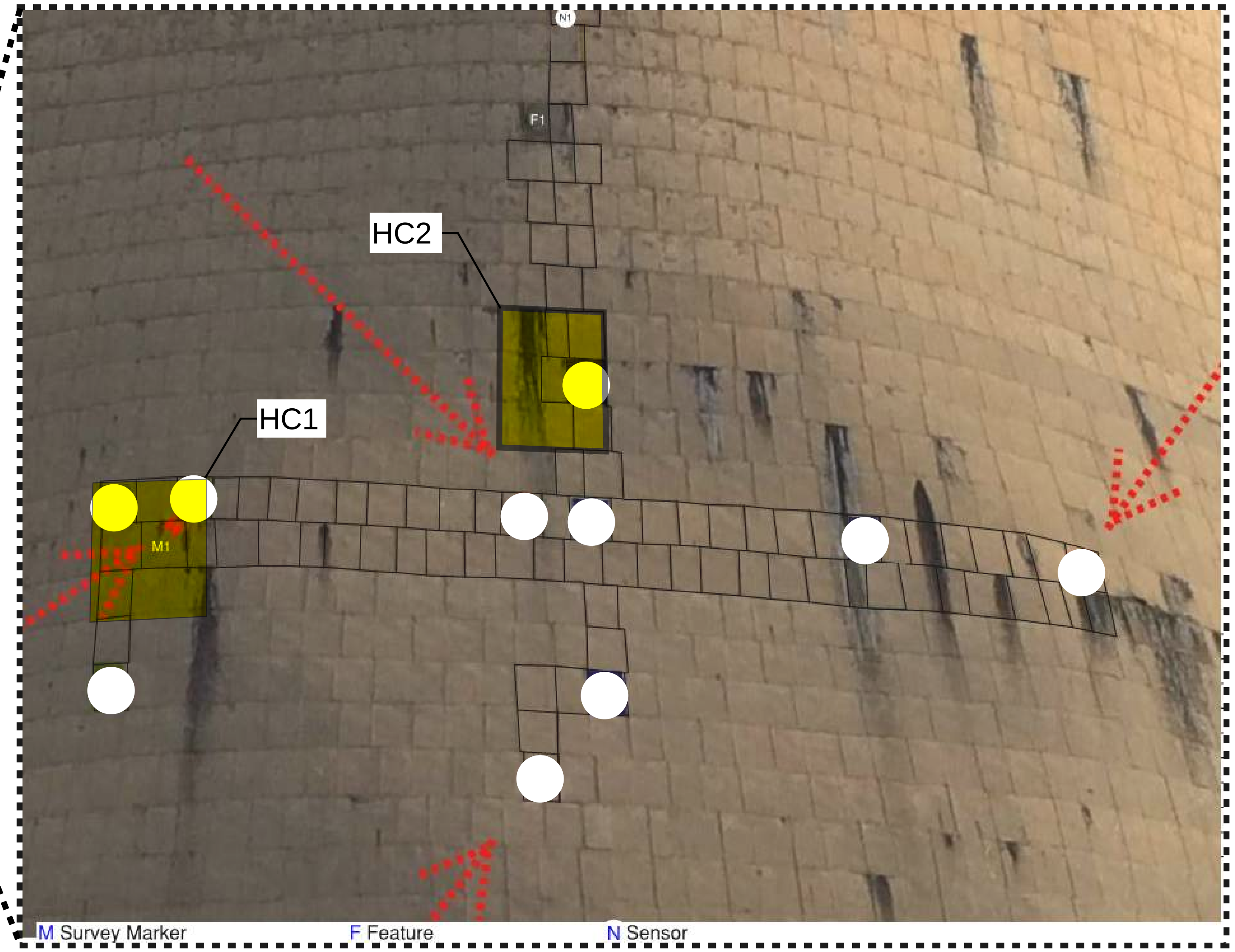
Project Name:
UNIT 2 HYPERBOLIC COOLING TOWER
EVALUATION AND MONITORING

Client:
AMERICAN ELECTRIC POWER

Date: 08/16/2018
Content: Appendix B - Report Exhibit
Eng: KG
Drafter: N/A
Proj. No. D03.16093.01

Sheet:
EX1





NORTHWEST ELEVATION

1 LOCATIONS FOR HALF-CELL CORROSION TESTS

Not To Scale

WALTER P MOORE
WALTER P. MOORE AND ASSOCIATES, INC.
1301 McKINNEY, SUITE 1100
HOUSTON, TEXAS 77010
PHONE: 713.630.7300 FAX: 713.630.7396

Project Name: UNIT 2 HYPERBOLIC COOLING TOWER EVALUATION AND MONITORING

Client: AMERICAN ELECTRIC POWER

Date: 08/16/2018

Content: Appendix B - Report Exhibit

Eng: KG

Drafter: N/A

Proj. No. D03.16093.01

Sheet: EX2

EAST ELEVATION

1 HALF-CELL CORROSION TEST AREAS

Not To Scale

WALTER P MOORE
WALTER P. MOORE AND ASSOCIATES, INC.
1301 McKINNEY, SUITE 1100
HOUSTON, TEXAS 77010
PHONE: 713.630.7300 FAX: 713.630.7396

Project Name:
UNIT 2 HYPERBOLIC COOLING TOWER EVALUATION AND MONITORING

Client: AMERICAN ELECTRIC POWER

Date: 08/16/2018

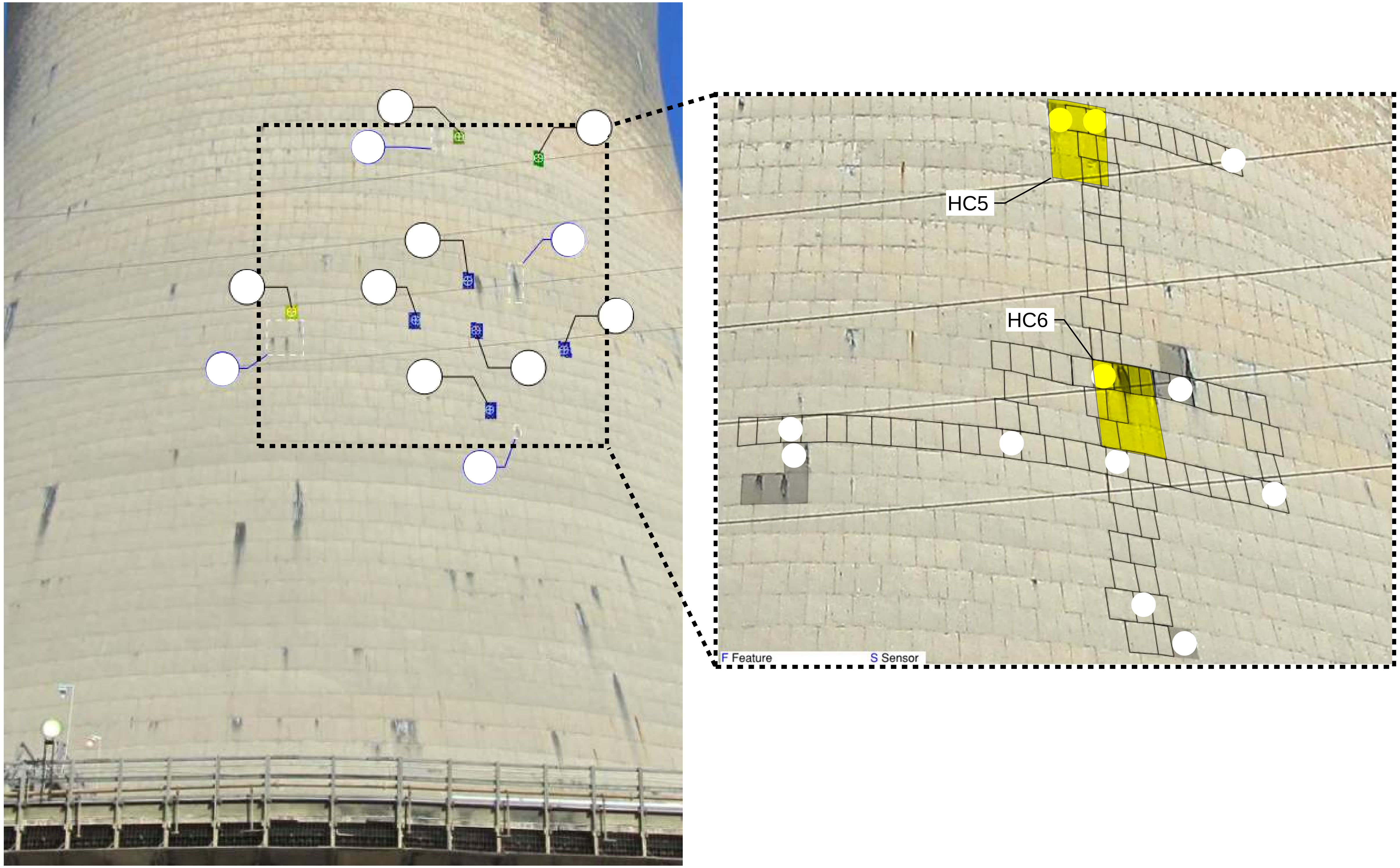
Content: Appendix B - Report Exhibit

Eng: KG

Drafter: N/A

Proj. No. D03.16093.01

Sheet: EX3



SOUTHEAST ELEVATION

1 HALF-CELL CORROSION TEST AREAS

Not To Scale

WALTER P MOORE
WALTER P. MOORE AND ASSOCIATES, INC.
1301 McKINNEY, SUITE 1100
HOUSTON, TEXAS 77010
PHONE: 713.630.7300 FAX: 713.630.7396

Project Name: UNIT 2 HYPERBOLIC COOLING TOWER EVALUATION AND MONITORING

Client: AMERICAN ELECTRIC POWER

Date: 08/16/2018

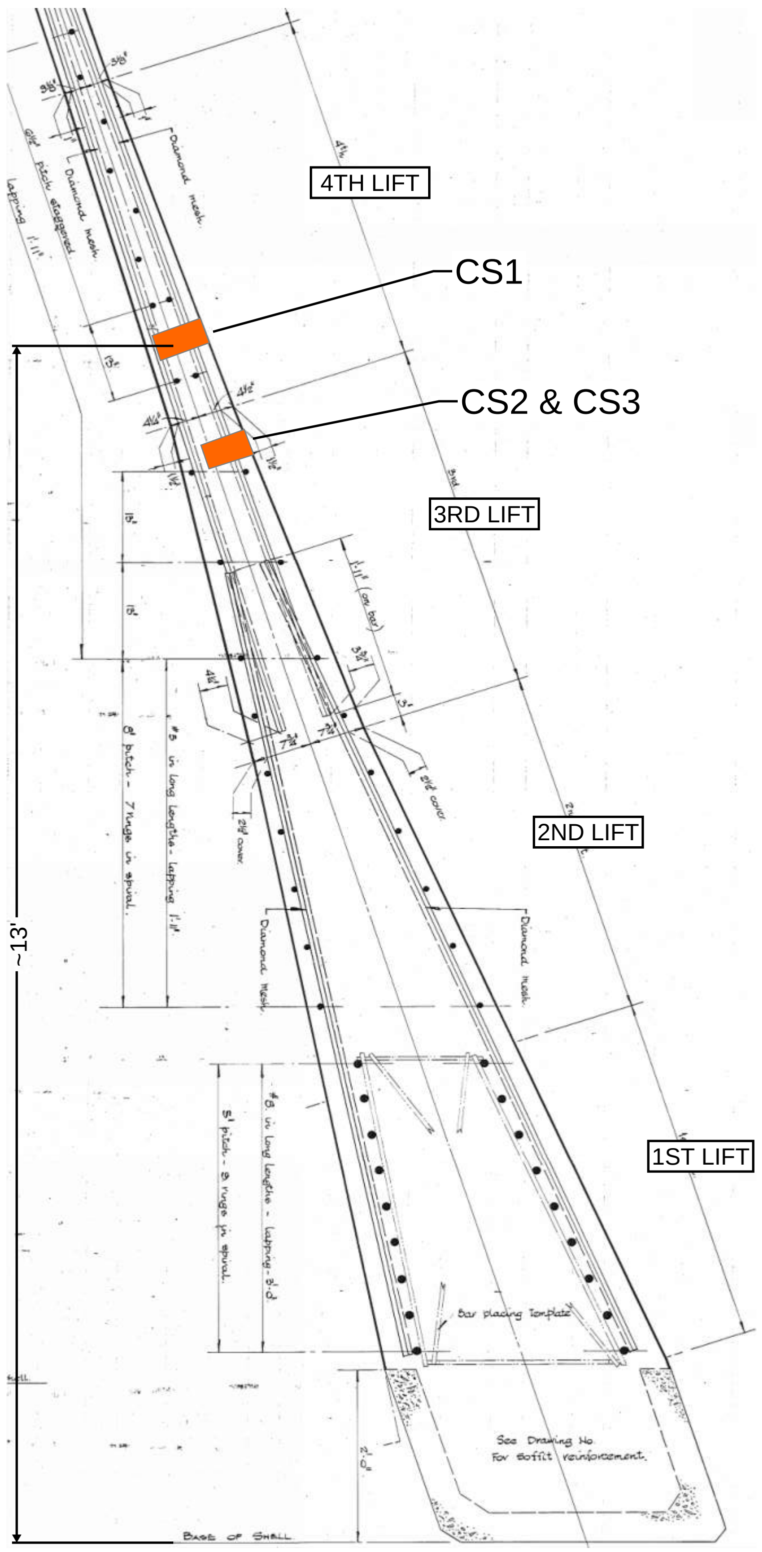
Content: Appendix B - Report Exhibit

Eng: KG

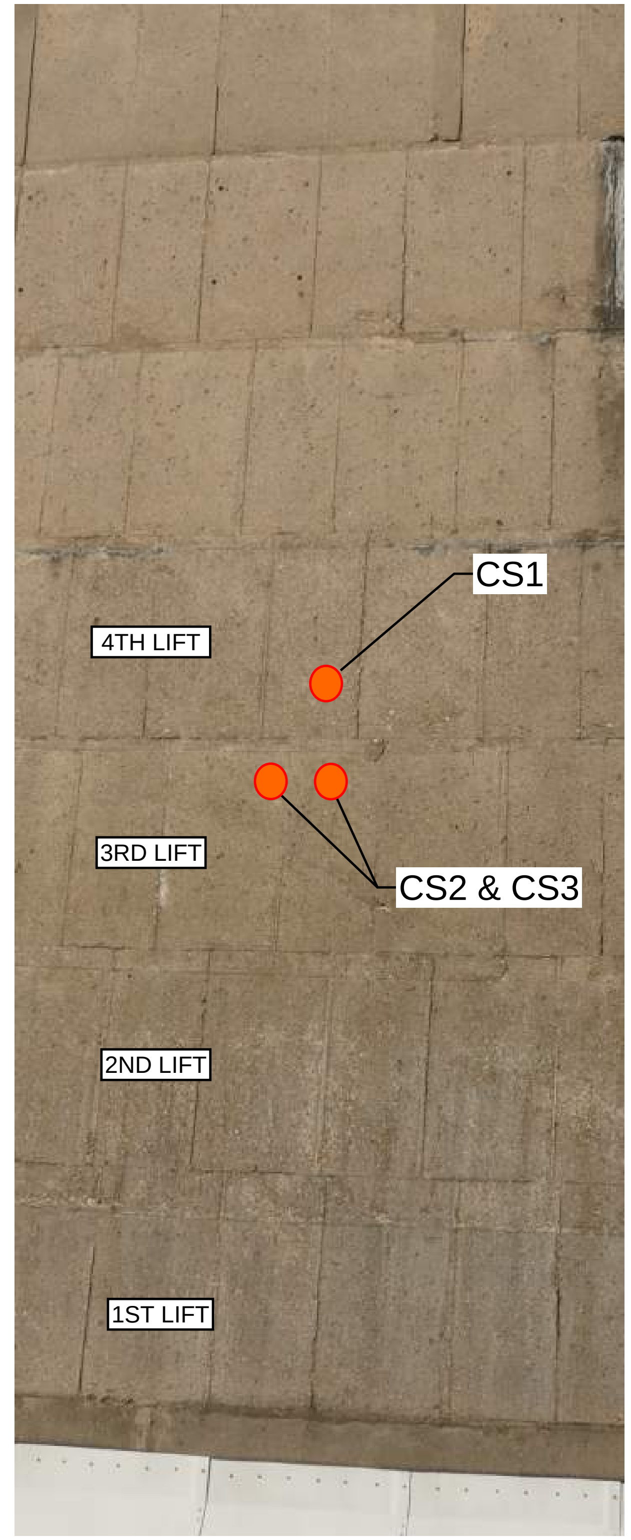
Drafter: N/A

Proj. No. D03.16093.01

Sheet: EX4

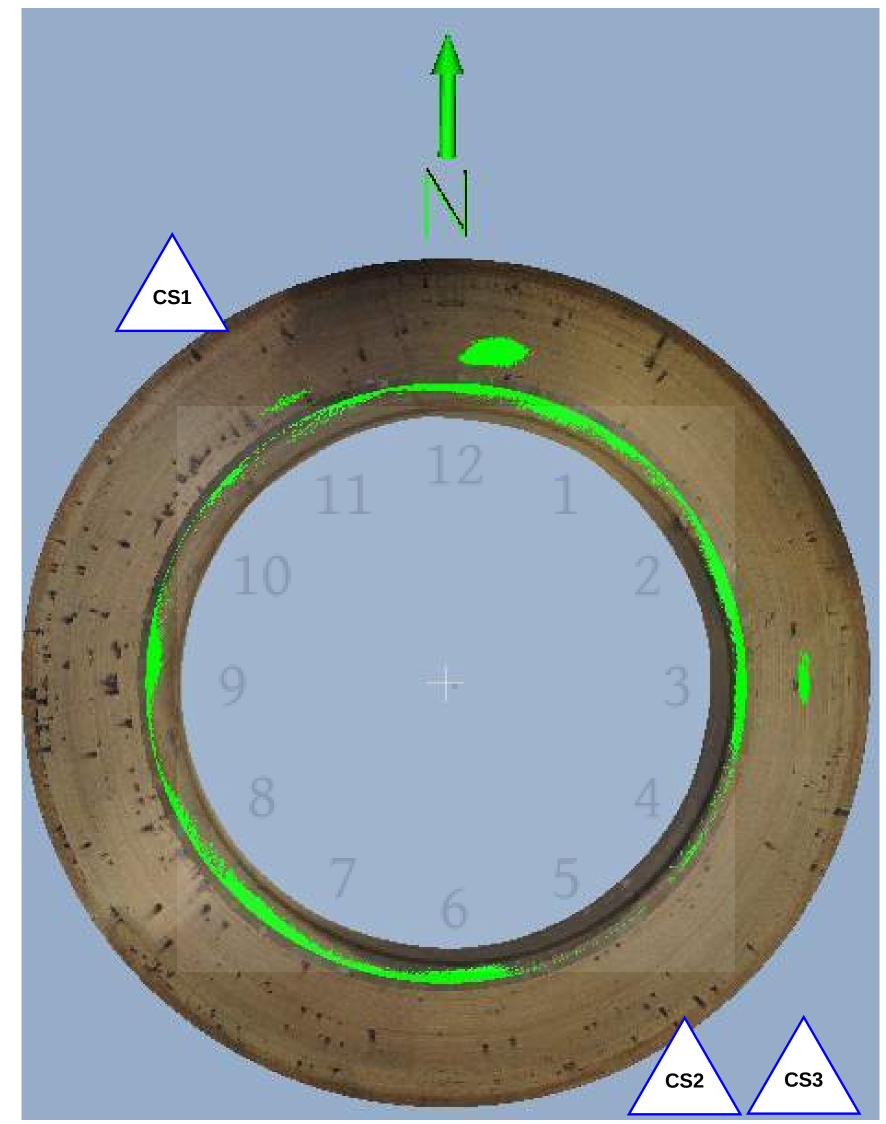


SECTION



ELEVATION

CORE ID	LOCATION
CS1	NW (11:00)
CS2	SE (5:00)
CS3	SE (5:00)



PLAN LOCATIONS

① CONCRETE CORE LOCATIONS FOR COMPRESSIVE STRENGTH TESTS

Not To Scale

WALTER P MOORE
WALTER P. MOORE AND ASSOCIATES, INC.
1301 McKINNEY, SUITE 1100
HOUSTON, TEXAS 77010
PHONE: 713.630.7300 FAX: 713.630.7396

Project Name: UNIT 2 HYPERBOLIC COOLING TOWER EVALUATION AND MONITORING

Client: AMERICAN ELECTRIC POWER

Date: 08/16/2018

Content: Appendix B - Report Exhibit

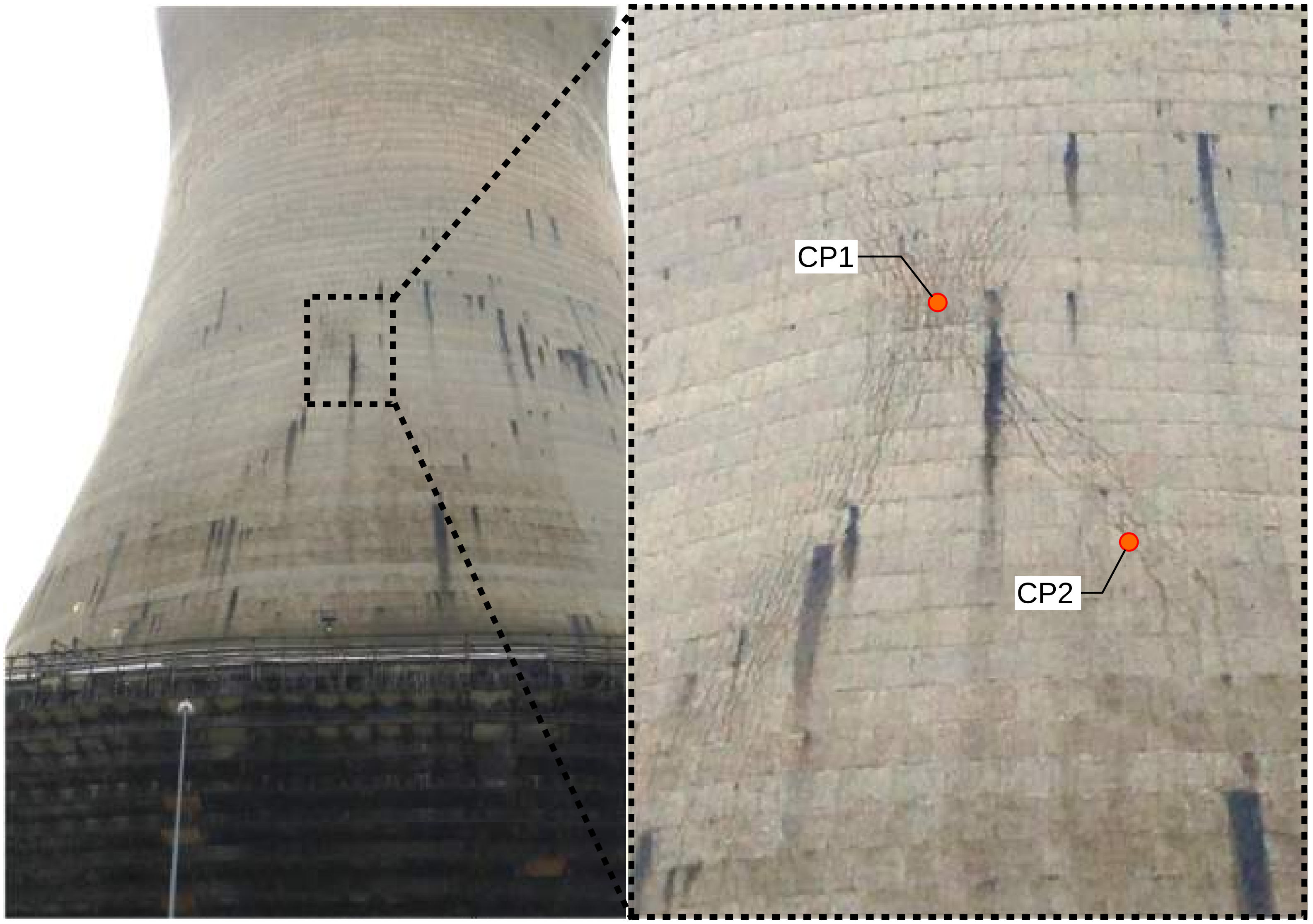
Eng: KG

Drafter: N/A

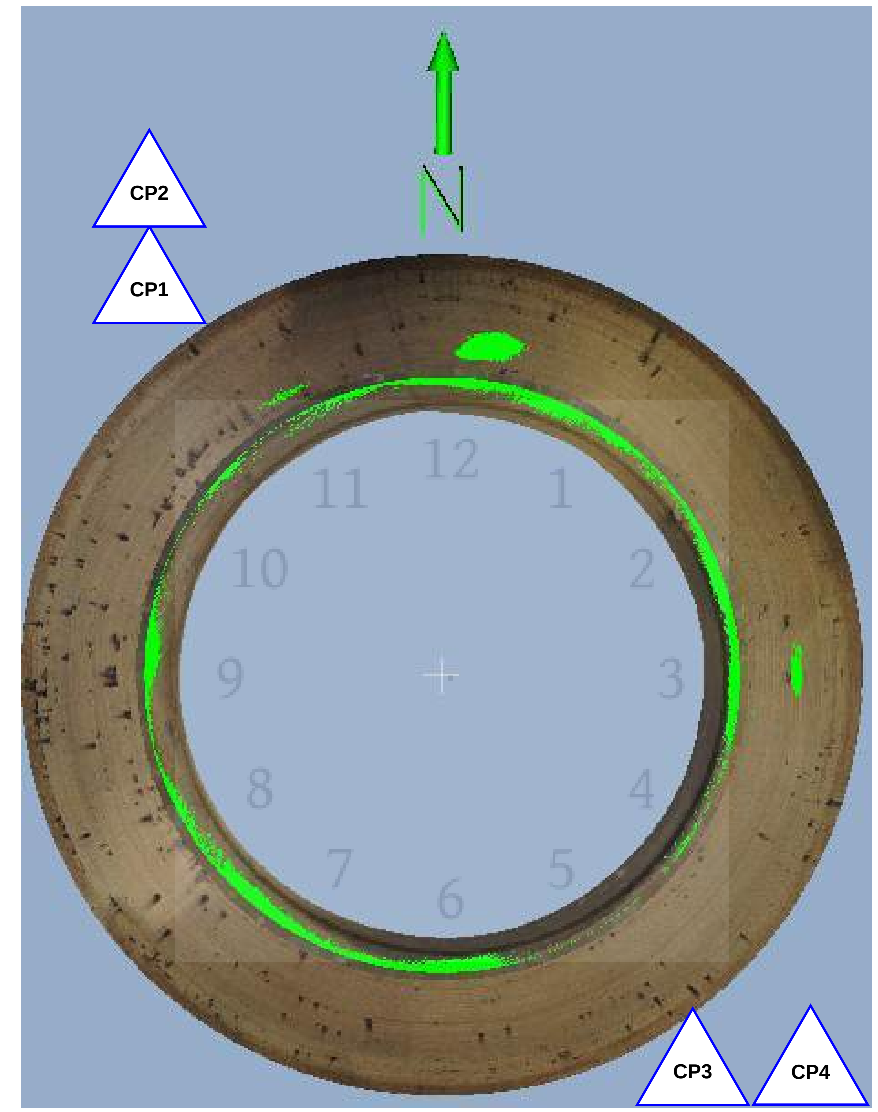
Proj. No. D03.16093.01

Sheet: EX5

CORE ID	LOCATION
CP1	NW (11:00)
CP2	NW (11:00)
CP3	SE (5:00)
CP4	SE (5:00)



NORTHWEST ELEVATION



PLAN LOCATIONS

1 CONCRETE CORE LOCATIONS FOR PETROGRAPHIC ANALYSIS

Not To Scale

WALTER P MOORE
WALTER P. MOORE AND ASSOCIATES, INC.
1301 McKINNEY, SUITE 1100
HOUSTON, TEXAS 77010
PHONE: 713.630.7300 FAX: 713.630.7396

Project Name: UNIT 2 HYPERBOLIC COOLING TOWER EVALUATION AND MONITORING

Client: AMERICAN ELECTRIC POWER

Date: 08/16/2018

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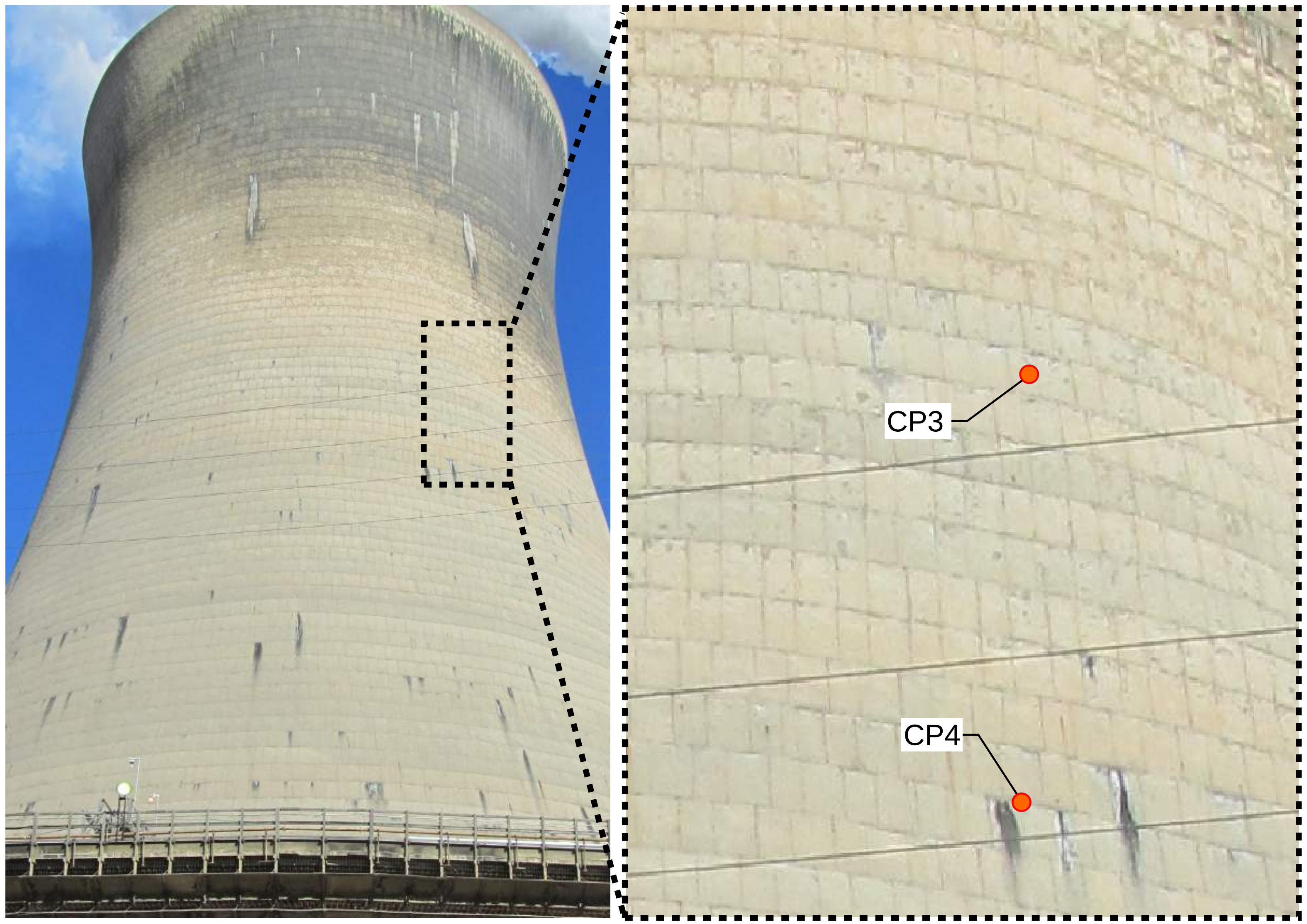
Eng: KG

Drafter: N/A

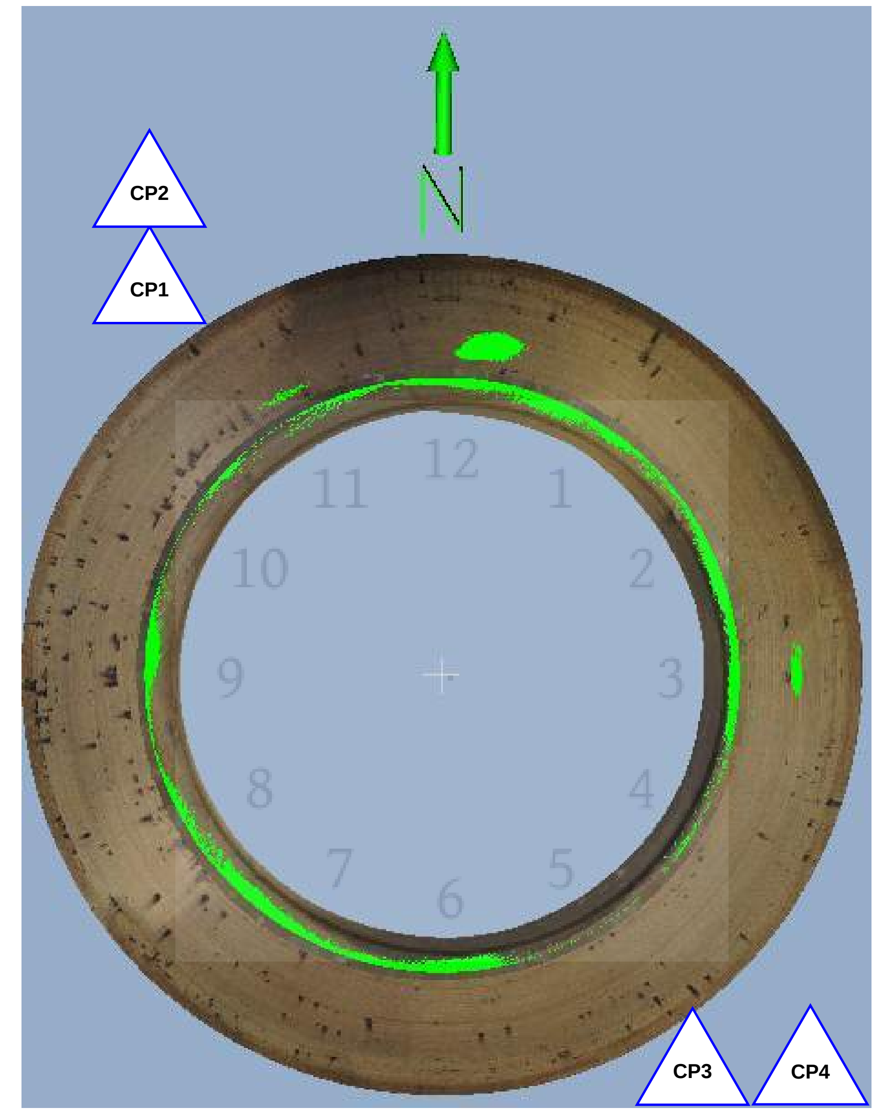
Proj. No. D03.16093.01

Sheet: EX6

CORE ID	LOCATION
CP1	NW (11:00)
CP2	NW (11:00)
CP3	SE (5:00)
CP4	SE (5:00)



SOUTHEAST ELEVATION



PLAN LOCATIONS

1 CONCRETE CORE LOCATIONS FOR PETROGRAPHIC ANALYSIS

Not To Scale

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WALTER P. MOORE AND ASSOCIATES, INC.
1301 McKINNEY, SUITE 1100
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Project Name: UNIT 2 HYPERBOLIC COOLING TOWER EVALUATION AND MONITORING

Client: AMERICAN ELECTRIC POWER

Date: 08/16/2018

Content: Appendix B - Report Exhibit

Eng: KG

Drafter: N/A

Proj. No. D03.16093.01

Sheet: EX7

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APPENDIX C

NON-DESTRUCTIVE CONCRETE TESTING

HOUSTON	DALLAS / FT WORTH	972.432.6666
1036 1st St E, Ste A3	SAN ANTONIO / SO. TEXAS	210.775.1637
Humble, TX 77338	AUSTIN / WACO	512.551.0336
P 281.446.7363	CHICAGO	847.459.9090
F 800.516.5732	MIAMI	954.676.4147

TECHNICAL REPORT

CONDITION ASSESSMENT TESTING OF COOLING TOWER SHELL

at the

MITCHELL POWER PLANT

MOUNDSVILLE, WEST VIRGINIA 26041

for

AMERICAN ELECTRIC POWER

APRIL 3-5 AND APRIL 25-28, 2018

PROJECT NO. RV7352

UNIVERSAL RADARVIEW
CIVIL/STRUCTURAL - GEOPHYSICAL SURVEYS

HOUSTON	DALLAS / FT WORTH	972.432.6666
1036 1st St E, Ste A3	SAN ANTONIO / SO. TEXAS	210.775.1637
Humble, TX 77338	AUSTIN / WACO	512.551.0336
P 281.446.7363	CHICAGO	847.459.9090
F 800.516.5732	MIAMI	954.676.4147

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Humble, TX 77338	AUSTIN / WACO	512.551.0336
P 281.446.7363	CHICAGO	847.459.9090
F 800.516.5732	MIAMI	954.676.4147

1 EXECUTIVE SUMMARY

Client:	*American Electric Power*	*Project No:*	*RV7352*
Location:	*Mitchell Power Plant*	*Total Pages:*	10
Client P.O. No:		*Date:*	April 5, 2018
Report Title:	Condition Assessment Testing of the Cooling Tower Shell		

Summary:

On April 5th, 2018 Radarview was contracted to perform Condition Assessment Testing of a concrete cooling tower wall at the Mitchell Power Plant in Moundsville, West Virginia.

The objective of this survey was to utilize Half-Cell Testing to determine corrosion potentials in areas where no obvious corrosion was present. In addition reinforcement was to be marked out by Ground Penetrating Radar for core extractions.

Cores were extracted by others, and then shipped to our Chicago Forensic Laboratory. The results of that testing is contained in a separate report.

Result summary:

- In locations HC1, HC2, HC3, and HC5 there was a 90% probability of no corrosion.
- In locations HC4 and Hc6 there was a couple readings that show an **increasing probability** of corrosion in a few spots.

Prepared by *Jimmy Gann*	*Reviewed By* *Todd Allen*	[signature]

2 INTRODUCTION

On April 5th, 2018 Radarview was contracted to perform Condition Assessment Testing of a concrete cooling tower shell at the Mitchell Power Plant in Moundsville, West Virginia.

The objective of this survey was to utilize Half-Cell Testing (ASTM C876) to determine corrosion potentials in areas where no obvious corrosion was present. In addition reinforcement is to be marked out by Ground Penetrating Radar for core extractions. Samples were shipped to our Chicago Laboratory for Petrogaphy, Chlorides, and Compressive Strength. Those results are documented in a separate report.

For the onsite work performed, a James Instrument Cor-Map II Corrosion Half-Cell Testing system was utilized for the survey. It includes a Cu/$CuSO_4$ reference electrode and a data acquisition device. A GSSI 1600MHz Mini Hand Held GPR system was used for scanning.

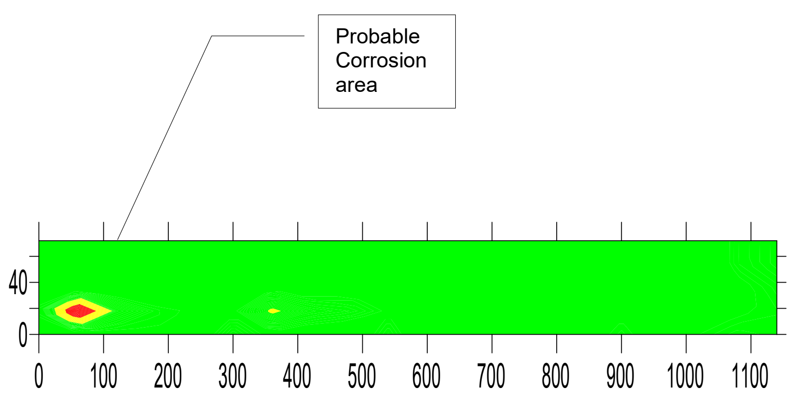
3 TESTING METHODOLOGY DETAILS

3.1 Corrosion Half Cell Testing

Introduction: Corrosion Half-Cell Potential Testing. ASTM C876

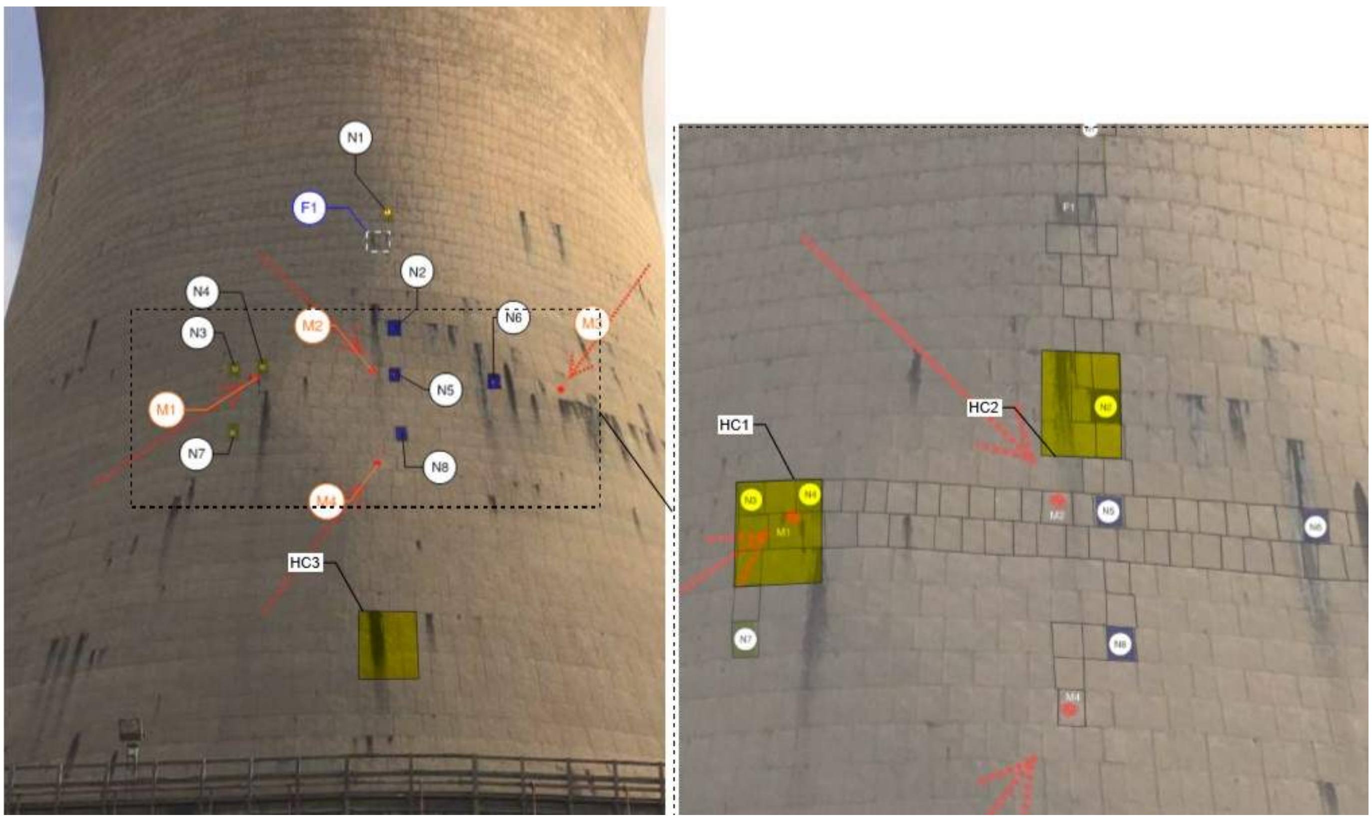
Theory: For steel reinforcing bars in concrete, corrosion is an exchange of ions from the steel to the concrete. This chemical exchange of ions produces rust (FeO2). It also produces areas of concrete where there is a larger concentration of negative ions due to the corrosion process of the steel reinforcing bar than areas where there is no corrosion. This larger concentration of ions creates a small electric voltage potential. By measuring and mapping the voltage potential found in the concrete we are able to determine rapidly the presence of corroded steel reinforcement without costly and time consuming demolition of concrete.

This is done by recording the voltage between the rebar and half cell, which is mapped across the surface of the concrete. Areas of rust with high corrosion will exhibited significantly lower voltage than areas without corrosion, thus areas of corroding steel reinforcing bar in concrete can be rapidly found. There is no need to know the exact position of the steel reinforcing bar or the amount of cover. The presence of the steel is all that is required; however, the voltmeter has to be connected to an exposed piece of the rebar network, and because the concrete is being tested, any material on the surface should be removed. Radarview uses a Cu/CuSO4 reference electrode for all testing.



4 HALF-CELL TESTING

4.1 Locations of Tested Areas



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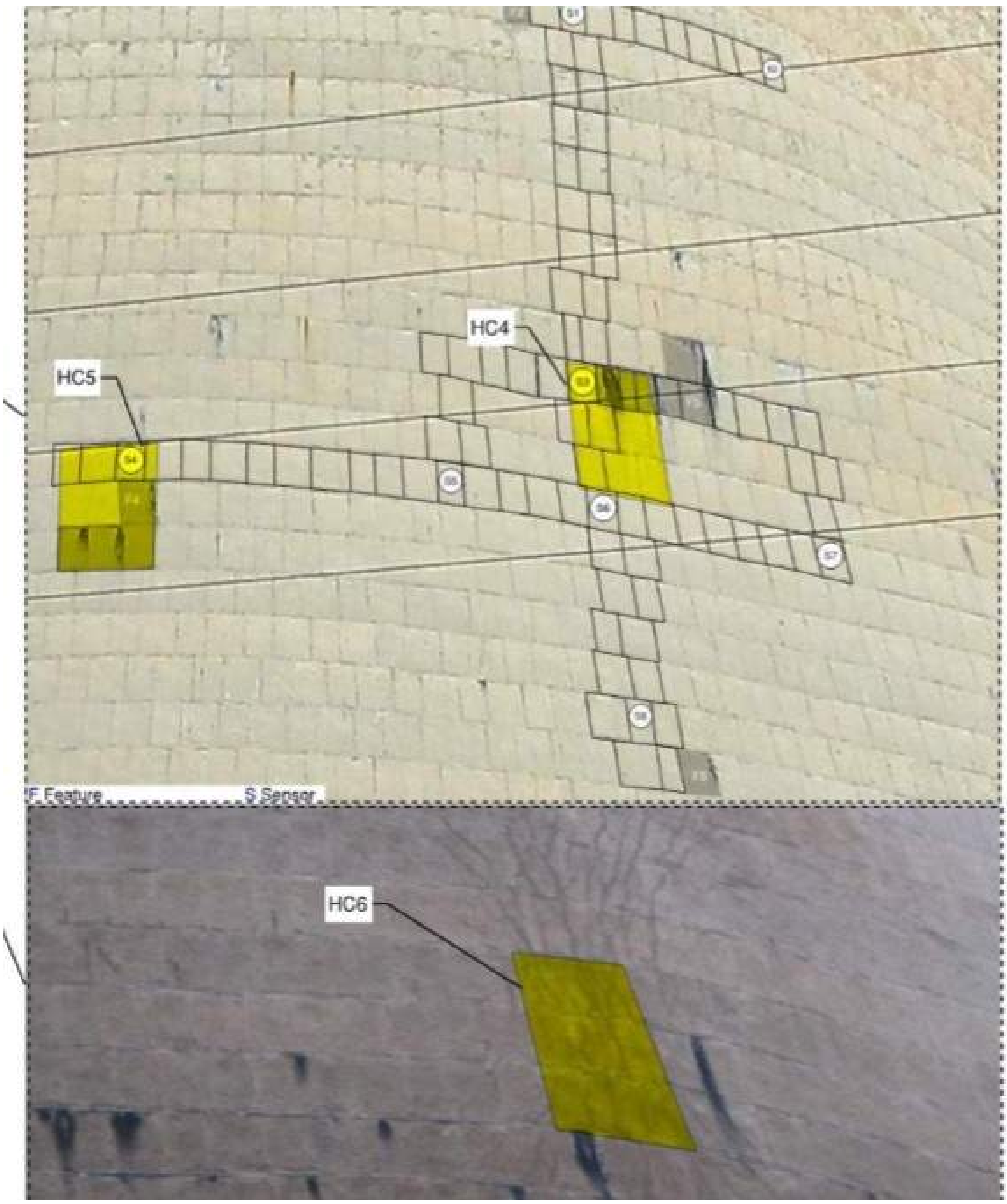
Humble, TX 77338	AUSTIN / WACO	512.551.0336
P 281.446.7363	CHICAGO	847.459.9090
F 800.516.5732	MIAMI	954.676.4147



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P 281.446.7363	CHICAGO	847.459.9090
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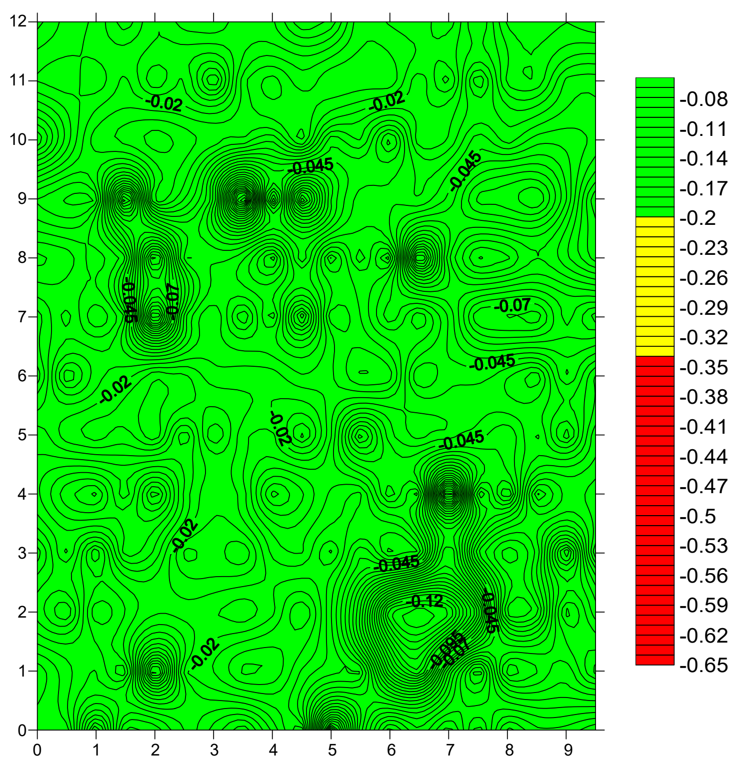
4.2 Examination Results

4.2.1 **HC1**



Half-Cell Reading Results:

A= -.420

B= -.350

C= -.280

D= -.210

E= -.140

F= -.070

G= -.000

A&B = 90% chance corrosion is occurring in this area.

C&D = Corrosion activity over this area is uncertain

E-G = 90% chance that no corrosion activity is present over this area.

Red = A&B

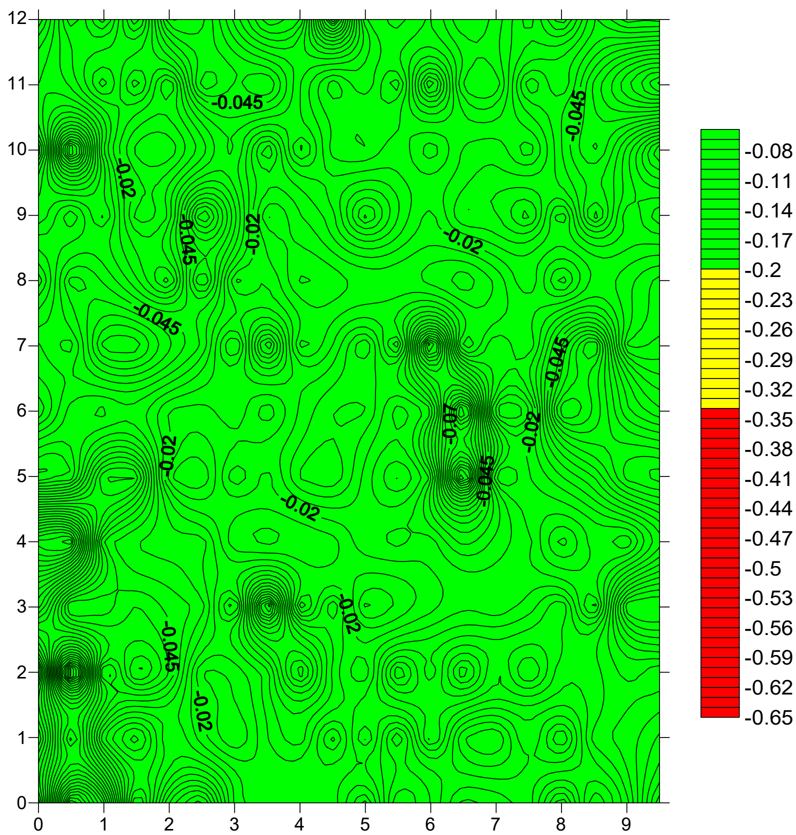
Yellow = C&D

Green = E-G

Samples were taken on a 9.5' by 12' grid.

The area that was examined showed a 90% chance that **no** corrosion activity is present.

4.2.2 **HC2**



Half-Cell Reading Results:

A= -.420

B= -.350

C= -.280

D= -.210

E= -.140

F= -.070

G= -.000

A&B = 90% chance corrosion is occurring in this area.

C&D = Corrosion activity over this area is uncertain

E-G = 90% chance that no corrosion activity is present over this area.

Red = A&B

Yellow = C&D

Green = E-G

Samples were taken on a 9.5' by 12' grid.

The area that was examined showed a 90% chance that **no** corrosion activity is present.

UNIVERSAL RADARVIEW
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HOUSTON	DALLAS / FT WORTH	972.432.6666
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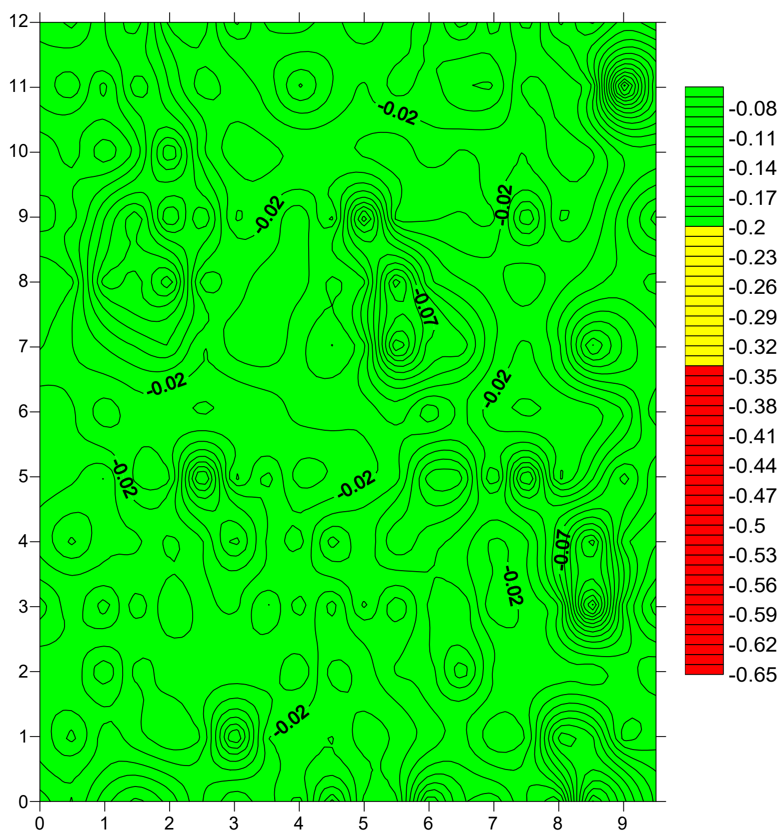
Humble, TX 77338	AUSTIN / WACO	512.551.0336
P 281.446.7363	CHICAGO	847.459.9090
F 800.516.5732	MIAMI	954.676.4147

4.2.3 **HC3**



Half-Cell Reading Results:

A= -.420

B= -.350

C= -.280

D= -.210

E= -.140

F= -.070

G= -.000

A&B = 90% chance corrosion is occurring in this area.

C&D = Corrosion activity over this area is uncertain

E-G = 90% chance that no corrosion activity is present over this area.

Red = A&B

Yellow = C&D

Green = E-G

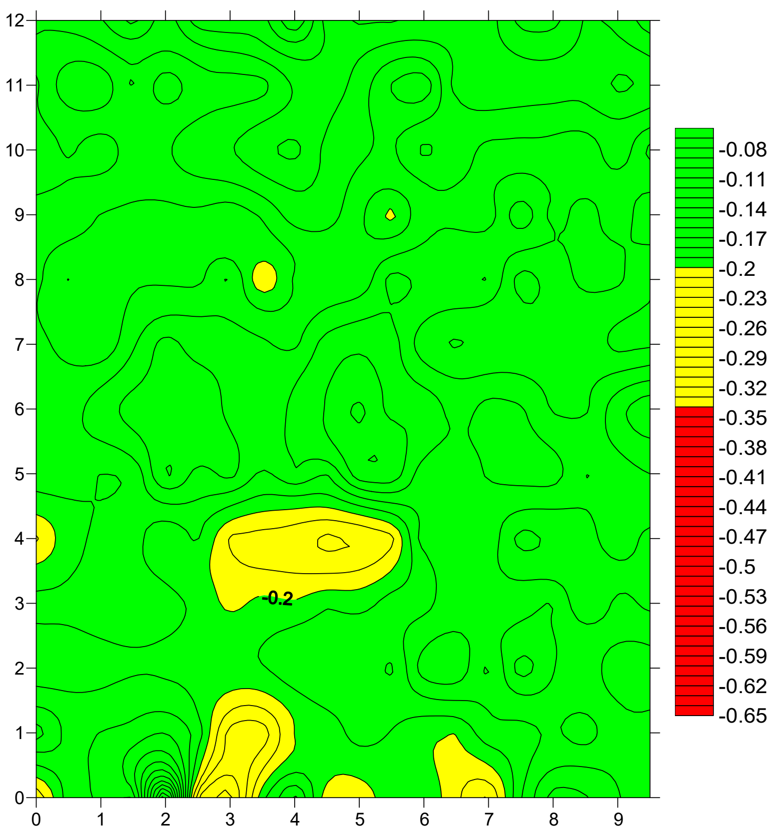
Samples were taken on a 9.5' by 12' grid.

The area that was examined showed a 90% chance that **no** corrosion activity is present.

UNIVERSAL RADARVIEW
CIVIL/STRUCTURAL · GEOPHYSICAL SURVEYS

HOUSTON	DALLAS / FT WORTH	972.432.6666
1036 1st St E, Ste A3	SAN ANTONIO / SO. TEXAS	210.775.1637
Humble, TX 77338	AUSTIN / WACO	512.551.0336
P 281.446.7363	CHICAGO	847.459.9090
F 800.516.5732	MIAMI	954.676.4147

4.2.4 **HC4**



Half-Cell Reading Results:

A= -.420

B= -.350

C= -.280

D= -.210

E= -.140

F= -.070

G= -.000

A&B = 90% chance corrosion is occurring in this area.

C&D = Corrosion activity over this area is uncertain

E-G = 90% chance that no corrosion activity is present over this area.

Red = A&B

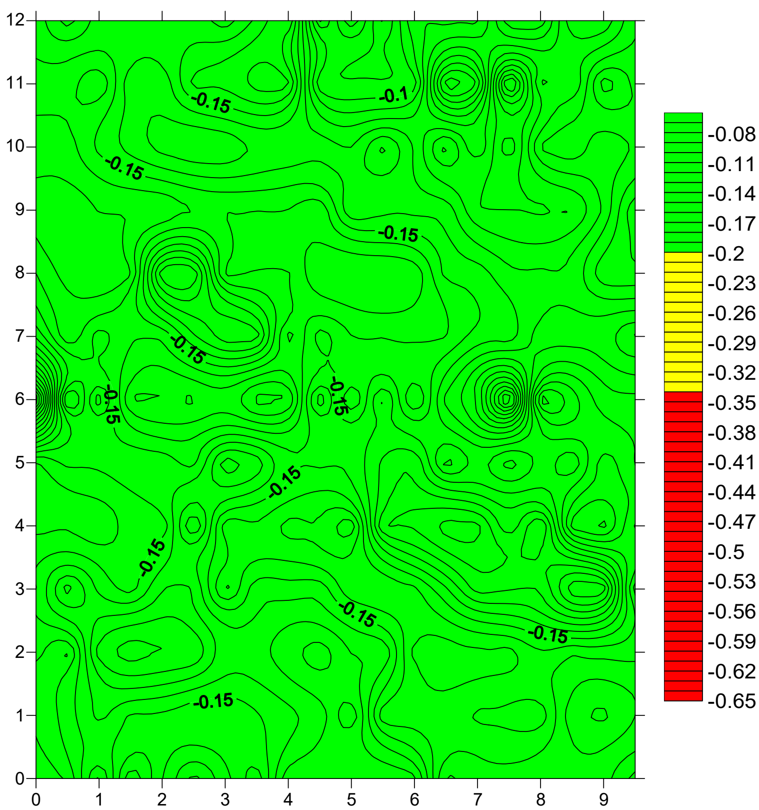
Yellow = C&D

Green = E-G

Samples were taken on a 9.5' by 12' grid.

There are a few areas that show an **increasing probability** of corrosion.

4.2.5 **HC5**



Half-Cell Reading Results:

A= -.420

B= -.350

C= -.280

D= -.210

E= -.140

F= -.070

G= -.000

A&B = 90% chance corrosion is occurring in this area.

C&D = Corrosion activity over this area is uncertain

E-G = 90% chance that no corrosion activity is present over this area.

Red = A&B

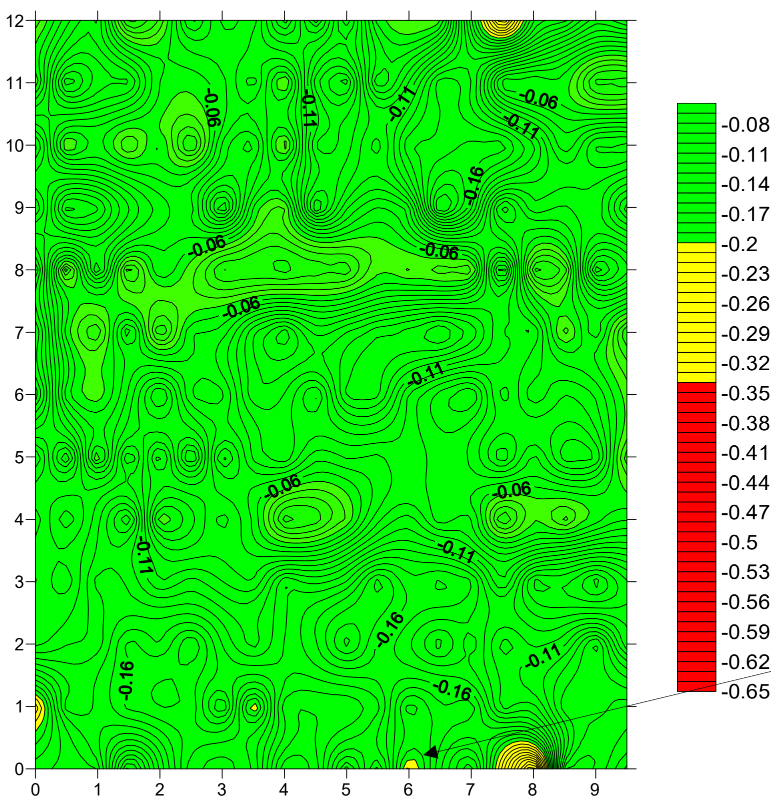
Yellow = C&D

Green = E-G

Samples were taken on a 9.5' by 12' grid.

The area that was examined showed a 90% chance that **no** corrosion activity is present.

4.2.6 **HC6**



Half-Cell Reading Results:

A= -.420

B= -.350

C= -.280

D= -.210

E= -.140

F= -.070

G= -.000

A&B = 90% chance corrosion is occurring in this area.

C&D = Corrosion activity over this area is uncertain

E-G = 90% chance that no corrosion activity is present over this area.

Red = A&B

Yellow = C&D

Green = E-G

Samples were taken on a 9.5' by 12' grid.

There was one area that shows an **increasing probability** of corrosion.

WALTER P MOORE

APPENDIX D

DESTRUCTIVE CONCRETE TESTING

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61 Garlisch Dr.
Elk Grove Village, IL60007
P 847-459-9090
F 847-459-9015

DALLAS / FT WORTH 972.432.6666
SAN ANTONIO / SO. TEXAS 210.775.1637
AUSTIN / WACO 512.551.0336
HOUSTON 281.446.7363
MIAMI 954.676.4147

Mr. Doug Polack dspolack@aep.com
American Electric Power
1 Riverside Plaza
Columbus, Ohio 43215

Re: Laboratory Studies of Concrete Core Samples
Mitchell Unit #2 Elevation
Moundsville, West Virginia

Dear Mr. Polack:

Universal Construction Testing, Ltd. (UCT) has completed laboratory studies of eight (8) concrete core samples from the referenced project, which were delivered to our laboratories on April 12, 2018 and May 1, 2018.

Reportedly, the cores were excised from a concrete hyperbolic cooling tower constructed in the 1960's, which is experiencing various signs of deterioration.

The scope of our work consisted of compressive strength testing, water-soluble chloride content analysis and petrographic examination. The testing and examination were requested to evaluate the concrete properties and to identify the nature of the observed cracking and deterioration.

Refer to Table 1 below for sample identification and requested testing protocol.

Table 1 - Sample Identification and Test Program

Core ID	Location	Compression Test (ASTM C42)	Chloride Content Analysis (ASTM C1218)	Petrographic Examination (ASTM C856/C457)
CS1	NW quadrant	X	---	---
CS2-A	SE quadrant	---	---	---
CS2-B	SE quadrant	X	---	---
CS3	SE quadrant	X	---	---
CP1	NW quadrant	---	X	X
CP2	NW quadrant	---	X	X
CP3	SE quadrant	---	X	X
CP4	SE quadrant	---	X	X

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SUMMARY OF FINDINGS

Compressive Strength: Test results obtained indicate that the in-situ compressive strength of the concrete represented by Cores CS1, CS2-B and CS3 ranges from approximately 4,300 to 8,500 psi (see Table 2).

Chloride Content Analysis: According to American Concrete Institute, 0.15% maximum water-soluble chloride contents expressed by weight of cement is the suggested threshold to minimize the risk of chloride-induced corrosion in conventionally reinforced concrete.

Chemical analysis indicates that the chloride ion content of Cores CP1, CP2, CP3 and CP4 is negligibly low at all three (3) depth increments analyzed and is typical of “background” contamination stemming from the concrete constituents (see Table 3).

Petrographic Analysis: In general, the concrete represented by Cores CP1 CP2, CP3 and CP4 is compositionally similar and was produced using a fairly well-graded, 3/4-inch (20 mm) maximum size, river rock coarse aggregate and a siliceous sand fine aggregate, both dispersed fairly uniformly in a hardened portland-cement and fly ash paste.

The concrete appears to be air-entrained, based on the presence of small, spherical air-voids, with estimated air-contents ranging between marginally air-entrained with 2-4% air content in Core CP2 to 5-7% air content in Core CP3. Although air-entrained, a majority of the voids are completely filled with secondary deposits (ettringite), which essentially lowers the overall void space available to accommodate displaced water and is problematic for freeze-thaw durability.

The exterior surface of all four cores is overall intact but worn, exposing fine aggregate particles. The interior surface of the core is irregular due to loss of the paste matrix, exposing coarse aggregate particles.

Paste along the interior surface of all four (4) cores is discolored light-beige and is very soft and friable – crumbles easily. Additionally, the paste within the near-surface region of the interior surface of the cores appears leached of calcium-hydroxide. This, in conjunction with abundant secondary deposits (ettringite) present lining/filling a majority of the air-voids, is characteristic of external sulfate attack.

A full-depth crack, oriented perpendicular to the core surfaces, bisects Cores CP1, CP2 and CP3 (nearly full-depth); passing around and through coarse aggregate particles. The crack widths are greatest along the exterior surface of the cores and narrow with depth (towards the interior surface). Multiple cracks observed “branching-off” from the full-depth cracks, with white, secondary deposits lining a majority of the finer cracks.

A lift-line bisects Core CP4 from the exterior surface of the core to the interior surface. A full-depth crack is present along the full-depth of the lift-line and passes predominately around aggregate particles.

Horizontal cracking was observed within the exterior 2 inches (51 mm) of Core CP3. The cracks pass through and around coarse aggregate particles. Randomly oriented microcracking was observed within the paste of all four (4) cores.

Depth of paste carbonation in Cores CP1, CP2, CP3 and CP4 measured from the exterior surface, ranges from approximately 0.2 to 0.3 inches (5-8 mm), with minimal to no paste carbonation along the interior surfaces of the cores.

LABORATORY STUDIES

Compressive Strength Testing: The compression strength testing was performed in general accordance with applicable provisions of ASTM Standard C42 - *Standard Test Method for Obtaining and Testing Drilled Cores of Concrete*.

Refer to Table 2 below for the results of compression testing.

Table 2 - Compressive Strength Test Results

Core ID	**Length, L (in.)**	**Diameter, D (in.)**	**L/D: Correction Factor:**	**Total Load (lbs)**	**Uncorrected Compressive Strength (psi)**	**Corrected Compressive Strength (psi)**
CS1	4.44	2.75	1.61 0.97	33,660	5,670	**5,500**
CS2-B	7.12	3.70	1.92 0.99	46,330	4,310	**4,270**
CS3	7.25	3.70	1.96 0.99	92,250	8,580	**8,500**
Remarks: The cores were tested in air-dry conditions.						

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F 847-459-9015

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Chloride Content Analysis: The analysis was performed in general accordance with the applicable provisions of ASTM Standard C1218 - *Standard Test Method for Water-Soluble Chloride in Mortar and Concrete*.

Refer to Table 3 below for results of chloride content analysis.

Table 3 - Water-Soluble Chloride Content Analysis Results

Core ID	**Level Tested from Top**	**Chloride (CL^-) Content**		
		CL^- by weight of concrete (PPM)*	CL^- by weight of concrete (%)	**CL^- by weight of cement (%)***
CP1	0 to 1 in. (0-25 mm)	60	0.006	**0.04**
	1 to 2 in. (25-51 mm)	40	0.004	**0.03**
	2 to 3 in. (51-76 mm)	20	0.002	**0.01**
CP2	0 to 1 in. (0-25 mm)	40	0.004	**0.03**
	1 to 2 in. (25-51 mm)	20	0.002	**0.01**
	2 to 3 in. (51-76 mm)	20	0.002	**0.01**
CP3	0 to 1 in. (0-25 mm)	60	0.006	**0.04**
	1 to 2 in. (25-51 mm)	40	0.004	**0.03**
	2 to 3 in. (51-76 mm)	30	0.003	**0.02**
CP4	0 to 1 in. (0-25 mm)	60	0.006	**0.04**
	1 to 2 in. (25-51 mm)	40	0.004	**0.03**
	2 to 3 in. (51-76 mm)	30	0.003	**0.02**
*Assumed cement content 600 lbs/cu.yd. and U.W. = 3900 pcy.				

Petrographic Examination: The examination was performed in general accordance with applicable provisions of ASTM Standard C856 - *Standard Practice for Petrographic Examination of Hardened Concrete*.

Individual results of the petrographic examination are summarized below.

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F 847-459-9015	HOUSTON	281.446.7363
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Core Sample CP1 (NW Quadrant)

General

The core is 2.7 inches (69 mm) in diameter and 5.8 inches (147 mm) long; full wall thickness. The exterior surface of the core is relatively flat and worn, with exposed fine aggregate particles. A crack bisects the exterior surface of the core and appears to be filled/lined with a crack-filler. The interior surface of the core is irregular with exposed coarse and fine aggregate particles – paste appears discolored/lighter. The concrete is fairly well consolidated with no signs of segregation.

Figure 1 – Core CP1 as received for examination (exterior surface oriented to the left).

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Reinforcement

None present in core sample.

Deterioration/Cracking

Paste along the interior surface of the core is discolored light beige and is weak and friable – crumbles easily. Abundant coarse aggregate exposed along the interior surface of the core – aggregate not fractured or broken suggesting the removal of paste around the aggregate due to deterioration (sulfate or sulfuric acid attack).

Full-depth crack (oriented perpendicular to the exterior surface) observed bisecting the core – passing both through and around coarse aggregate. The crack width is greater along the exterior surface of the core and narrows with depth (towards the interior surface of the core). Microcracks observed "branching" off of the full-depth crack – some cracks filled with white secondary deposits.

Randomly oriented microcracking observed throughout the paste.

Unit Weight

The unit weight of the concrete sample, as received, is 142.3pcf.

Air Content

The concrete is air-entrained having an air content estimated at **3-5**%, with a majority of the voids filled with secondary deposits.

Paste Properties

Physical Paste Properties (stereomicroscope)	
Color	Medium beige-gray
Hardness	Moderately Hard
Luster	Dull to Sub-vitreous
Paste Volume	Average
Microscopical Paste Morphology (petrographic microscope)	
Portland Cement	Residual Clinker Particles
Supplementary Cementitious Material	Fly Ash
Calcium Hydroxide	Leached near interior core surface
Hydration	Normal

Secondary Deposits

Abundant white, secondary deposits (ettringite) observed lining/filling cracks and voids.

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Carbonation

Depth of paste carbonation, measured from the exterior surface of the core, is approximately 0.2 inches (5 mm). Minimal to no paste carbonation observed along the interior surface of the core.

Water-Cementitious Materials Ratio

The water-cementitious materials ratio is estimated at moderate to moderately-low.

Paste-Aggregate Bond

The paste-aggregate bond is moderately weak; fractures created in the laboratory mainly pass around coarse aggregate particles.

Aggregate

The aggregate is fairly well-graded and uniformly distributed. The aggregate appears sound exhibiting no evidence of deleterious reactions with the paste.

The coarse aggregate is a siliceous river rock mix with a 3/4-inch (20 mm) top size. The aggregate particles are predominately rounded with a blocky to elongate sphericity.

The fine aggregate is sand composed primarily of quartz, with minor amounts of other minerals and rocks. Individual sand grains are angular to well-rounded, and range from irregular/blocky to spherical in shape.

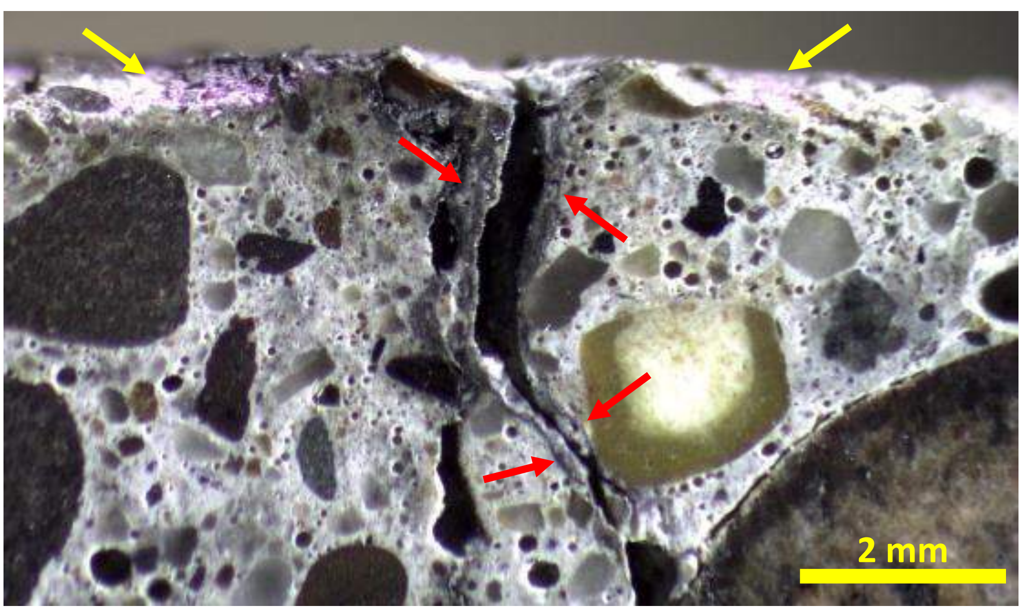

Figure 2 – Photomicrograph illustrating a portion of the full-depth crack in Core CP1. Yellow arrows denote exterior surface of the core. Red arrows indication crack-filler lining the crack surfaces.

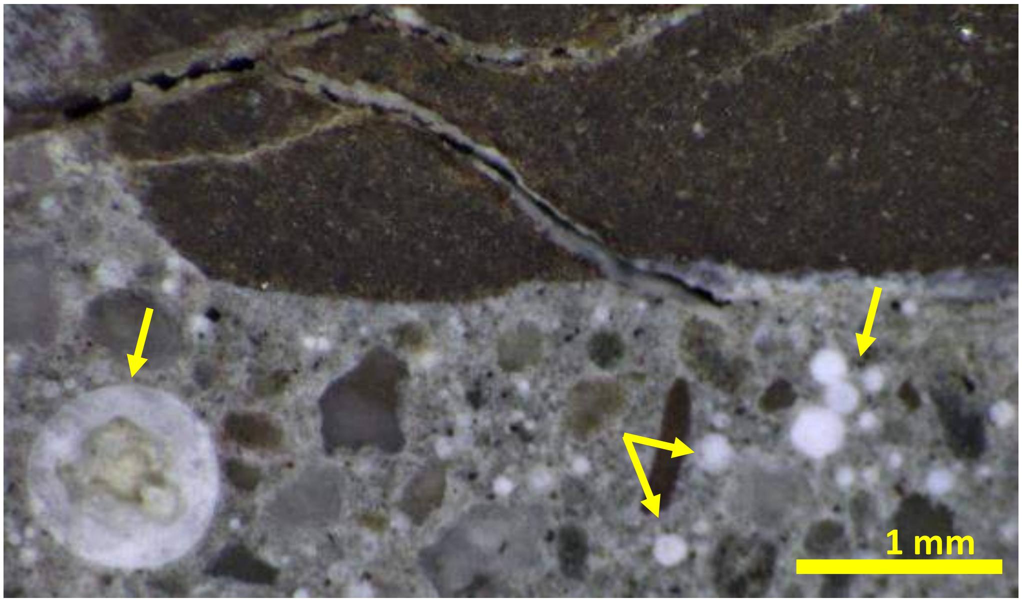

Figure 3 – Photomicrograph illustrating air-voids located along the full-depth crack in Core CP1 filled with white, secondary deposits (yellow arrows).

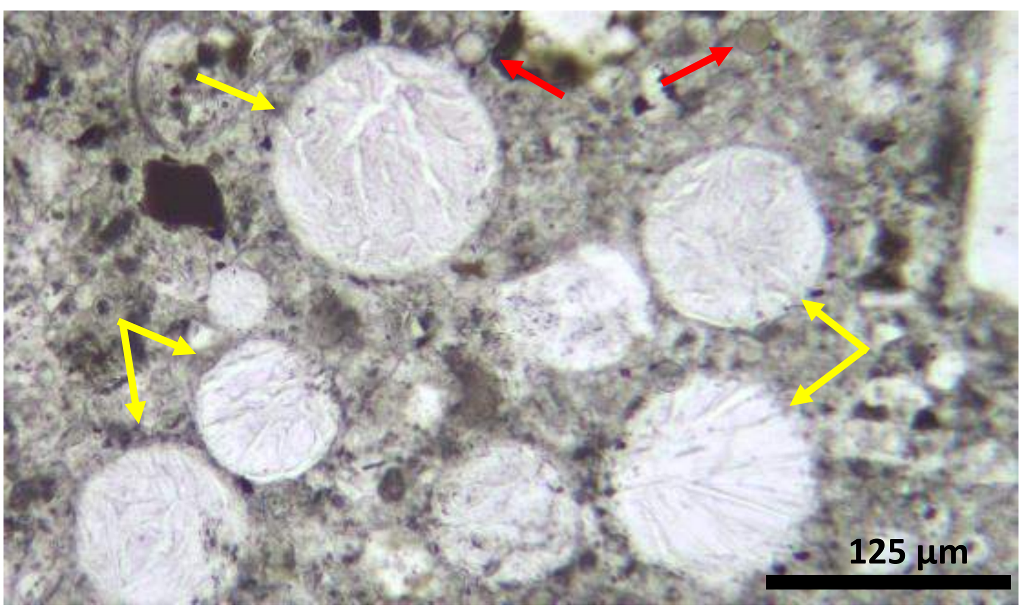

Figure 4 – Thin-section photomicrograph illustrating the hardened cementitious-paste microstructure in Core CP1 (200X magnification, plane-polarized light). Red arrows indicate fly ash particles. Yellow arrows indicate air-voids filled with secondary deposits.

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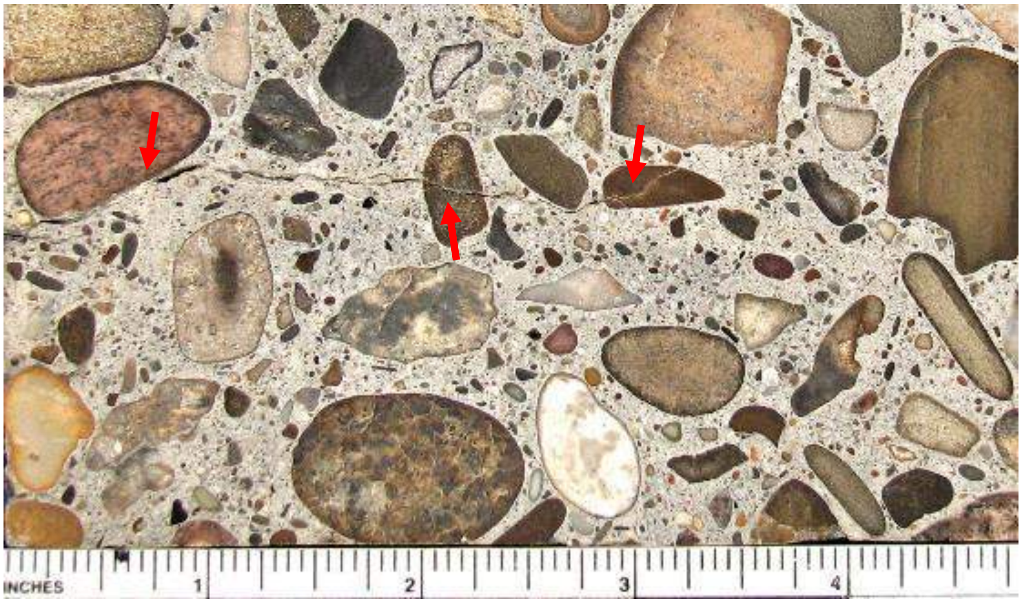

Figure 5 – Photomicrograph illustrating the condition and distribution of the aggregate in Core CP1 (exterior surface oriented to the left). Note full-depth crack that bisects the core and passes through and around coarse aggregate particles (red arrows).

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F 847-459-9015	HOUSTON	281.446.7363
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Core Sample CP2 (NW Quadrant)

General

The core is 2.7 inches (69 mm) in diameter and 5.5 inches (140 mm) long; full wall thickness. The exterior surface of the core is relatively flat and worn, with exposed fine aggregate particles. A crack bisects the exterior surface of the core and appears to be filled/lined with a crack filler. The interior surface of the core is irregular with exposed coarse and fine aggregate particles – paste appears discolored/lighter. The concrete is fairly well consolidated with no signs of segregation.

Figure 6 – Core CP2 as received for examination (exterior surface oriented to the left).

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Reinforcement

None present in core sample.

Cracks

Paste along the interior surface of the core is discolored light beige and is weak and friable – crumbles easily. Abundant coarse aggregate exposed along the interior surface of the core – aggregate not fractured or broken suggesting the removal of paste around the aggregate due to deterioration (sulfate or sulfuric acid attack).

Full-depth crack (oriented perpendicular to the exterior surface) observed bisecting the core – passing both through and around coarse aggregate. The crack width is greater along the exterior surface of the core and narrows with depth (towards the interior surface of the core). Microcracks observed “branching” off of the full-depth crack – some cracks filled with white secondary deposits.

Randomly oriented microcracking observed throughout the paste.

Unit Weight

The unit weight of the concrete sample (SSD), as received, is 144.7 pcf.

Air Content

The concrete is marginally air-entrained having an air content estimated at **2-4**%, with a majority of the voids filled with secondary deposits.

Paste Properties

Physical Paste Properties (stereomicroscope)	
Color	Medium to Dark Beige
Hardness	Moderately Hard
Luster	Dull to Sub-vitreous
Paste Volume	Average
Microscopical Paste Morphology (petrographic microscope)	
Portland Cement	Residual Clinker Particles
Supplementary Cementitious Material	Fly Ash
Calcium Hydroxide	Leached near interior core surface
Hydration	Normal

Secondary Deposits

Abundant white, secondary deposits (ettringite) observed lining/filling cracks and voids.

Carbonation

Depth of paste carbonation, measured from the exterior surface of the core, is approximately 0.3 inches (8 mm). Minimal to no paste carbonation observed along the interior surface of the core.

Water-Cementitious Materials Ratio

The water-cementitious materials ratio is estimated at moderate to moderately-low.

Paste-Aggregate Bond

The paste-aggregate bond is moderately weak; fractures created in the laboratory mainly pass around coarse aggregate particles.

Aggregate

The aggregate is fairly well-graded and uniformly distributed. The aggregate appears sound exhibiting no evidence of deleterious reactions with the paste.

The coarse aggregate is a siliceous river rock mix with a 3/4-inch (20 mm) top size. The aggregate particles are predominately rounded with a blocky to elongate sphericity.

The fine aggregate is sand composed primarily of quartz, with minor amounts of other minerals and rocks. Individual sand grains are angular to well-rounded, and range from irregular/blocky to spherical in shape.

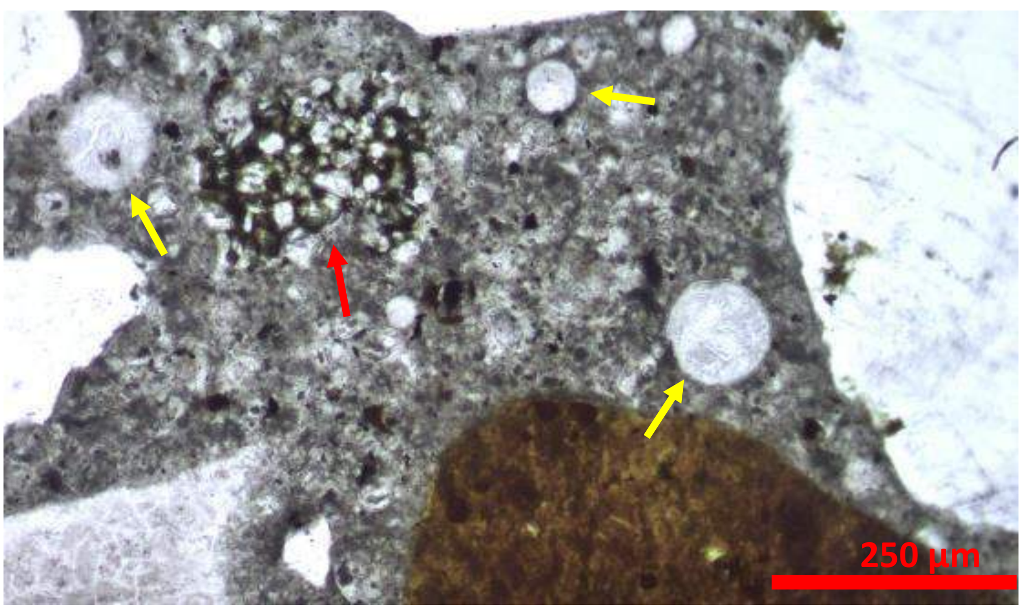

Figure 7 – Thin-section photomicrograph showing the hardened cementitious-paste microstructure in Core CP2 (100X magnification, plane-polarized light). Red arrow indicates residual cement grain. Yellow arrows indicate voids filled with secondary deposits.

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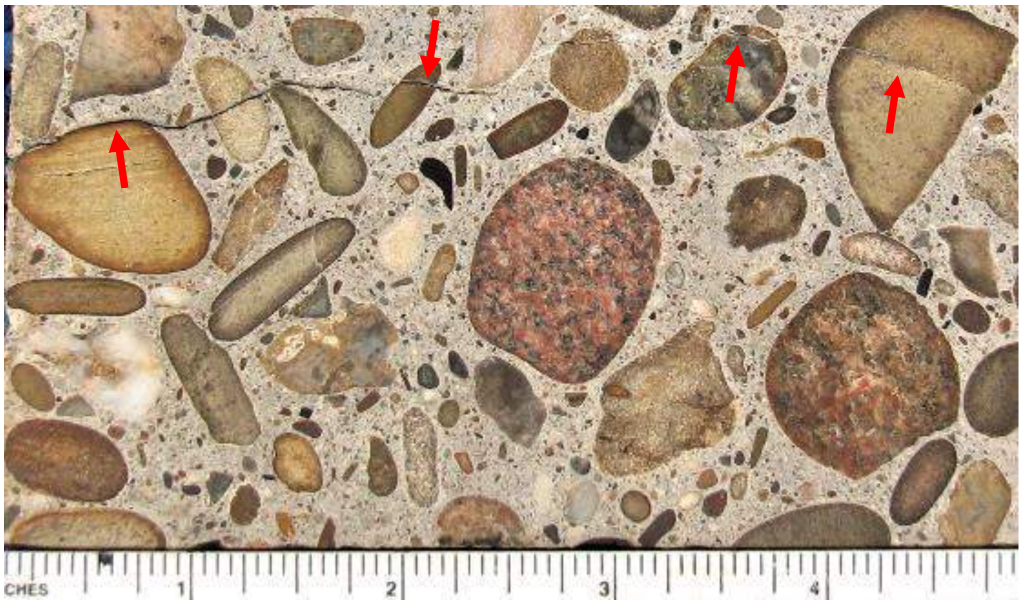

Figure 8 – Photomicrograph illustrating the condition and distribution of the aggregate in Core CP2 (exterior surface oriented to the left). Note full-depth crack that bisects the core and passes through and around coarse aggregate particles (red arrows).

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Core Sample CP3 (SE Quadrant)

General

The core is 2.7 inches (69 mm) in diameter and 5.6 inches (142 mm) long; full wall thickness. The exterior surface of the core is relatively flat and worn, with exposed fine aggregate particles. Multiple fractures/separations present along the exterior surface of the core. The interior surface of the core is irregular with exposed coarse and fine aggregate particles – paste appears discolored/lighter. The concrete is fairly well consolidated with no signs of segregation.

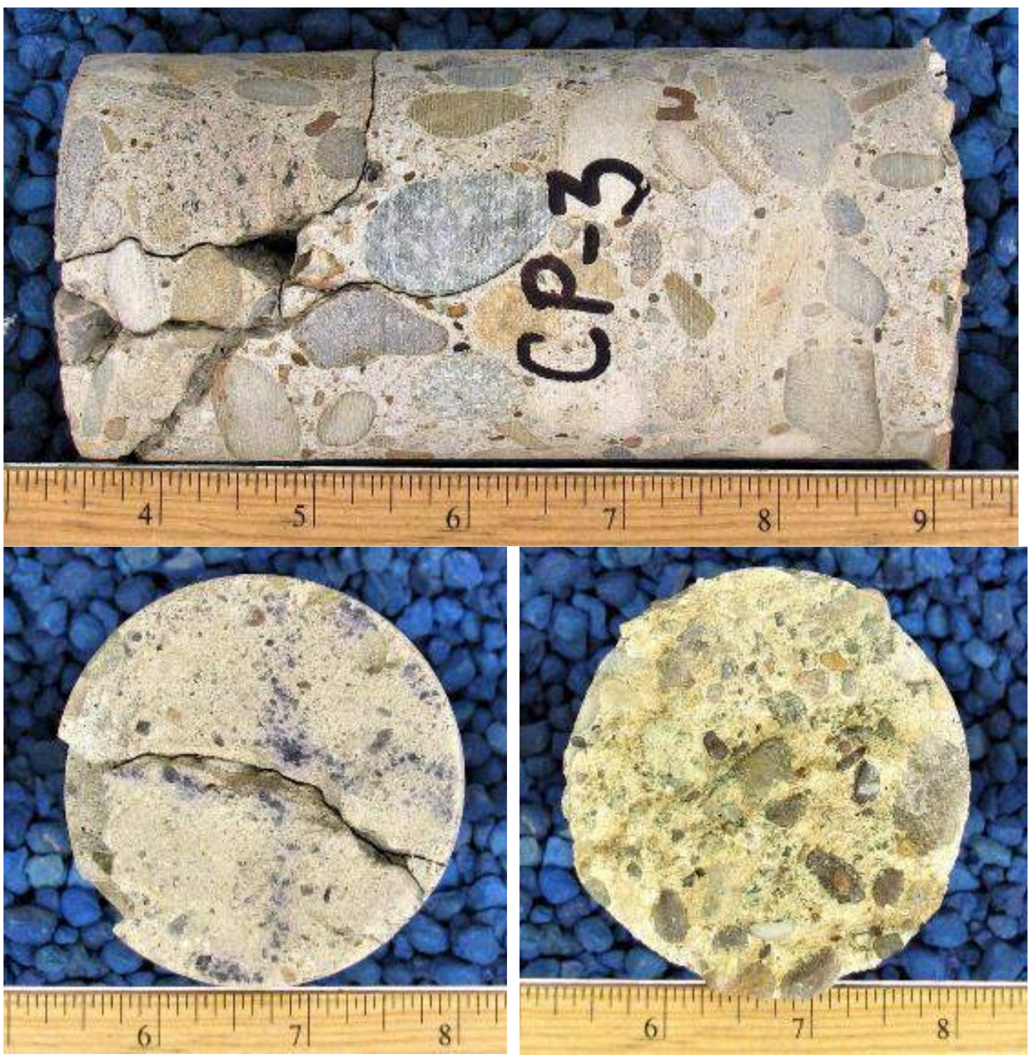

Figure 9 – Core CP3 as received for examination (exterior surface oriented to the left).

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Reinforcement

None present in core sample.

Deterioration/Cracking

Paste along the interior surface of the core is discolored light beige and is weak and friable – crumbles easily. Abundant coarse aggregate exposed along the interior surface of the core – aggregate not fractured or broken suggesting the removal of paste around the aggregate due to deterioration (sulfate or sulfuric acid attack).

Large crack (oriented perpendicular to the exterior surface) observed extending from the exterior surface of the core to a depth of approximately 4.7 inches (119) – passing through and around aggregate particles. The crack width is greater along the exterior surface of the core and narrows with depth (towards the interior surface of the core). Microcracks observed "branching" off of the full-depth crack – some cracks filled with white secondary deposits. Horizontal cracking (oriented parallel to sub-parallel to the exterior surface of the core) observed within the exterior 2 inches (51 mm) of the core.

Randomly oriented microcracking observed throughout the paste.

Unit Weight

The unit weight of the concrete sample, as received, is 143.6pcf.

Air Content

The concrete is air-entrained having an air content estimated at **5-7**%. Some of the voids are filled with secondary deposits.

Paste Properties

Physical Paste Properties (stereomicroscope)	
Color	Medium beige-gray
Hardness	Moderately Hard
Luster	Dull to Sub-vitreous
Paste Volume	Average
Microscopical Paste Morphology (petrographic microscope)	
Portland Cement	Residual Clinker Particles
Supplementary Cementitious Material	Fly Ash
Calcium Hydroxide	Leached near interior core surface
Hydration	Normal

Secondary Deposits

Abundant white, secondary deposits (ettringite) observed lining/filling cracks and voids.

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Carbonation

Depth of paste carbonation, measured from the exterior surface of the core, is approximately 0.3 inches (8 mm). Minimal to no paste carbonation observed along the interior surface of the core.

Water-Cementitious Materials Ratio

The water-cementitious materials ratio is estimated at moderate to moderately-low.

Paste-Aggregate Bond

The paste-aggregate bond is moderately weak; fractures created in the laboratory mainly pass around coarse aggregate particles.

Aggregate

The aggregate is fairly well-graded and uniformly distributed. The aggregate appears sound exhibiting no evidence of deleterious reactions with the paste.

The coarse aggregate is a siliceous river rock mix with a 3/4-inch (20 mm) top size. The aggregate particles are predominately rounded with a blocky to elongate sphericity.

The fine aggregate is sand composed primarily of quartz, with minor amounts of other minerals and rocks. Individual sand grains are angular to well-rounded, and range from irregular/blocky to spherical in shape.

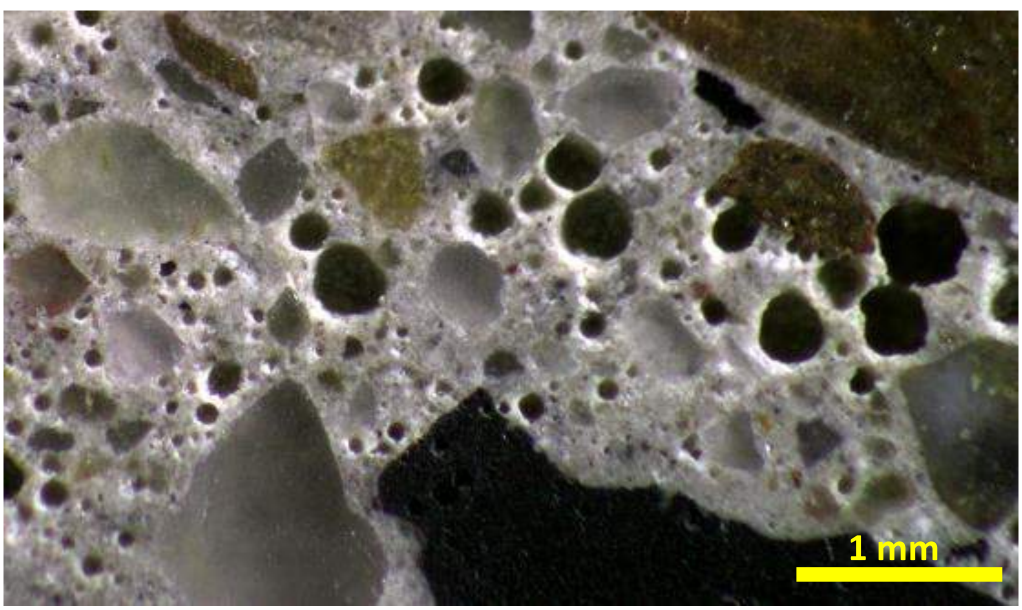

Figure 10 – Photomicrograph illustrating the air-void system in Core CP3 within the exterior 2 inches (51 mm) of the core where minimal secondary deposits are present.

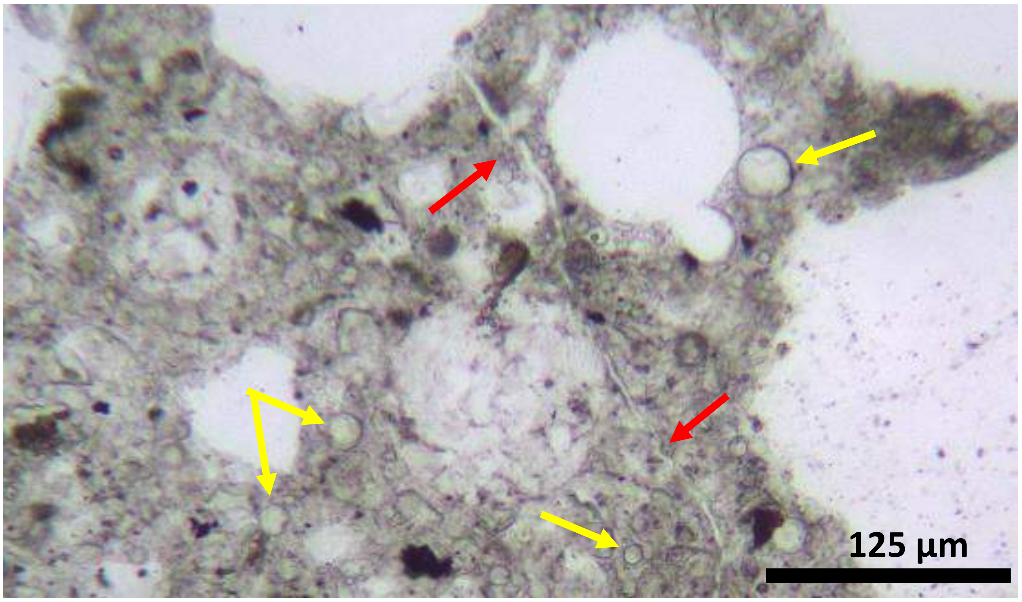

Figure 11 – Thin-section photomicrograph illustrating the hardened cementitious-paste microstructure in Core CP3 (200X magnification, plane-polarized light). Red arrows indicate micro-cracking within the paste. Yellow arrows indicate fly ash particles.

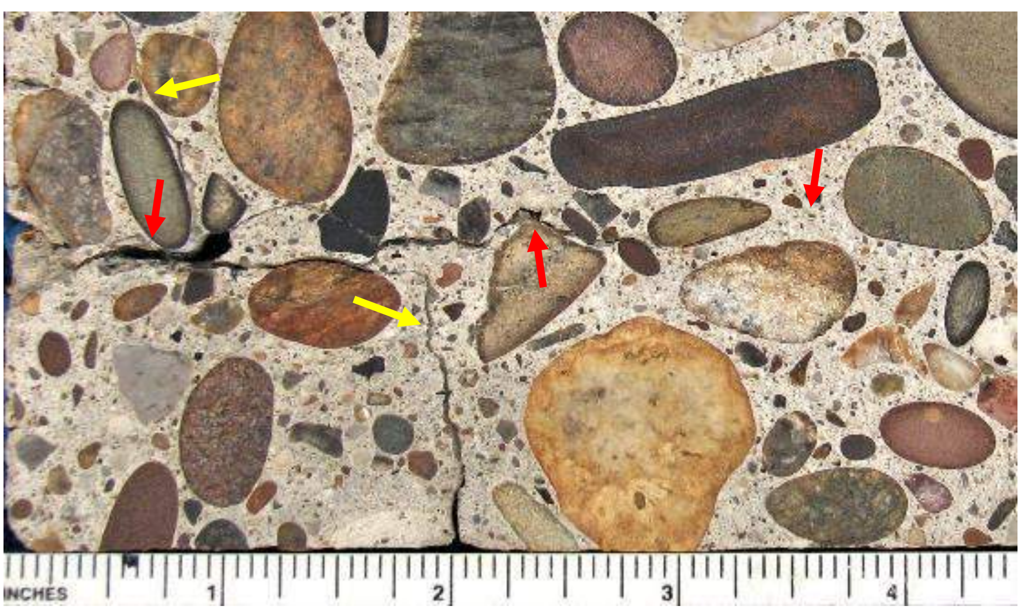

Figure 12 – Photomicrograph illustrating the condition and distribution of the aggregate in Core CP3 (exterior surface oriented to the left). Note cracking that bisects the core and passes through and around coarse aggregate particles (red arrows), as well as horizontal cracking (yellow arrows).

Core Sample CP4 (SE Quadrant)

General

The core is 2.7 inches (69 mm) in diameter and 5.2 inches (132 mm) long; full wall thickness. The exterior surface of the core is relatively flat and worn, with exposed fine aggregate particles. A crack bisects the exterior surface of the core and appears to be filled/lined with a crack-filler. The interior surface of the core is irregular with exposed coarse and fine aggregate particles – paste appears discolored/lighter. The concrete is fairly well consolidated with no signs of segregation.

Figure 13 – Core CP4 as received for examination (exterior surface oriented to the left).

Reinforcement

None present in core sample.

Deterioration/Cracking

Paste along the interior surface of the core is discolored light beige and is weak and friable – crumbles easily. Abundant coarse aggregate exposed along the interior surface of the core – aggregate not fractured or broken suggesting the removal of paste around the aggregate due to deterioration (sulfate or sulfuric acid attack).

A lift-line is present bisecting the full-length of the core – extending from the exterior surface of the core to the interior surface. A full-depth crack located along the lift-line (mostly) passing around aggregate particles. Microcracks observed “branching” off of the full-depth crack – some cracks filled with white secondary deposits.

Randomly oriented microcracking observed throughout the paste.

Unit Weight

The unit weight of the concrete sample, as received, is 142.6pcf.

Air Content

The concrete is air-entrained having an air content estimated at **3-5**%, with a majority of the voids filled with secondary deposits.

Paste Properties

Physical Paste Properties (stereomicroscope)	
Color	Medium beige-gray to medium gray
Hardness	Moderately Hard
Luster	Dull to Sub-vitreous
Paste Volume	Average
Microscopical Paste Morphology (petrographic microscope)	
Portland Cement	Residual Clinker Particles
Supplementary Cementitious Material	Fly Ash
Calcium Hydroxide	Small-size crystals (exterior surface)
Hydration	Normal

Secondary Deposits

Abundant white, secondary deposits (ettringite) observed lining/filling cracks and voids.

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CHICAGO 61 Garlisch Dr. Elk Grove Village, IL60007 P 847-459-9090 F 847-459-9015	DALLAS / FT WORTH 972.432.6666 SAN ANTONIO / SO. TEXAS 210.775.1637 AUSTIN / WACO 512.551.0336 HOUSTON 281.446.7363 MIAMI 954.676.4147

Carbonation

Depth of paste carbonation, measured from the exterior surface of the core, is approximately 0.1 inches (3 mm). Minimal to no paste carbonation observed along the interior surface of the core.

Water-Cementitious Materials Ratio

The water-cementitious materials ratio is estimated at moderate to moderately-low.

Paste-Aggregate Bond

The paste-aggregate bond is moderately weak; fractures created in the laboratory mainly pass around coarse aggregate particles.

Aggregate

The aggregate is fairly well-graded and uniformly distributed. The aggregate appears sound exhibiting no evidence of deleterious reactions with the paste.

The coarse aggregate is a siliceous river rock mix with a 3/4-inch (20 mm) top size. The aggregate particles are predominately rounded with a blocky to elongate sphericity.

The fine aggregate is sand composed primarily of quartz, with minor amounts of other minerals and rocks. Individual sand grains are angular to well-rounded, and range from irregular/blocky to spherical in shape.

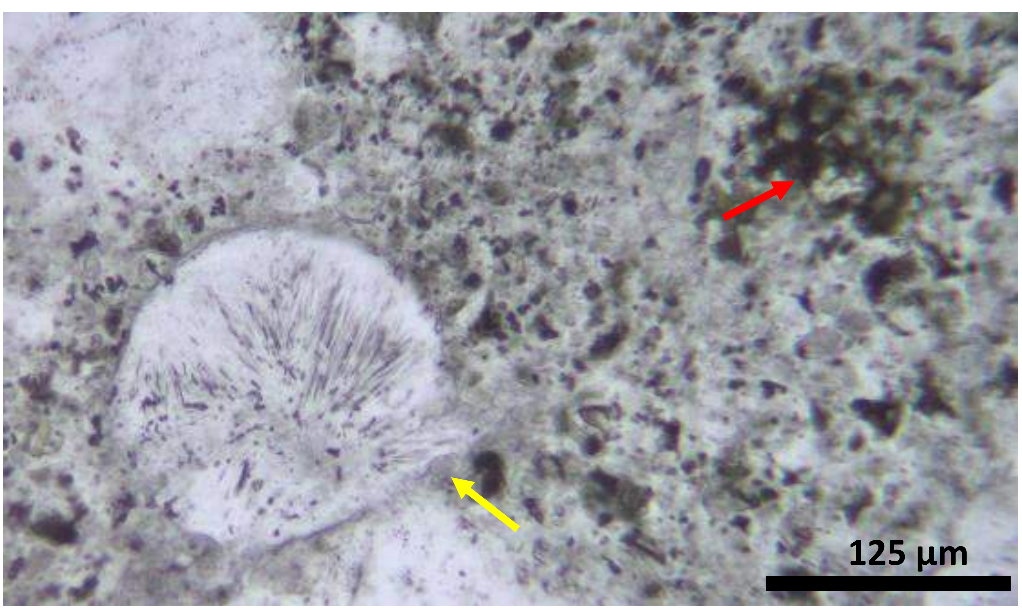

Figure 14 – Thin-section photomicrograph illustrating the hardened cementitious-paste microstructure in Core CP4 (200X magnification, plane-polarized light). Red arrow indicates residual cement grain. Yellow arrow indicates air-void filled with secondary deposits.

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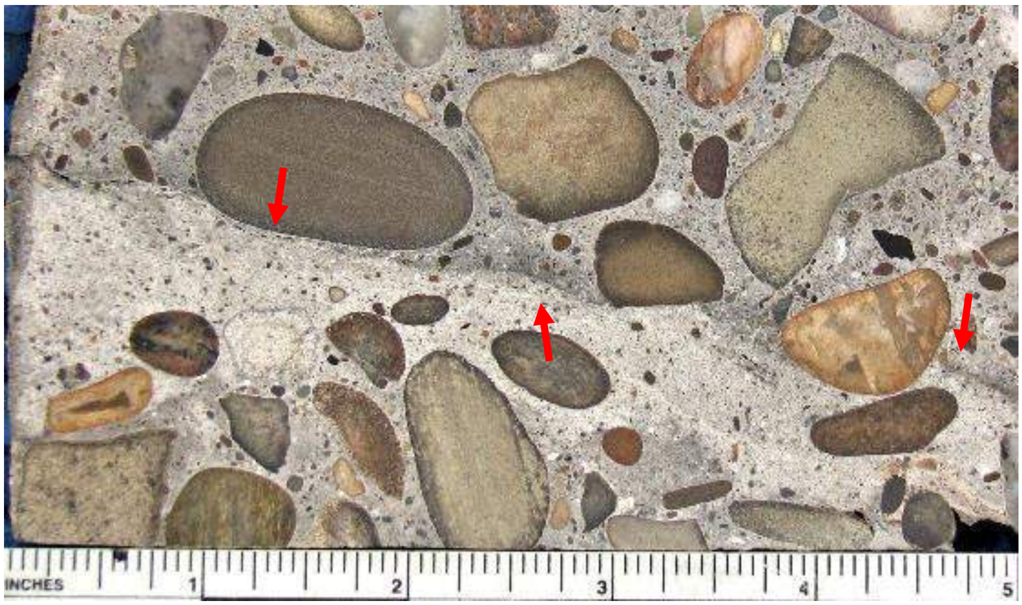


Figure 15 – Photomicrograph illustrating the condition and distribution of the aggregate in Core CP4 (exterior surface oriented to the left). Note lift-line bisecting the full-depth of the core (red arrows).

****

We appreciate the opportunity to be of service to you. Should you have any questions, please do not hesitate to contact us.

Sincerely yours,

Universal Construction Testing, Ltd.

Jacqueline Kowalik
Petrographer

Elena I. Emerson
Operations Manager

Sample(s) will be discarded after ninety (90) days unless other disposition is requested by you.

DRONES THAT WORK, LLC

AEP MITCHELL U2 COOLING TOWER AERIAL IMAGING

REPORT AND RECOMMENDATIONS APRIL 16-17, 2016

Wendell Adkins
4/29/2016

AEP MITCHELL UNIT 2

COOLING TOWER AERIAL IMAGING

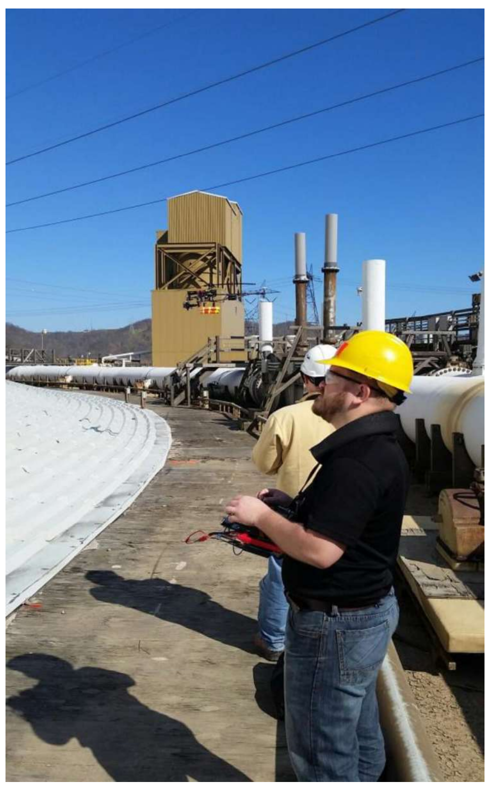
APRIL 16 - 17, 2016

DRONES THAT WORK, LLC

FAA SECTION 333 EXEMPTION #11414

SUMMARY

On April 16-17, 2016 the Drones That Work, LLC team conducted drone aerial imaging of the AEP Mitchell Unit 2 Cooling Tower near Moundsville, West Virginia under request of the AEP Civil Engineering Group. The scope of work included sequential collection of high resolution photographs of 100% of the exterior tower concrete surfaces and four (4) interior vertical runs located approximately 90 degrees apart (N,S,E,W). The individual images collected were then processed and software stitched into vertical runs for ease of scanning. Weather conditions were optimum on both days which resulted in excellent overall image quality.



Drone Pilot and Payload Operator

CONTENTS

PROCESS

The first step of the inspection process is completion of a 75 point risk assessment (JSA) specifically designed for aerial operations and site required safety orientation. Following the crew safety review, mapping of reference benchmarks around the tower base is completed. A total of 25 equally spaced reference numbers were painted along the base walkway located just outside of the fiberglass canopy. Each run is 9 canopy sections wide or every 14.4 degrees around the base circumference. The horizontal and vertical spacing of individual photos required is determined by the photo aspect ratio combined with the amount of overlap required by the stitching software (50% minimum). Reference number 1 (Figure 1) is on conduit located adjacent to the plant side crossover walkway with numerical progression advancing clockwise when viewed from above. In the vertical plane, individual photos are numbered starting at the tower base. For example, photo R25P1 represents the first photo located at the tower base in radial run 25. This reference system is not only required to identify run locations for both the current inspection but as an aide in providing consistent, repeatable results for any future, follow-up inspections performed. In Windows Picture Viewer the reference ID will be displayed in the top left corner when toggling through individual photos.

The stitching software employed is the most advanced currently available but was designed and intended for use with images collected from a camera that pivots from a central fixed location (nodal point) in order to prevent parallax errors. This presents enormous challenges when attempting to collect images from a continuously moving camera platform that is photographing a structure with a continuously changing hyperboloid shape. Drones That Work, LLC has pioneered a total data acquisition process that minimizes these parallax errors in the software stitched vertical image runs provided by manually inserting additional control points between adjacent images at key locations. The resulting vertically oriented image stacks have proven valuable for quickly determining relative spacing between areas of interest but are not void of all stitching errors. When errors are present, horizontal/vertical seams between concrete pours will converge/diverge/misalign relative to neighboring adjacent seams. There is also a moderate loss in image resolution that results from the stitching process. **Considering this, the individual photos at these locations should be reviewed for any final determination of conditions present at any specific locations.**

The four (4) interior runs performed are designated as North, South, East and West in the horizontal plan and also numbered starting with photo 1 located at the base of the concrete structure. (See Marley schematic view markup - Figure 2)

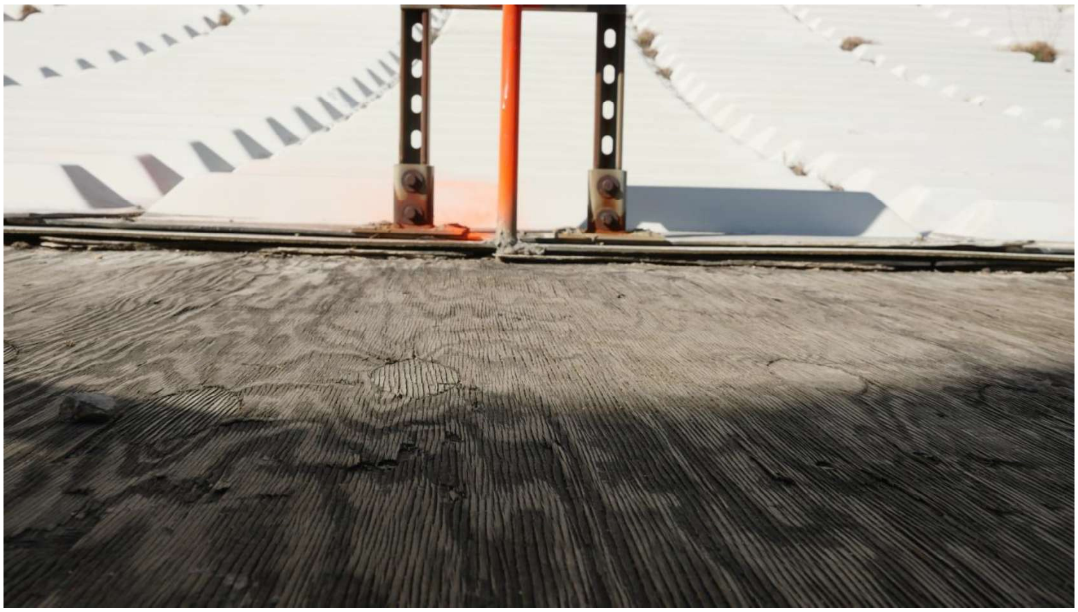


Figure 1 - Run 1 Reference Marking

In the media that accompanies this report will be found all of the stitched vertical runs along with the individual sequentially-captured photographs used to construct them.

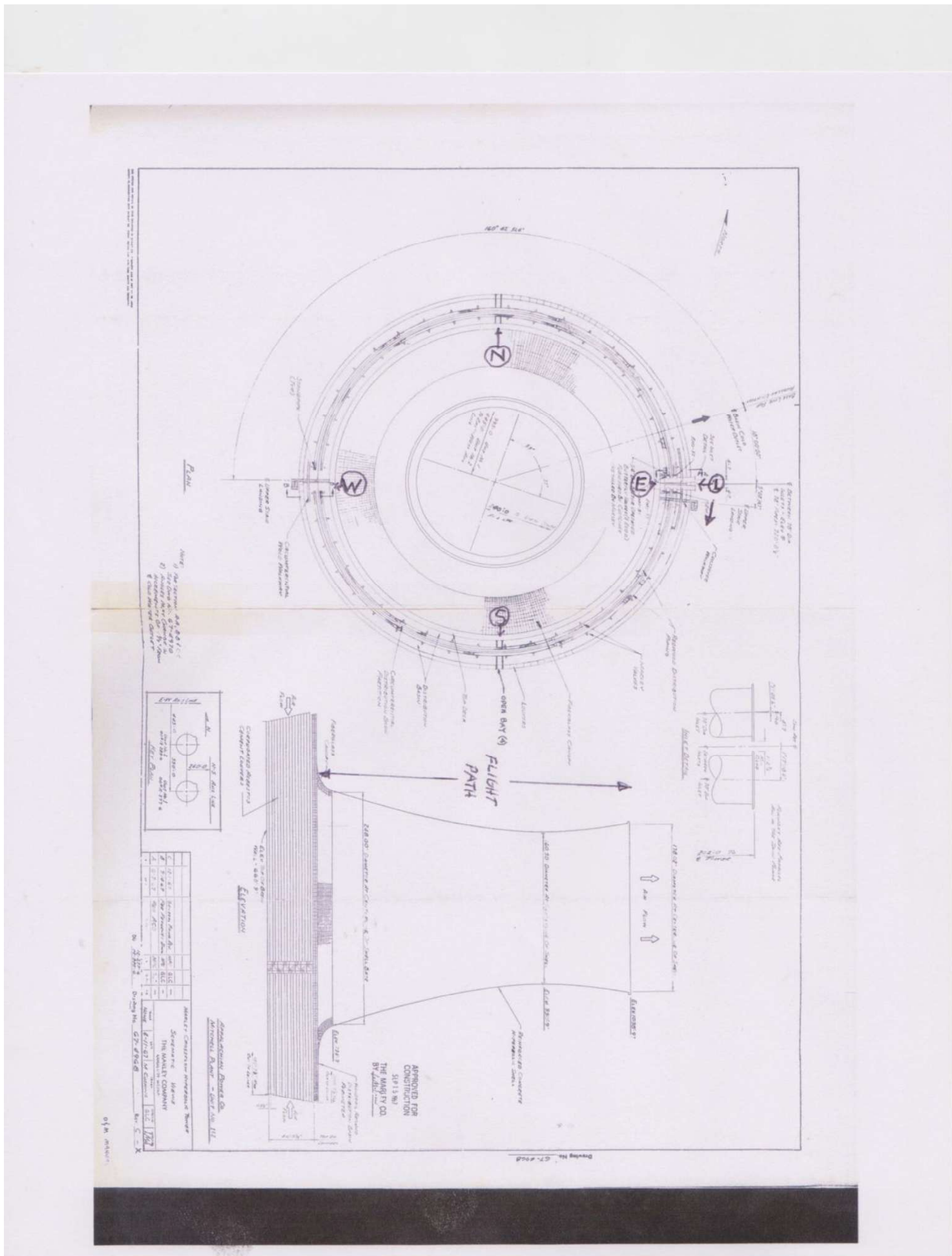


Figure 2 - Reference Marking

EXTERIOR IMAGING

Each stitched imaging run results in a very large file (~35 MB - JPEG) and so is supplied in either DVD or thumb drive formats. They can be easily viewed in most PC viewers like Windows Photo Viewer. Navigation within the viewing window or reduction and enlargement can quickly be performed using a mouse with roll wheel. Depressing and holding the left mouse button allows movement within an enlarged area by dragging the mouse in the desired direction.

The following table summarizes conditions noted from each exterior run:

Run	Conditions as Noted
1.	Numerous areas noted with seepage at mortar joints. Minor spalling noted at R1P45.
2.	Numerous areas noted with seepage at mortar joints. Cracking noted at R2P18, R2P22 and R2P28.
3.	Numerous areas noted with seepage at mortar joints. Minor spalling noted at R3P19. Cracking noted at R3P20, R3P26.
4.	Numerous areas noted with seepage at mortar joints. Fine cracking noted at R4P6, R4P13 and R4P34.
5.	Numerous areas noted with seepage at mortar joints. Fine cracking noted at R5P11, R5P14, R5P25 and R5P31.
6.	Numerous areas noted with seepage at mortar joints. Minor joint spalling noted at R6P1. Minor cracking at R6P11.
7.	Several areas noted with seepage at mortar joints.
8.	Minor joint spalling noted at R8P1. Several areas noted with seepage at mortar joints.
9.	Minor joint spalling noted at R8P1. Several areas noted with seepage at mortar joints. Fine cracking noted at R9P22.
10.	Minor joint spalling noted at R10P1. Numerous areas noted with seepage at mortar joints. Fine cracking noted at R10P32. Minor joint spalling noted at R10P31.
11.	Minor joint spalling noted at R11P1. Numerous areas noted with seepage at mortar joints. Minor joint spalling noted at R11P37.
12.	Numerous areas noted with seepage at mortar joints. Minor non-joint spalling noted at R12P30.
13.	Numerous areas noted with seepage at mortar joints. Minor joint spalling noted at R13P33.
14.	Fine cracking noted at R14P4. Numerous areas noted with seepage at mortar joints. Cracking noted at R14P22 and R14P27.
15.	Numerous areas noted with seepage at mortar joints. Fine cracking noted at R15P4 and R15P10.
16.	Numerous areas noted with seepage at mortar joints. Fine cracking noted at R16P4, R16P9 and R16P25. Minor non-joint spalling noted at R16P28.
17.	Numerous areas noted with seepage at mortar joints. Fine cracking noted at R17P4, R17P9 and R17P20. Minor non-joint spalling noted at R17P34.
18.	Numerous areas noted with seepage at mortar joints. Fine cracking noted at R18P4 and

R18P8. Cracking and large hole at R18P11.

19. Several areas noted with seepage at mortar joints. Several localized areas of cracking and spalling at R19P22.
20. Several areas noted with seepage at mortar joints. Fine cracking noted at R20P4 to R20P6, R20P10, R20P17 to R20P19.
21. Several areas noted with seepage at mortar joints. Fine cracking noted at R21P5 and R21P11. Large areas of deformation/buckling.
22. Several areas noted with seepage at mortar joints. Minor non-joint spalling noted at R22P1. Large areas of deformation/buckling.
23. Several areas noted with seepage at mortar joints. Fine cracking noted at R23P6 to R23P8. Large areas of deformation/buckling.
24. Several areas noted with seepage at mortar joints. Minor non-joint spalling noted at R24P1 and R24P41. Fine cracking noted at R24P3 and R24P20.
25. Several areas noted with seepage at mortar joints. Minor non-joint spalling noted at R25P1. Fine cracking noted at R25P5 and R25P19.

Misc Lightning protection system intact.

INTERIOR IMAGING

The following table summarizes conditions noted from each of the four interior runs:

Run	Conditions as Noted
North	Large hole at North P2
East	Small areas of localized spalling noted at East P5 and P13 (in joint).
South	No significant indications noted.
West	Small areas of localized spalling noted at West P1 and P3.

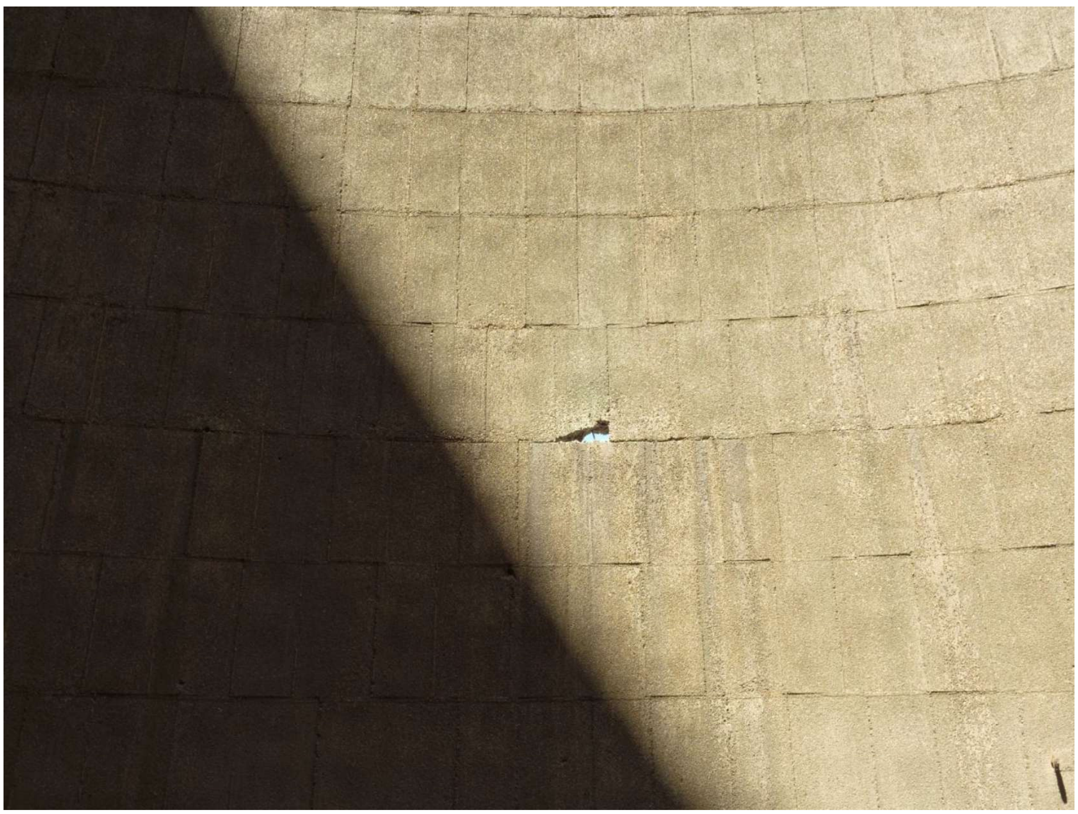


Figure 3 - Hole in North run

Recommendations

1. Possibly the greatest value in performing complete aerial imaging surveys of structural assets is in the establishment of a benchmark condition assessment. The imaging conducted during this inspection can be accurately and repeatedly reproduced at later points in time to look for change. It is recommended that this inspection be repeated at an interval of between 1 - 3 years for this purpose.

2. If the need arises to perform a physical inspection (hammer testing, core samples, etc.) of any areas of the tower, Drones That Work, LLC has pioneered and developed a precision aerial rigging process using drones to assist. A heavy lifting drone is used to haul lead lines up and over the tower at selected locations that can then be used to pull sky climber cables.

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net

Long Range Scan of Cooling Tower

Prepared for:

1 Riverside Plaza
Columbus, OH 43215
614-716-1393

Prepared by: Nick Manning

Approved by: Rob Glassburn, P.E.

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
rglassburn@3d-engineering.net

Date: 5/3/2016

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net

CERTIFICATE OF INSPECTION

CUSTOMER:	American Electric Power 1 Riverside Plaza Columbus, OH 43215 614-716-1393
PO NUMBER:	Verbal
PART DESCRIPTION:	Cooling Tower
UNIT OF MEASURE:	Feet
INSPECTED BY:	Nick Manning & Andrew Sudkamp
INSPECTION EQUIPMENT:	Faro Laser Scanner Focus^{3D} X330 S/N LLS071405659
INSPECTION DATE:	04/13/16

This is to certify that the item listed above was inspected with instrument(s) calibrated with standards traceable to the International System of Units (SI) through a National Metrological Institute (NMI) or an ISO17025 Accredited Laboratory.

Approved by: ______________ Date: 5/3/2016

Rob Glassburn, P.E.
VP of Operations

ENGINEERING SOLUTIONS

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net

Method:

The cooling tower was scanned using a FARO Laser Scanner Focus^{3D} X330. Point cloud data was collected for the tower in a set of individual scans that were brought into FARO Scene. Once imported into FARO Scene the individual scans were aligned to one other with the aid of the on board GPS of the X330. The scan data was then imported into PolyWorks IMInspect.

Two CAD models were created based on the data collected and supplied by the customer. The first CAD model was created using a cross section of the tower located in a "good" section of the tower. A profile of the tower was created in Solidworks by revolving the cross section about a center axis. The second CAD model was created based on the customer supplied drawing that outlined diameters and specific elevations. As with the first model a profile of the tower was created in Solidworks based on the cross section that was made from the supplied dimensions.

Three comparison methods were used in order to show the magnitude of the deviations between the created model and the collected point cloud data. Method one used the first CAD model in the position that it was created in order to compare the data. Method two used the first CAD model as well but this time a best-fit alignment was used to place the data. Finally for method three the second CAD model was used with a best-fit alignment. Color maps for each one of these comparison methods were created and can be found within the report. Points showing the approximate directions of North, South, East, and West were created to use as reference.

Color map screenshots in this report will show a scale on the right side of the image (Please note the scale may change from page to page). Positive deviations mean the scan data is above the CAD model surface; negative deviations mean the scan data are below the CAD model surface. Some areas may appear gray – these areas are either out of the color scale range or do not have data for comparison.

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net

Comparison Method 1
CAD Model 1 in Original Position

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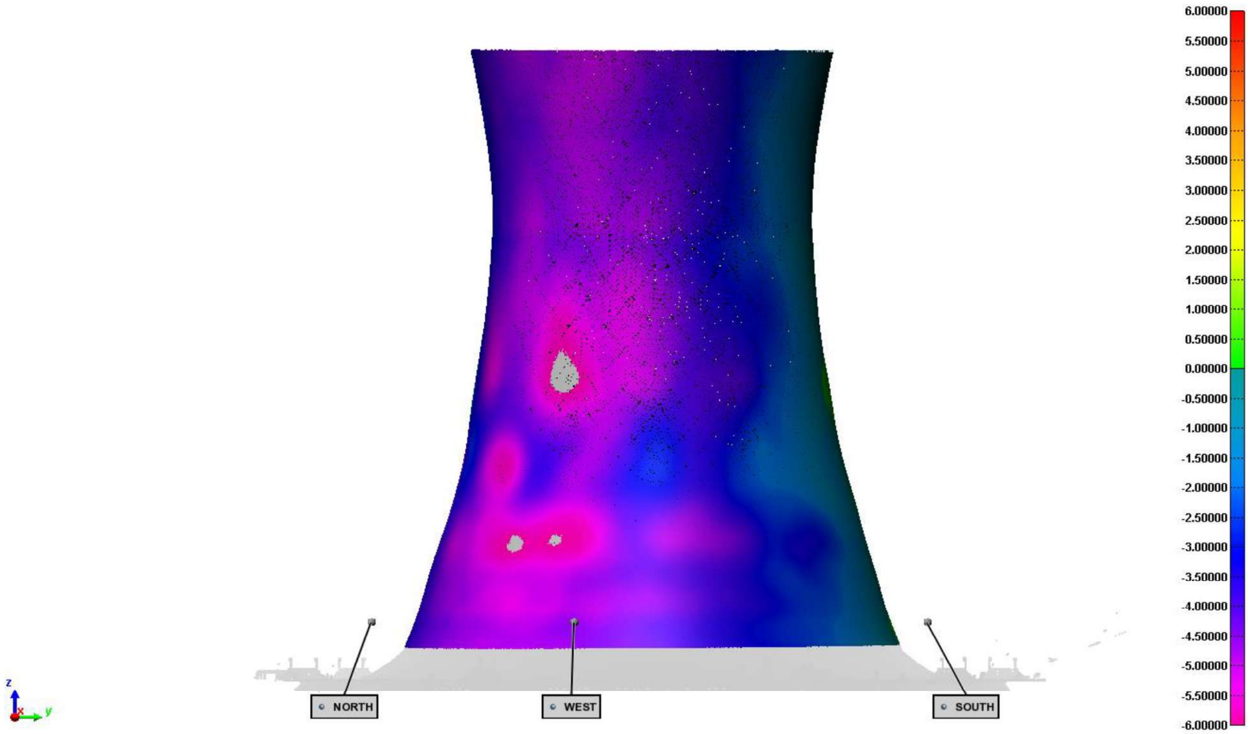
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net



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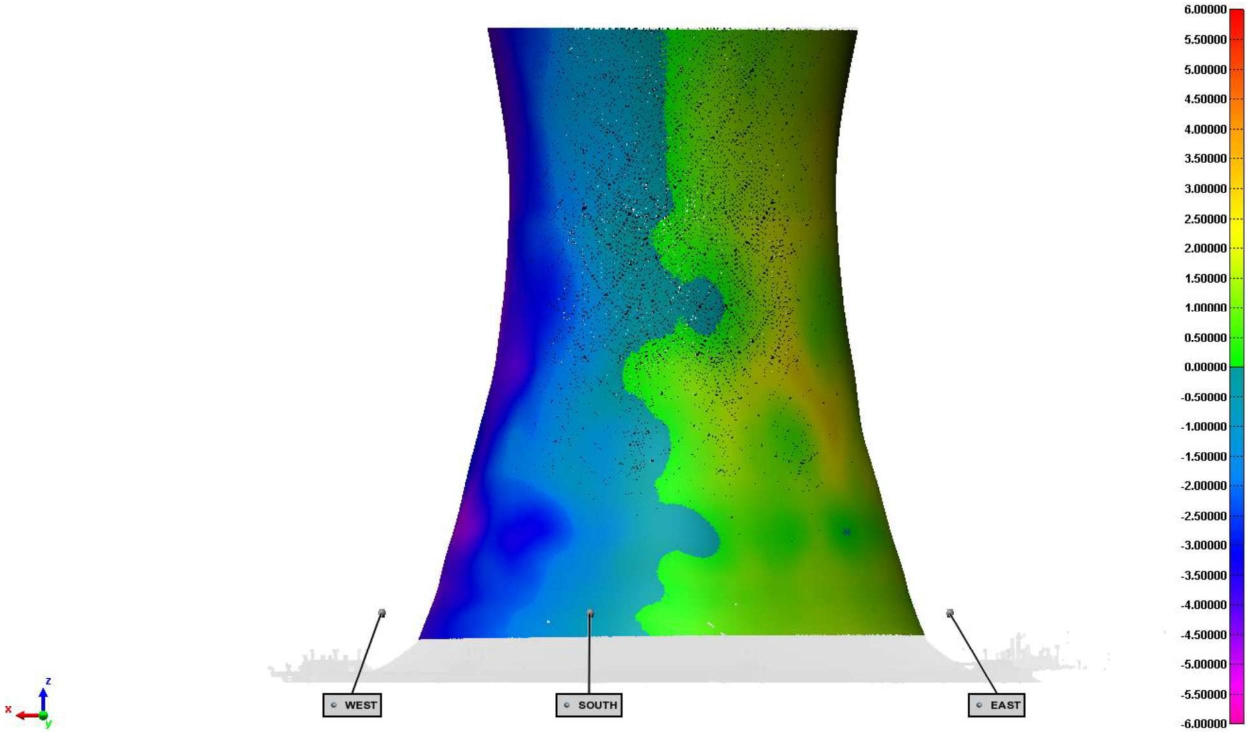

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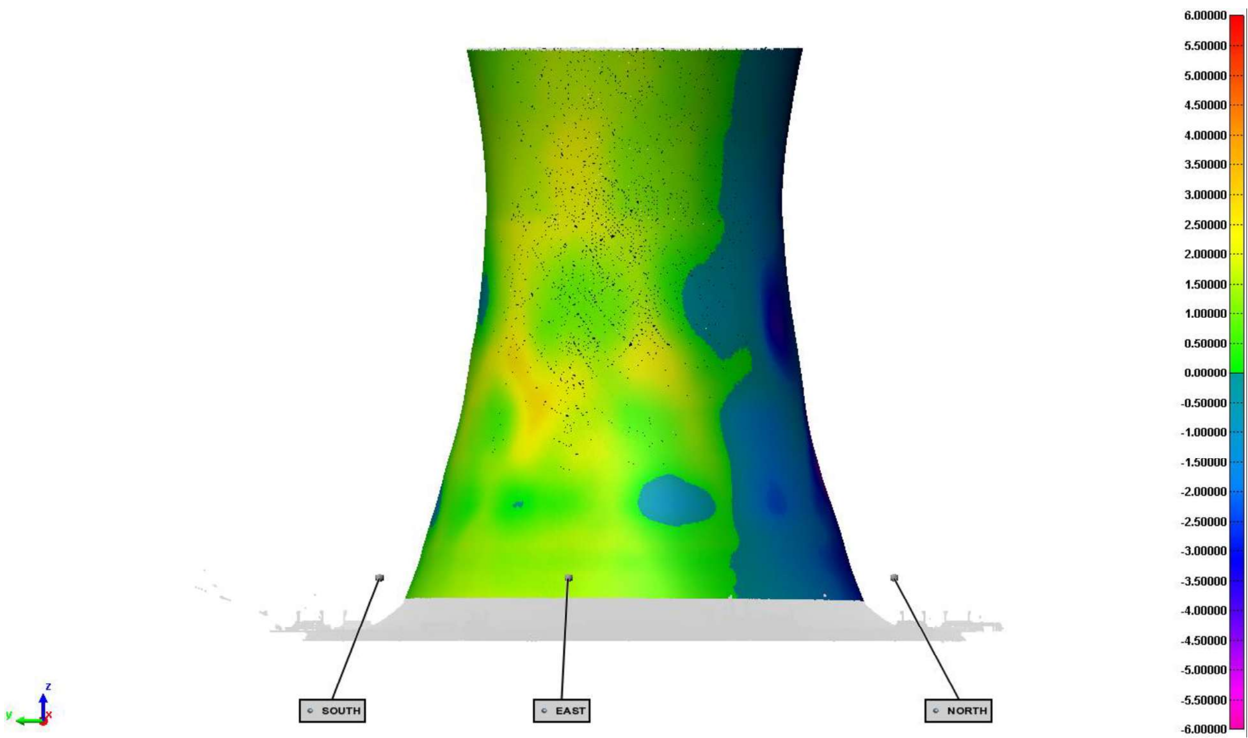
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net



10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net

Comparison Method 2
CAD Model 1 Best Fit Alignment

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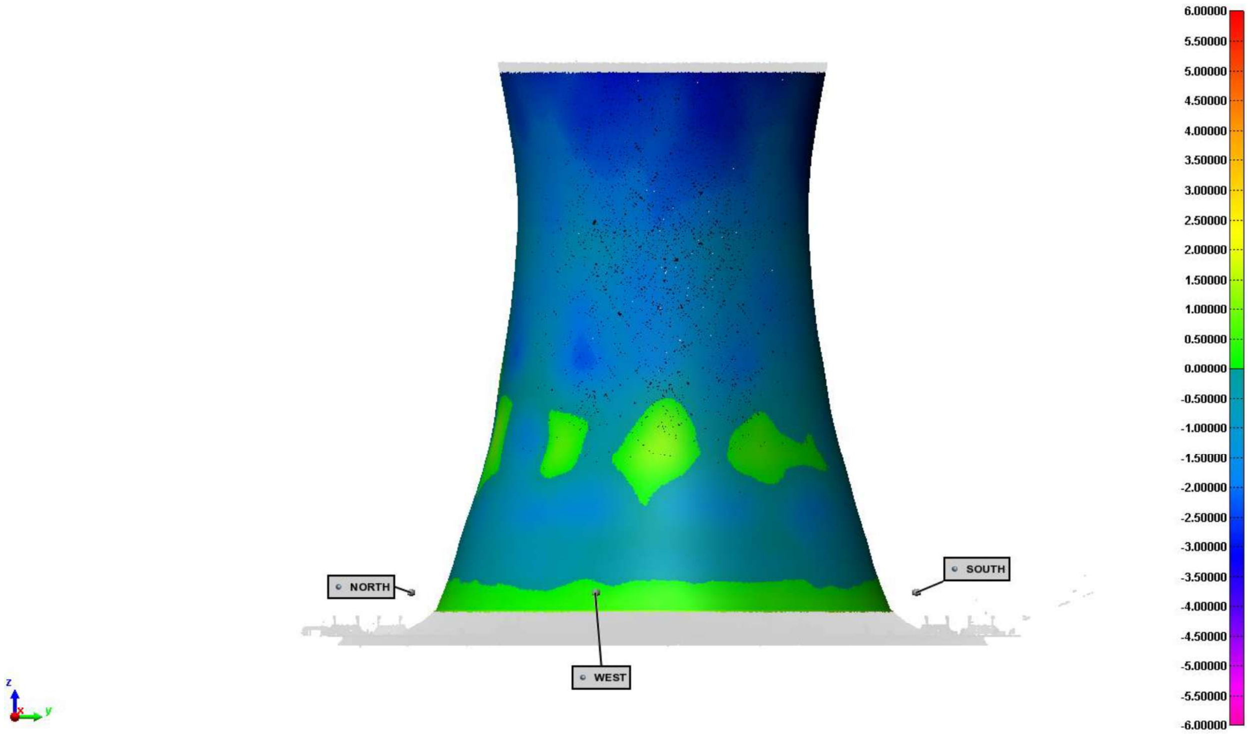
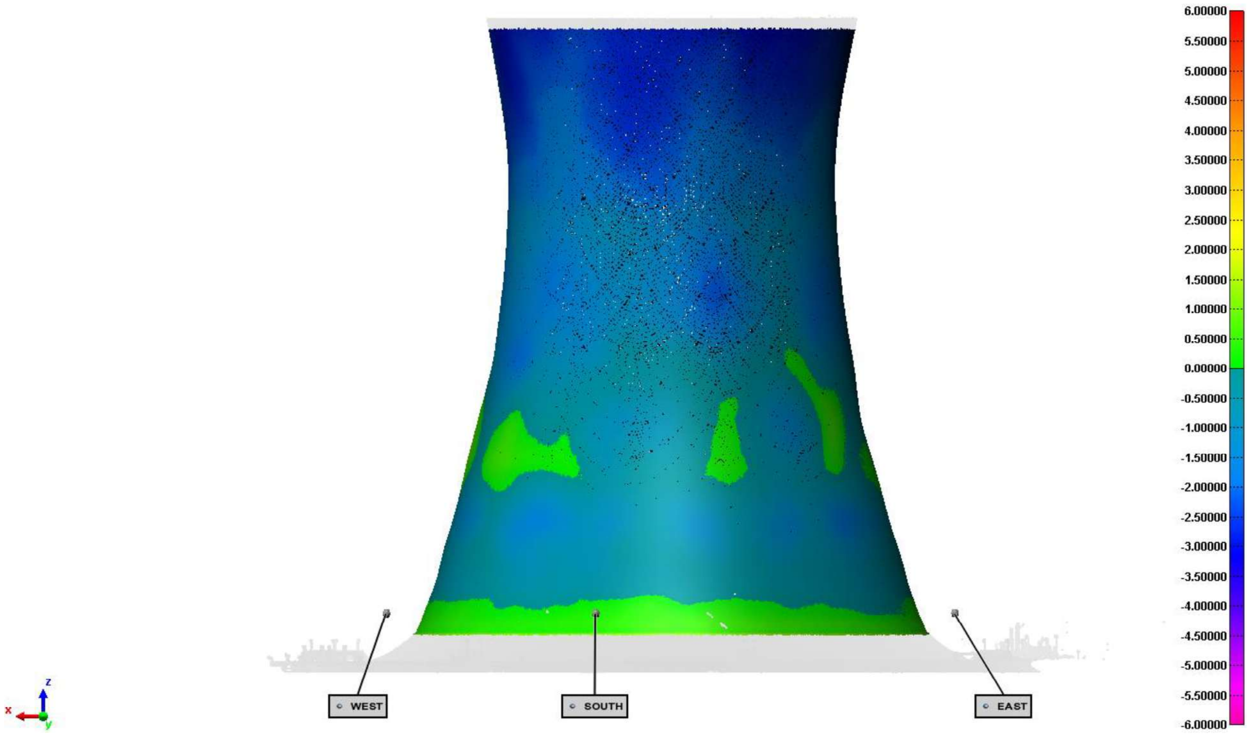
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net



3D Engineering Solutions
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net



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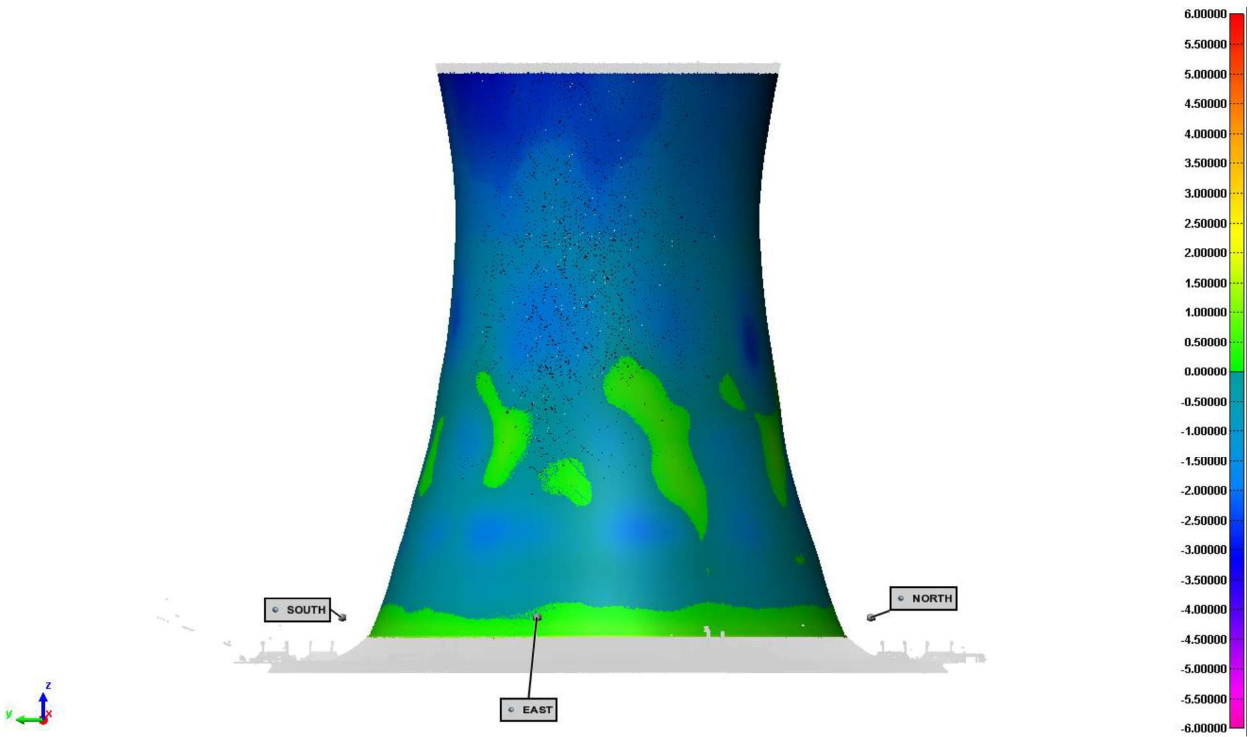
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net



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10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net

Comparison Method 3
CAD Model 2 Best Fit Alignment

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Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
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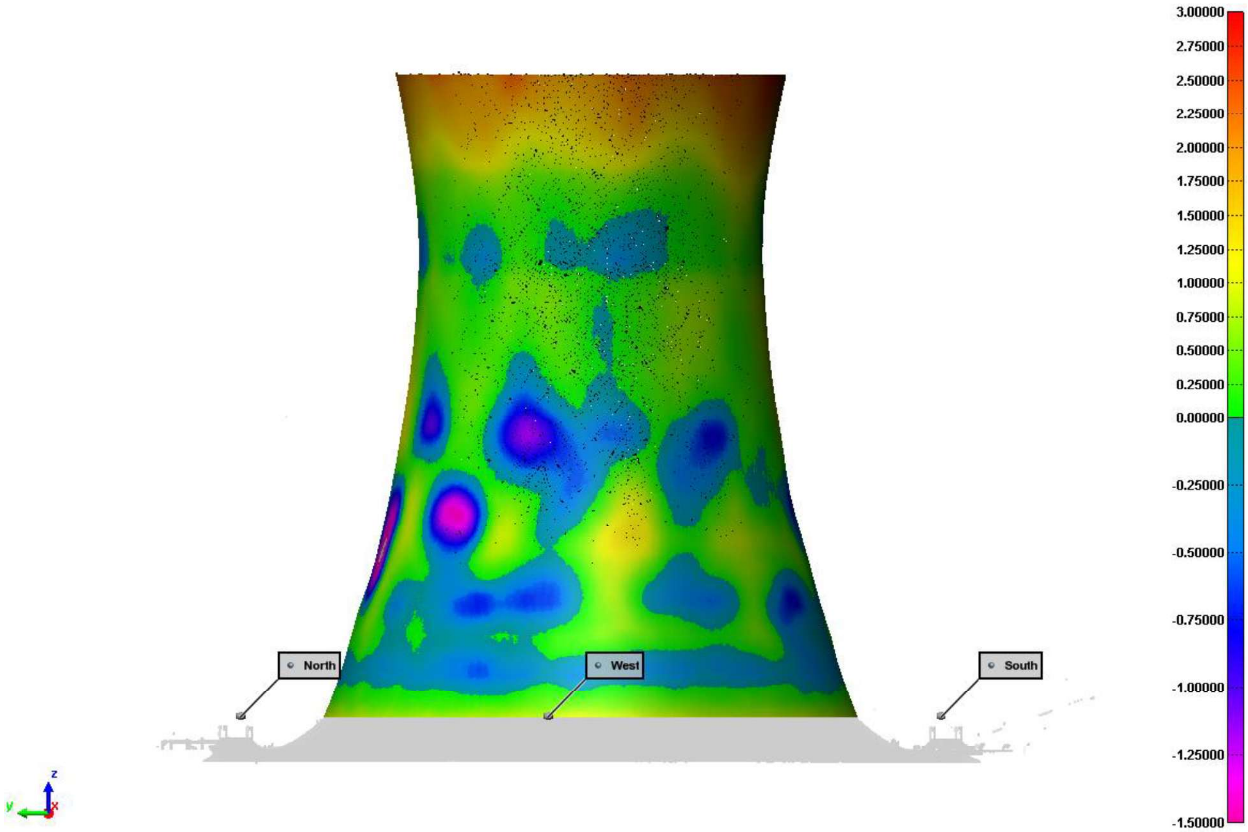

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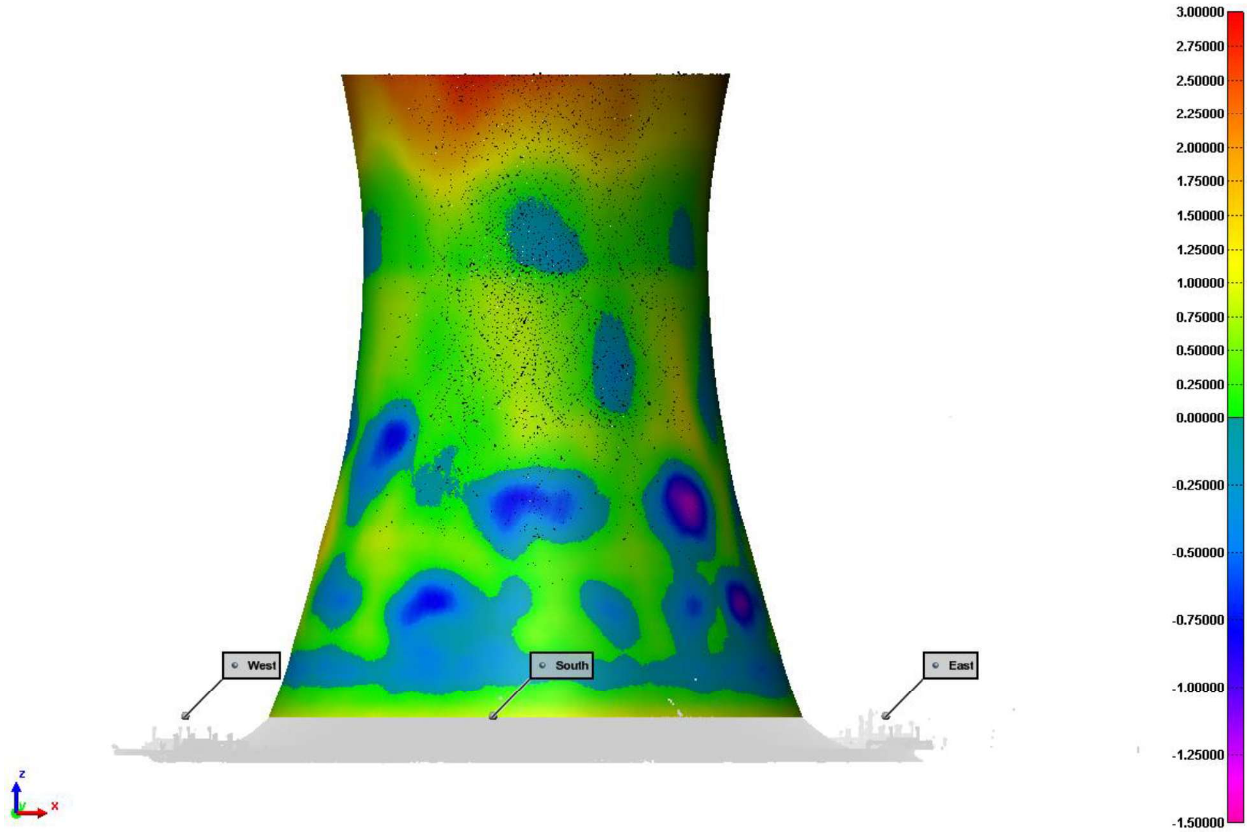
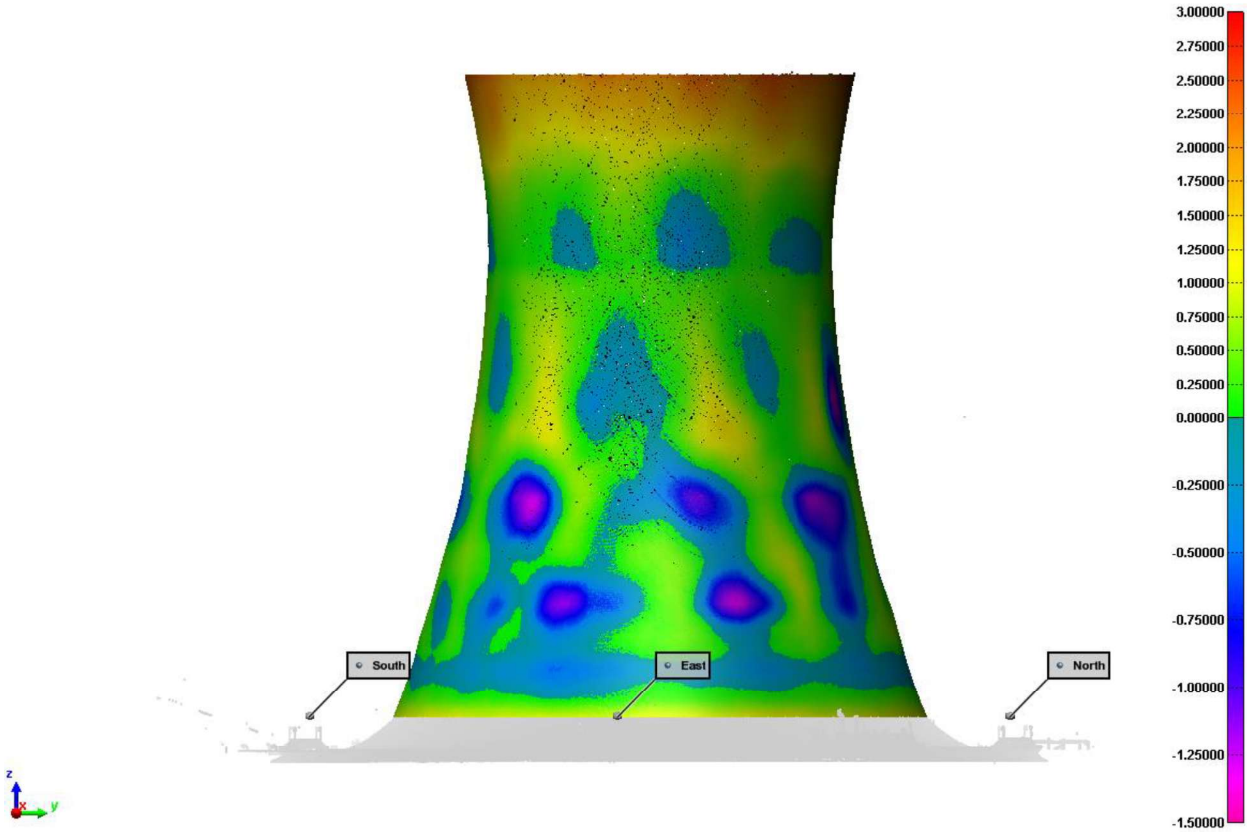
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net



Engineering Solutions

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
nmanning@3d-engineering.net



Trip Report

Project:	Mitchell Plant		
Subject:	Unit 2 – Cooling Tower Concrete Shell Observation Report		
Trip To:	Mitchell Plant	**Trip Date:**	April 6, 2016
From:	Douglas Polack	**Date:**	April 12, 2016
To:	Shane Bickmeier – Mitchell Plant System Owner Principal		
Cc:	Pedro Amaya, Bob Cashner, Keegan Kirwin, Frank Michell, George Tierney		
Report Number:	SES – RPT - 00269		
Participants:	Shane Bickmeier, Keegan Kirwin, Douglas Polack		
Purpose of Visit:	The Plant requested a structural observation of the Unit 2 cooling tower concrete shell. They had noticed several areas of the mid height shell surface that appear to be warped out of plane.		

Results:	**Objective Accomplished:**	**Yes**	X	**No**	
	Items Generated:	**Yes**	X	**No**	

Background

The Plant contacted the AEP Structural Engineering Section (SES) in Columbus regarding the cooling tower shells condition. Douglas Polack and Keegan Kirwin visited the site on April 6, 2016. Observations were limited to walkways on top of the water cooling fill structure, ground level, and the end of access walkway through the fill (south eastern side). The top of the concrete shell is 370 feet high and the bottom of the shell is at the top of the fill, 66 feet high. Thus, the shell is 304 tall.

Findings

1. The concrete shell has numerous surface dimples and flat spots. These dimples are most pronounced in-between roughly twenty percent to seventy percent of the tower height above the fill and they exist all around the tower. See the attached photos.
2. A hole through the shell in the northwest area about mid-height is visible from inside at the access walkway.

3. A severe spall on the outside may be the same as hole through the shell noted above.
4. AEP does not have the complete structural drawings for the shell only a few sections.
5. There are no records of previous structural inspections for the Unit 2 cooling tower.

Conclusions and Recommendations

In conclusion, structurally, the warping of the concrete shell is very concerning but the distortions in the concrete shell appear to be pre-existing for there is no evidence of recent cracking or spalling.

Therefore the SES recommends the following additional actions:

1. Drawings: Contact the engineer of record for the concrete towers to see if they can provide the existing drawings. The company was “The Marley Company” and they now are “SPX”.

2. Photos: Research to find old photos of these structures to verify the age and extent of the concrete surface irregularities.

3. Interviews: Contact employees who were at the Plant between 1967 and the 1980’s and ask them if they know of this condition.

4. Concrete Inspection (Ground/Lift Visual): Gain access to the interior of the tower and perform a concrete inspection from the ground and a lift (if possible). This inspection will provide additional visual perspectives of the concrete surface and limited physical concrete condition assessment.

5. Concrete Inspection (Drone Visual): Hire a consultant to fly the structure with a drone to get a closer look at the current condition.

6. Concrete Inspection (Suspended Scaffold Visual): Hire a consultant to perform an interior/exterior inspection from a suspended scaffold for the entire height in pre-determined locations.

7. Imaging: Hire a consultant to create a three dimensional model of the current state of the interior and exterior concrete surface. This will be used to determine the depth of the dimples and corresponding interior surface.

8. Engineer of Record: Ask SPX if they have any historic documentation of the current deformed shape of the concrete shell.

9. Consultants: Hire an outside consultant, regularly engaged in natural draft cooling tower design and repair, to visually inspect the towers and provide a letter of recommendations.

10. After review of the above findings, the SES will provide recommendations for further inspection, testing, monitoring and repairs.

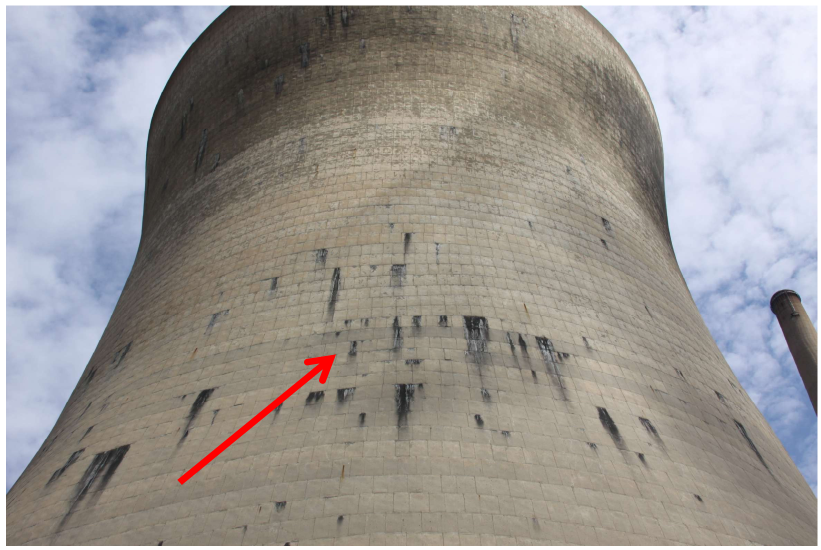
Photo # 1	
General photo of the exterior from the southwest. Arrow point to edge of dimple area.	
Photo # 2	
General photo of horizontal steel reinforcement where the concrete cover has spalled off.	

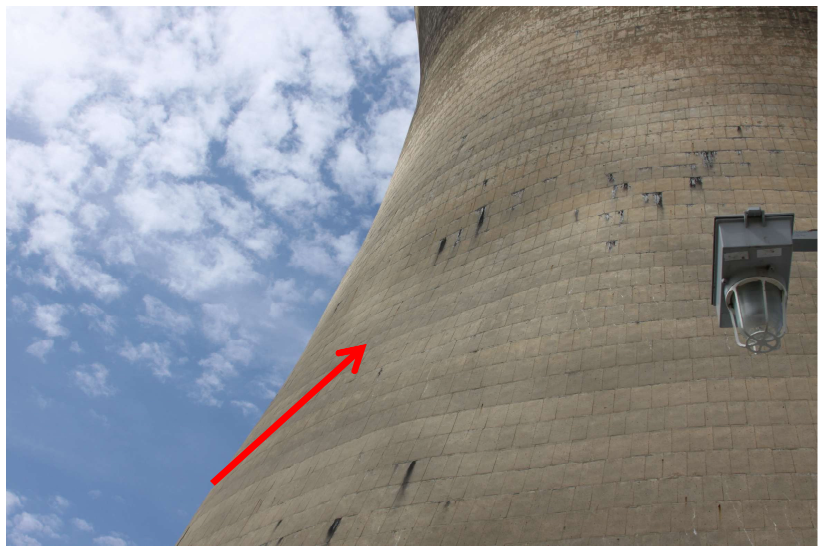
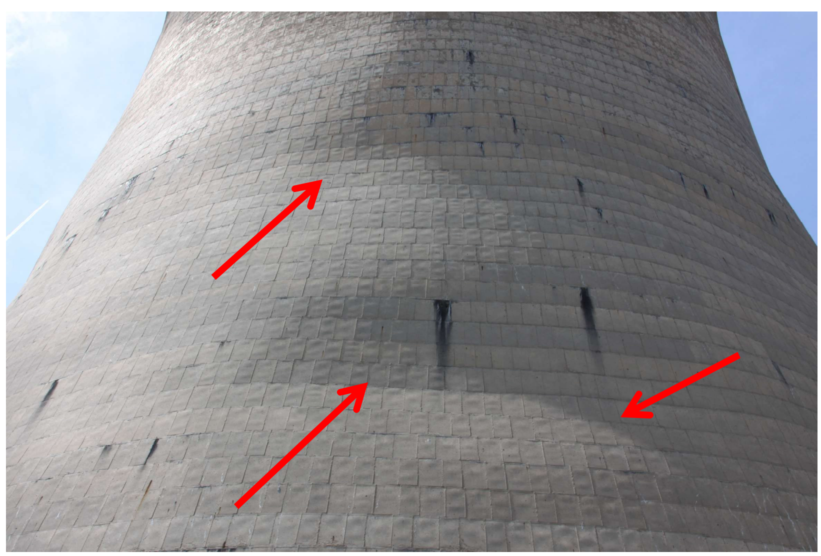
Photo # 3	
General photo of the southeast side. Arrow points to the edge of a large dimpled area.	
Photo # 4	
General photo of the east side. Arrows point to some irregular areas.	

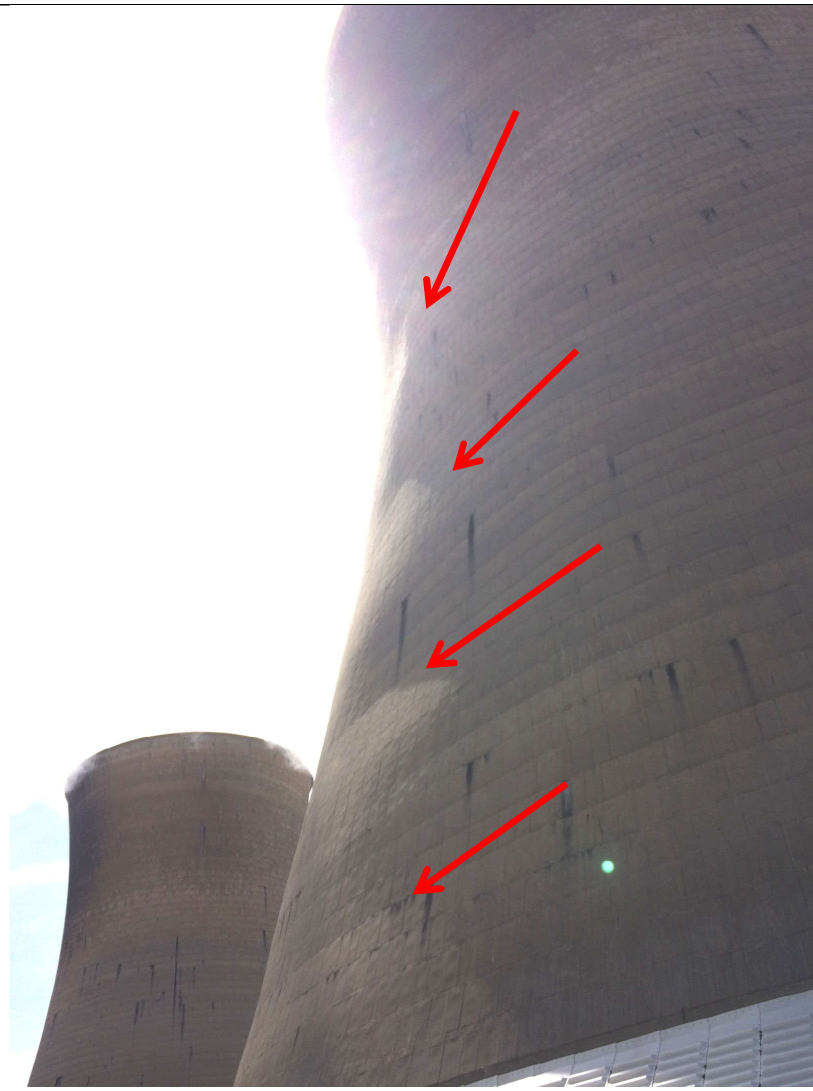
Photo # 5	
General photo from the northeast side of the east side. Arrows point to a recessed areas.	

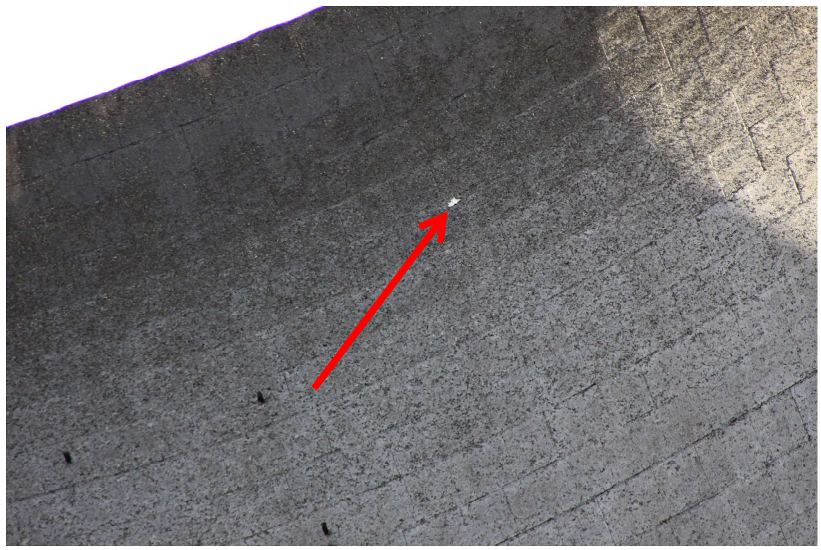
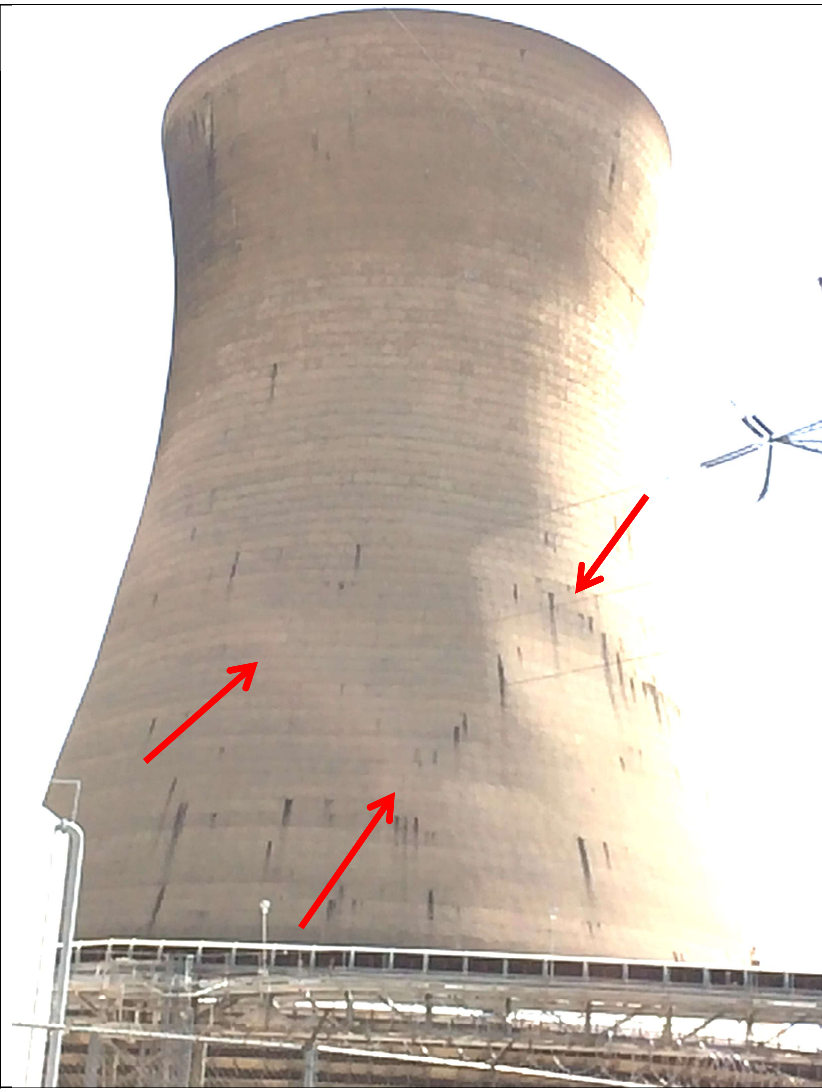
Photo # 6	
General photo of a hole in the northwest area of the cooling tower shell seen from the inside looking out. The hole is near the top of the wall.	

Photo # 7	
Another general photo of the north (northwest) side of the tower.	

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
asudkamp@3d-engineering.net

Long Range Scan of Cooling Towers

Prepared for:

1 Riverside Plaza
Columbus, OH 43215
614-716-1393

Prepared by: Andrew Sudkamp & Christopher Schreiber

Approved by: Rob Glassburn, P.E.

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
rglassburn@3d-engineering.net

Date: 1/23/2017

3D Engineering Solutions
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
asudkamp@3d-engineering.net

CERTIFICATE OF INSPECTION

CUSTOMER:	American Electric Power 1 Riverside Plaza Columbus, OH 43215 614-716-1393
PO NUMBER:	Verbal
PART DESCRIPTION:	Cooling Towers
UNIT OF MEASURE:	Feet
INSPECTED BY:	Andrew Sudkamp & Christopher Schreiber
INSPECTION EQUIPMENT:	Faro Laser Scanner FocusS 350 S/N LS-8-S-350
INSPECTION DATE:	01/13/17

This is to certify that the item listed above was inspected with instrument(s) calibrated with standards traceable to the International System of Units (SI) through a National Metrological Institute (NMI) or an ISO17025 Accredited Laboratory.

Approved by: ____________________ Date: 1/23/2017

Rob Glassburn, P.E.
VP of Operations

3D Engineering Solutions
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
asudkamp@3d-engineering.net

Method and Observations:

The cooling towers were scanned using a FARO Laser Scanner FocusS 350. Point cloud data was collected for the towers in a set of individual scans that were brought into FARO Scene. Once imported into FARO Scene the individual scans were aligned to one other with the aid of the on board GPS of the scanner. The scan data was then imported into PolyWorks IMInspect.

A CAD model was created based on the customer supplied drawing that outlined diameters and specific elevations. A surface profile of the tower was created in Solidworks based on the cross section that was made from the supplied dimensions.

The scan data for each tower was aligned to the CAD model using a best-fit alignment. Color maps for each tower were created and can be found within the report. Along with the scan to CAD comparisons, the scan data of Tower 2 collected for this project was aligned to the scan data from project AEP160407 of Tower 2 scanned 4/13/16. A scan to scan comparison was conducted for these, also using a best-fit alignment. Points showing the approximate directions of North, South, East, and West were created to use as reference.

Color map screenshots in this report will show a scale on the right side of the image (Please note the scale may change from page to page). Positive deviations mean the scan data is above the CAD model surface; negative deviations mean the scan data are below the CAD model surface. For the scan to scan comparison, the scan data from project AEP160407 was treated as the reference data (CAD model) and the scan data from this project was treated as the scan data. Some areas may appear gray – these areas are either out of the color scale range or do not have data for comparison.

The temperature range during the scan session on 4/13/16 was 32°F to 45°F. The temperature range during the scan session on 1/13/17 was 30°F to 36°F.From the scan to scan comparison, it should be noted that the new scan shows an overall pattern of negative deviation, and specifically, the northeast side of Tower 2 showed a larger deviation than the rest of the structure possibly due to wind effects.

10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
asudkamp@3d-engineering.net

Tower 1
Scan to CAD Comparison

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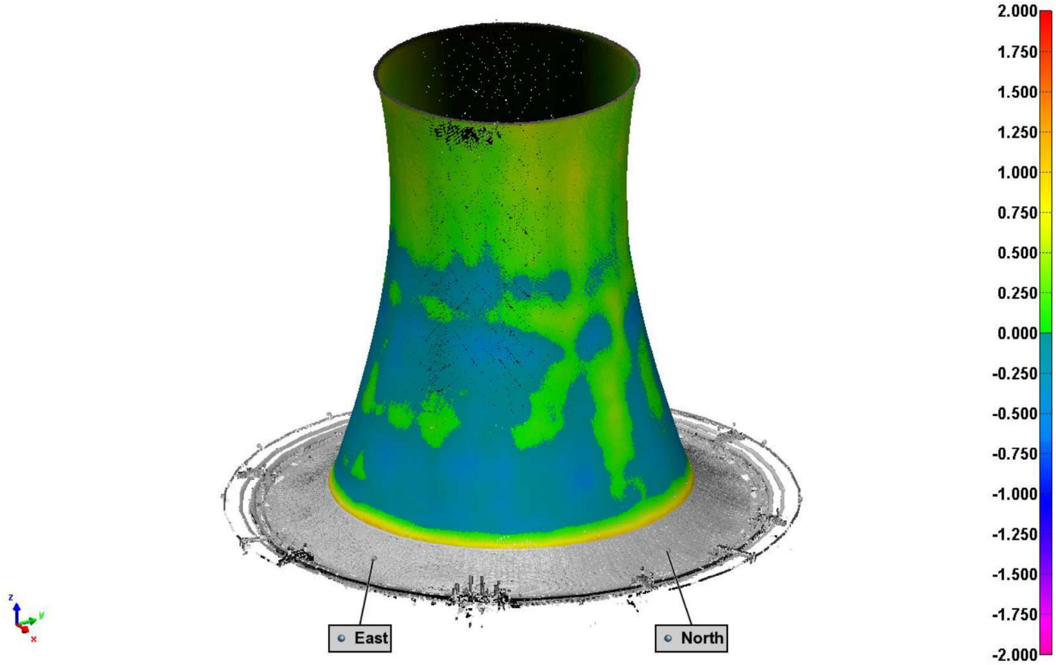
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
asudkamp@3d-engineering.net



Scan to CAD Comparison (Best Fit Alignment) with +/- 2.000 ft color scale range. Note that positive deviations mean the scan data is above the CAD model surface and negative deviations mean the scan data is below the CAD model surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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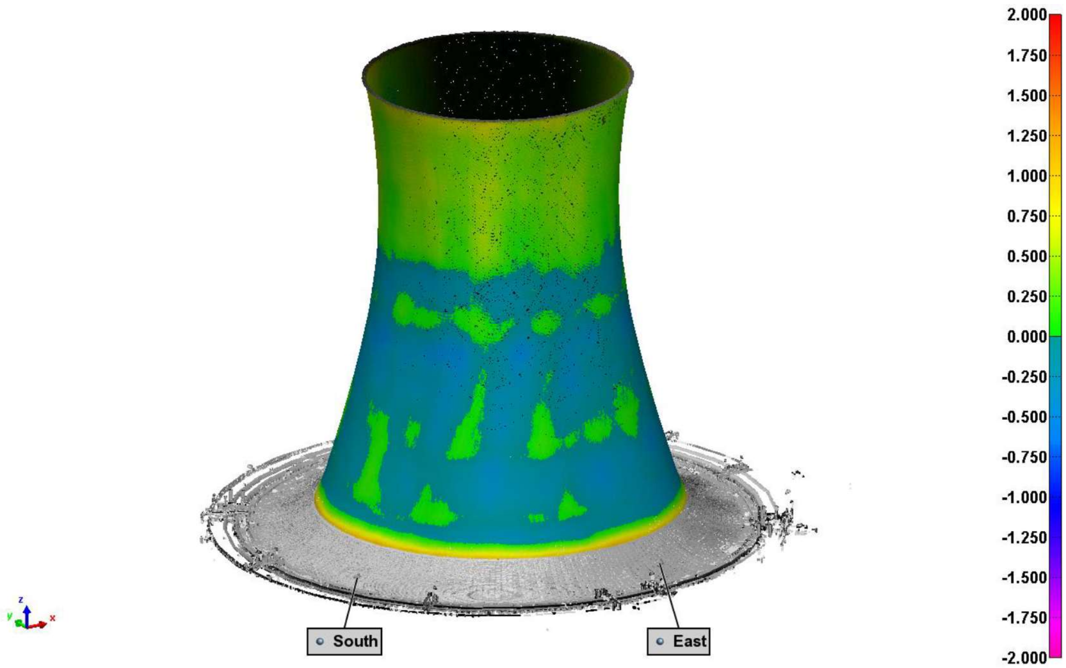

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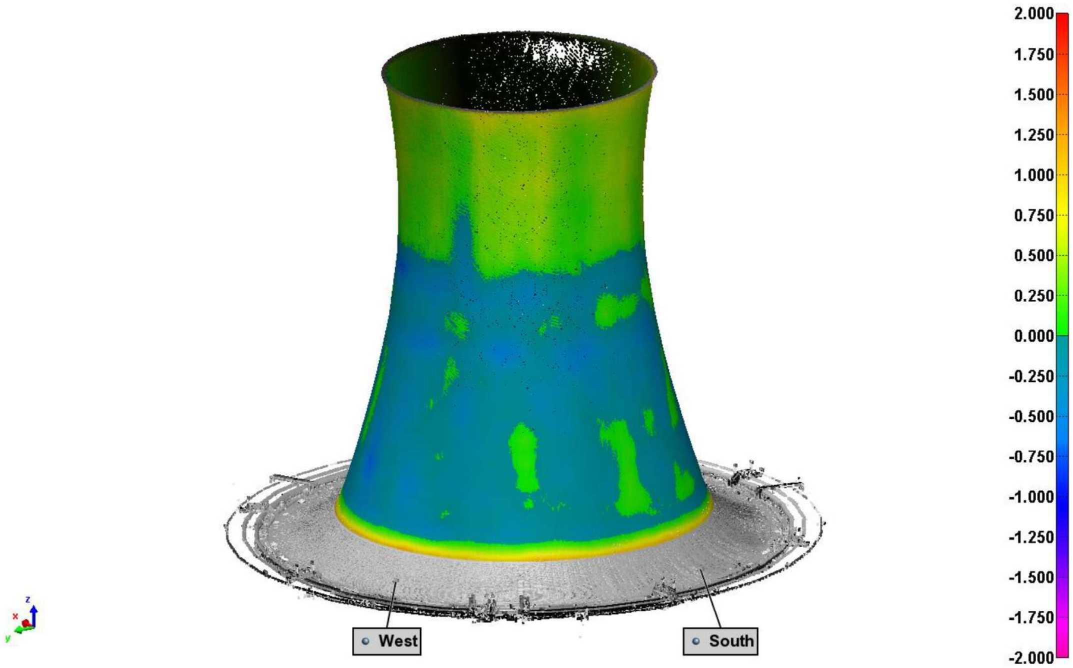

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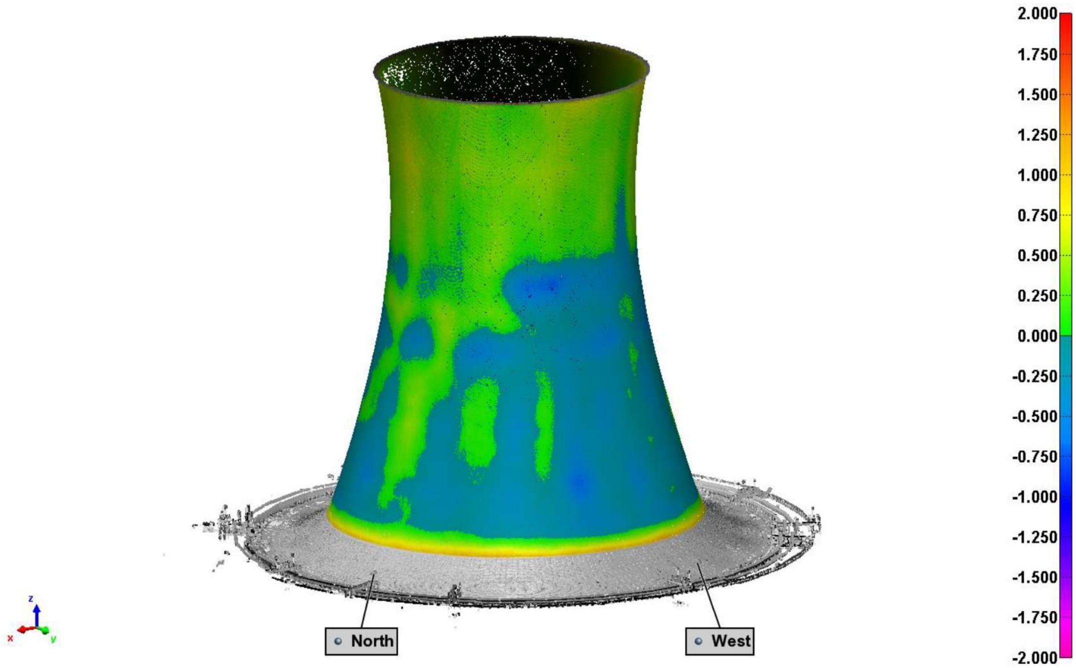

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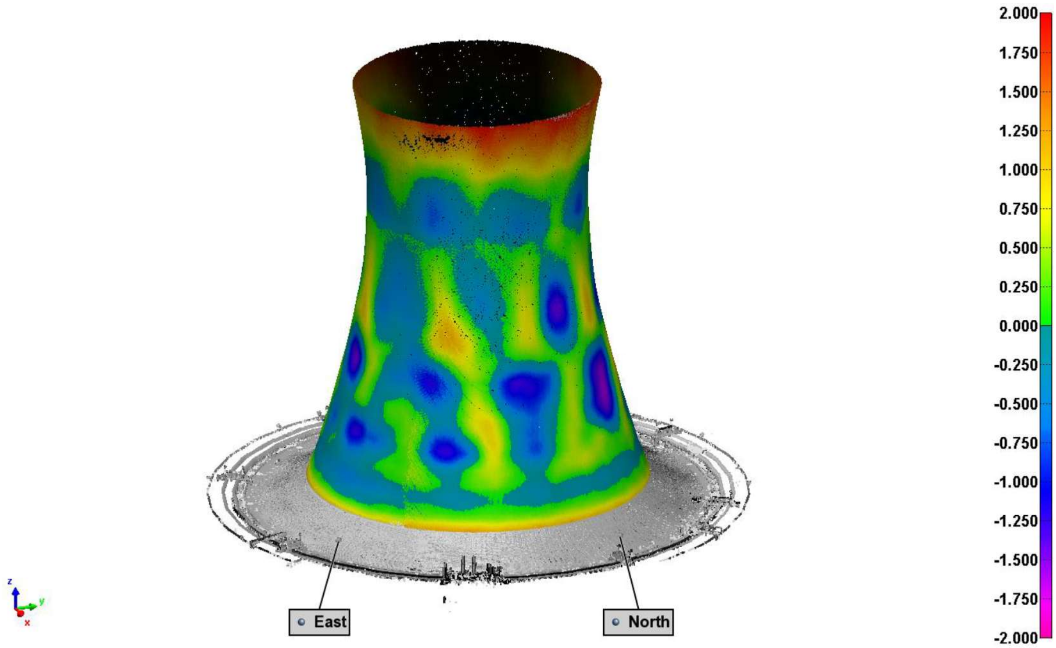
3D Engineering Solutions
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
asudkamp@3d-engineering.net

Tower 2
Scan to CAD Comparison

3D Engineering Solutions
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
asudkamp@3d-engineering.net



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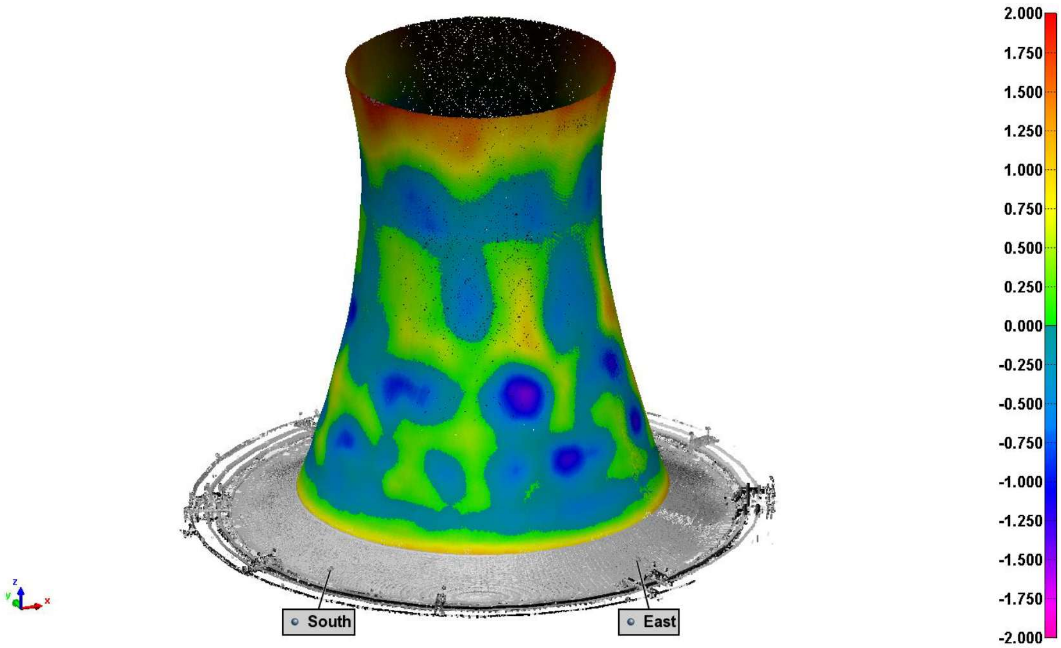

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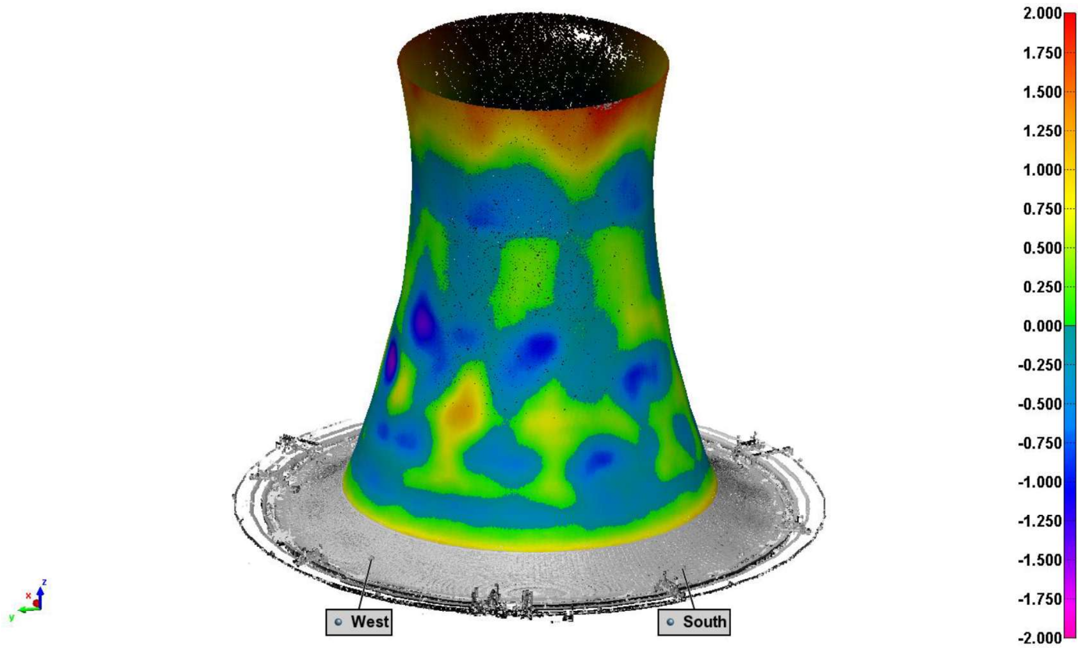

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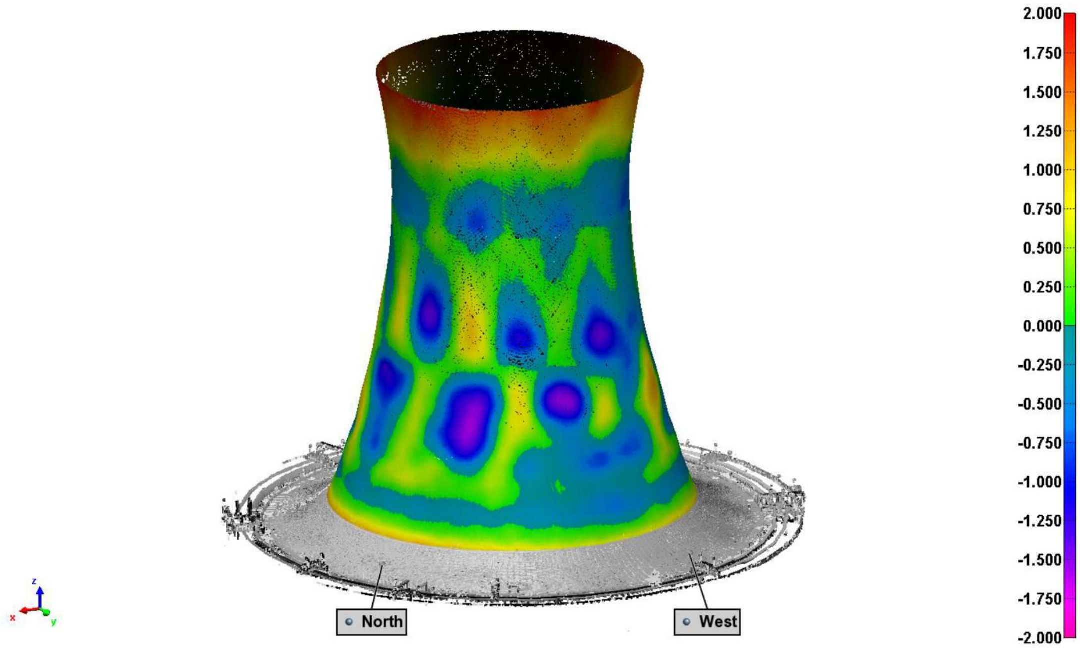

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Tower 2
Scan to Scan Comparison

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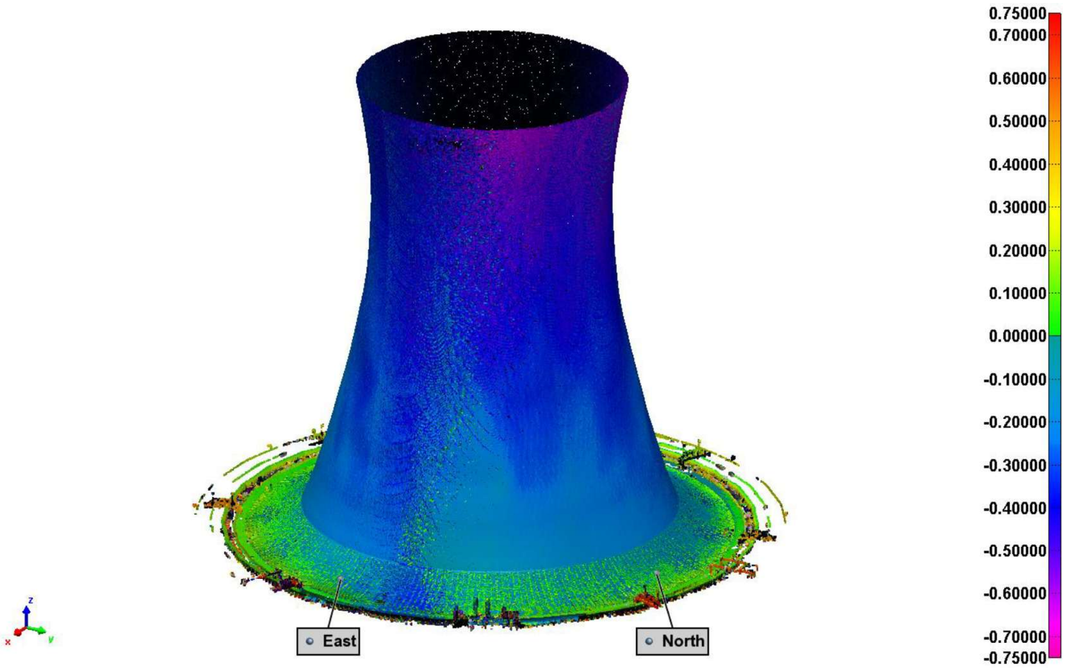

Scan to CAD Comparison (Best Fit Alignment) with +/- 0.750 ft color scale range. Note that positive deviations mean the 1/13/17 scan data is above the 4/13/16 scan surface and negative deviations mean the 1/13/17 scan data is below the 4/13/16 scan surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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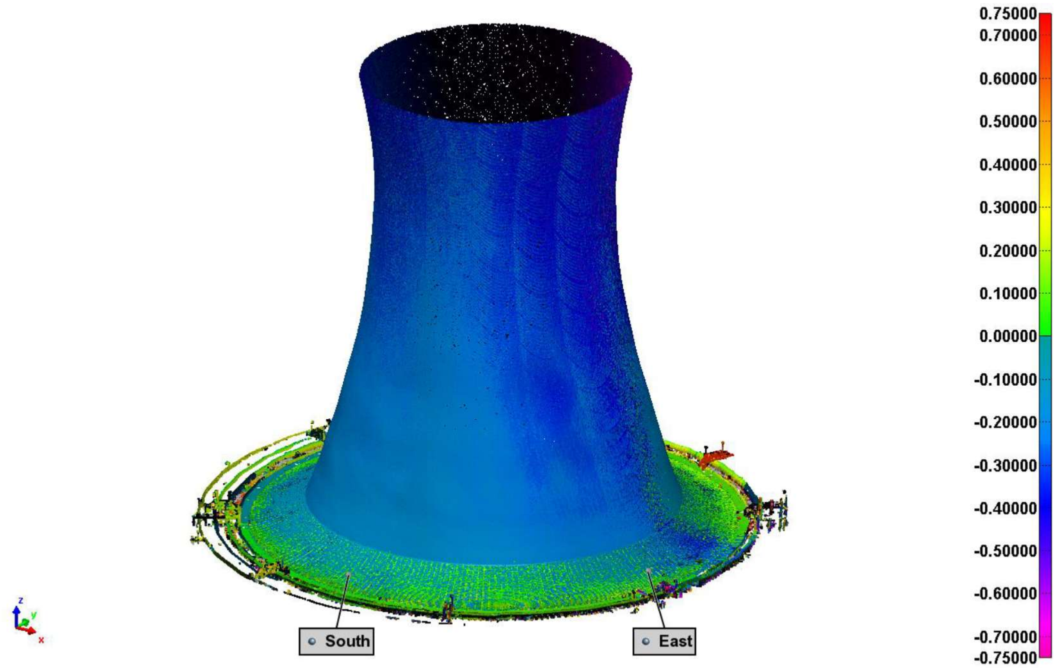

Scan to CAD Comparison (Best Fit Alignment) with +/- 0.750 ft color scale range. Note that positive deviations mean the 1/13/17 scan data is above the 4/13/16 scan surface and negative deviations mean the 1/13/17 scan data is below the 4/13/16 scan surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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10597 Chester Rd
Cincinnati, OH 45215
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Fax: 513.771.2120
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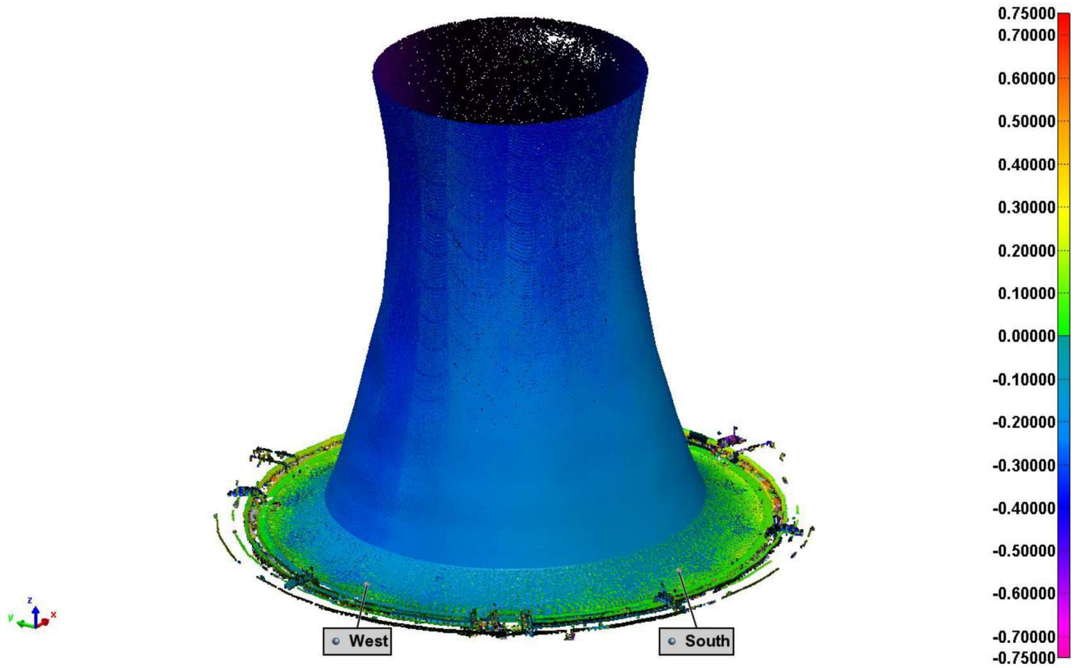

Scan to CAD Comparison (Best Fit Alignment) with +/- 0.750 ft color scale range. Note that positive deviations mean the 1/13/17 scan data is above the 4/13/16 scan surface and negative deviations mean the 1/13/17 scan data is below the 4/13/16 scan surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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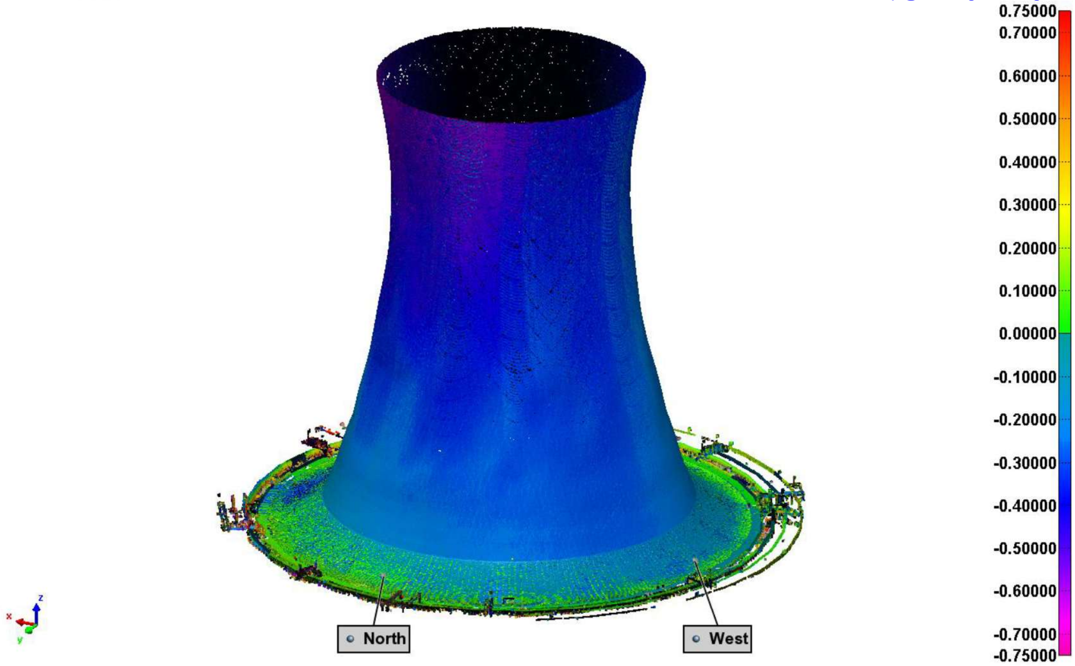

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10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
james@3d-engineering.net

Cooling Tower
Scan to Scan Comparison

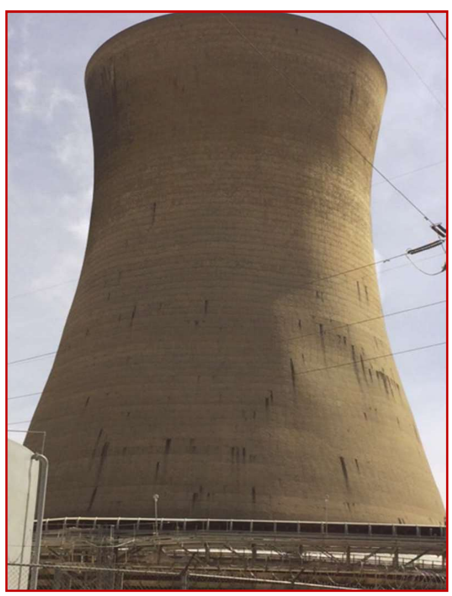
Prepared for:

American Electric Power Service Corporation
Turbine Generator & Piping Systems Engineering
1 Riverside Plaza
Columbus, Ohio 43215

Prepared by: James Irwin

Approved by: Rob Glassburn, P.E.
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710 Fax: 513.771.2120
rglassburn@3d-engineering.net

Date: 8/30/2018



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10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
james@3d-engineering.net

CERTIFICATE OF INSPECTION

CUSTOMER:	American Electric Power 1 Riverside Plaza Columbus, Ohio 43215
PO NUMBER:	Verbal
DESCRIPTION:	Cooling Tower
UNIT OF MEASURE:	feet
INSPECTED BY:	James Irwin and Jacob Moore
INSPECTION EQUIPMENT:	Faro Laser Scanner FocusS 350 S/N LS-8-S-350
INSPECTION DATE:	08/09/18

This is to certify that the item listed above was inspected with instrument(s) calibrated with standards traceable to the International System of Units (SI) through a National Metrological Institute (NMI) or an ISO17025 Accredited Laboratory.

Approved by: ______________________ Date: 8/30/2018
Rob Glassburn, P.E.
Vice President of Operations

3D ENGINEERING SOLUTIONS
10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
james@3d-engineering.net

Method

The cooling tower was scanned using a FARO Laser Scanner FocusS 350. Point cloud data was collected for the tower in a set of individual scans that were brought into FARO Scene. Once imported into FARO Scene the individual scans were aligned to one other with the aid of target spheres and the on board GPS of the scanner. The scan data was then imported into PolyWorks IMInspect.

The CAD model used in this report is the same model used for Project AEP161205. The scan data of the tower was aligned to the CAD model using a best-fit alignment. A Color map for the tower was created and can be found within the report. Along with the scan to CAD comparison, the scan data of the tower collected for this project was aligned to the scan data from project AEP161205 of Tower 2 scanned 1/13/17. A scan to scan comparison was conducted, also using a best-fit alignment. Points showing the approximate directions of North, South, East, and West were created to use as reference.

Color map screenshots in this report will show a scale on the right side of the image (Please note the scale may change from page to page). Positive deviations mean the scan data is above the CAD model surface; negative deviations mean the scan data are below the CAD model surface. For the scan to scan comparison, the scan data from project AEP161205 was treated as the reference data (CAD model) and the scan data from this project was treated as the scan data. Some areas may appear gray – these areas are either out of the color scale range or do not have data for comparison.

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10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
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Cooling Tower
Scan to CAD Comparison

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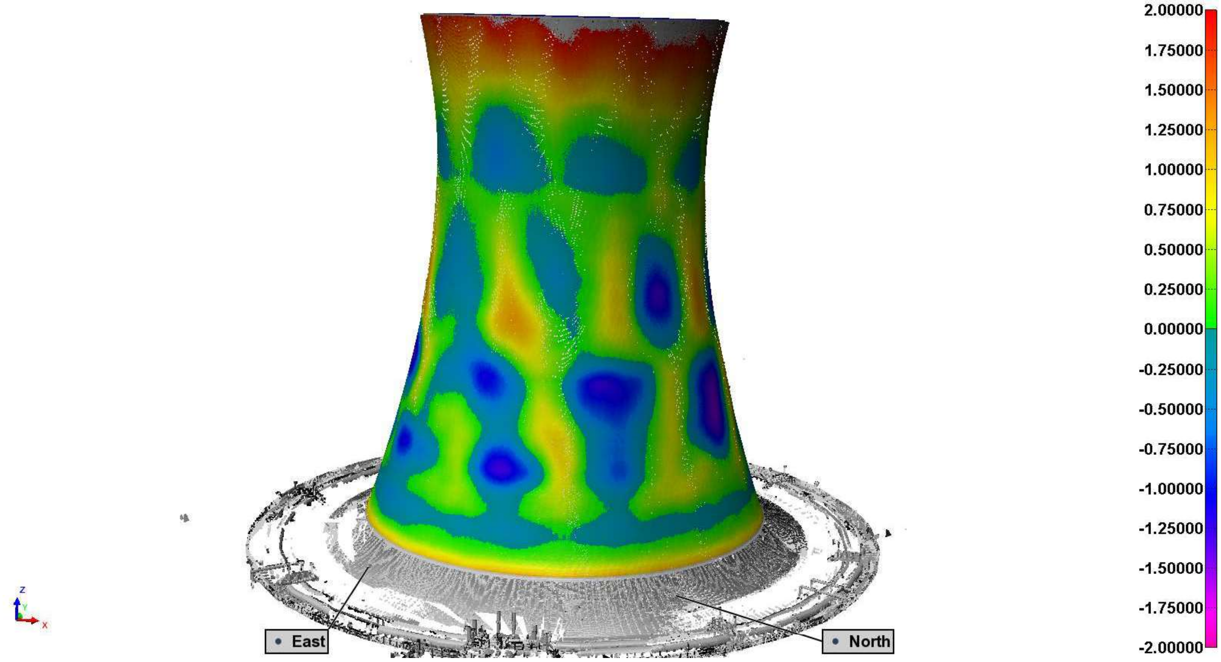

Scan to CAD Comparison (Best Fit Alignment) with ±2.00ft color scale range. Note that positive deviations mean the scan data is above the CAD model surface and negative deviations mean the scan data is below the CAD model surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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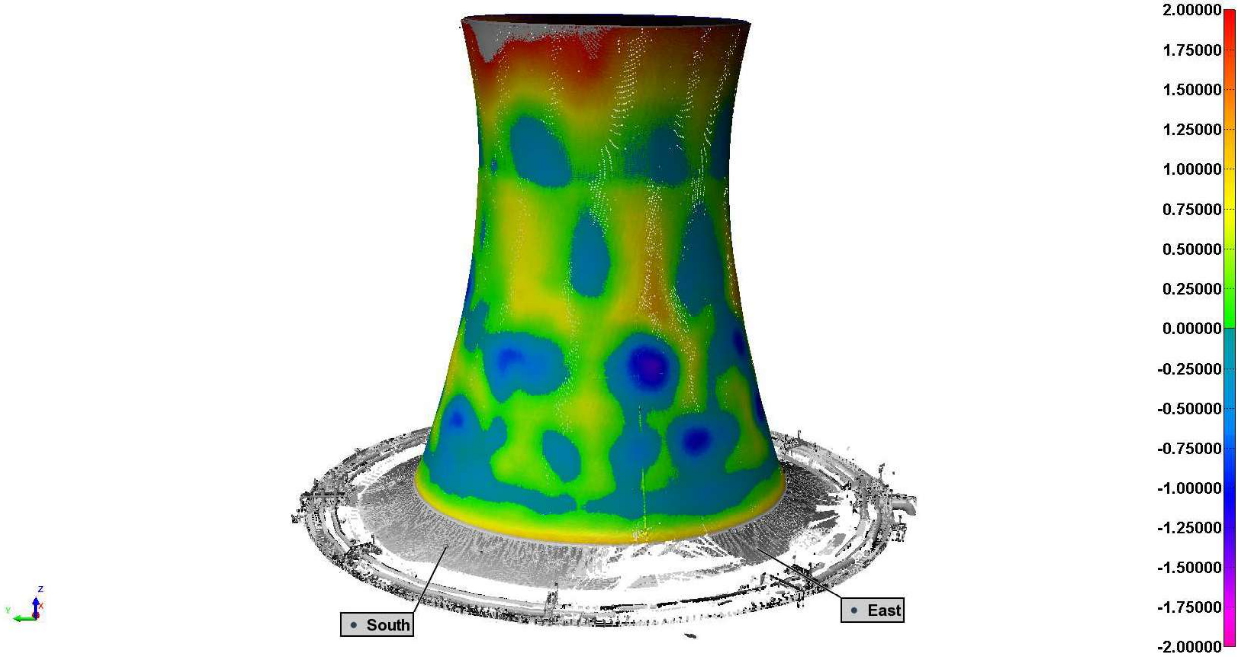

Scan to CAD Comparison (Best Fit Alignment) with $\underline{+}$2.00ft color scale range. Note that positive deviations mean the scan data is above the CAD model surface and negative deviations mean the scan data is below the CAD model surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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10597 Chester Rd
Cincinnati, OH 45215
Phone: 513.771.7710
Fax: 513.771.2120
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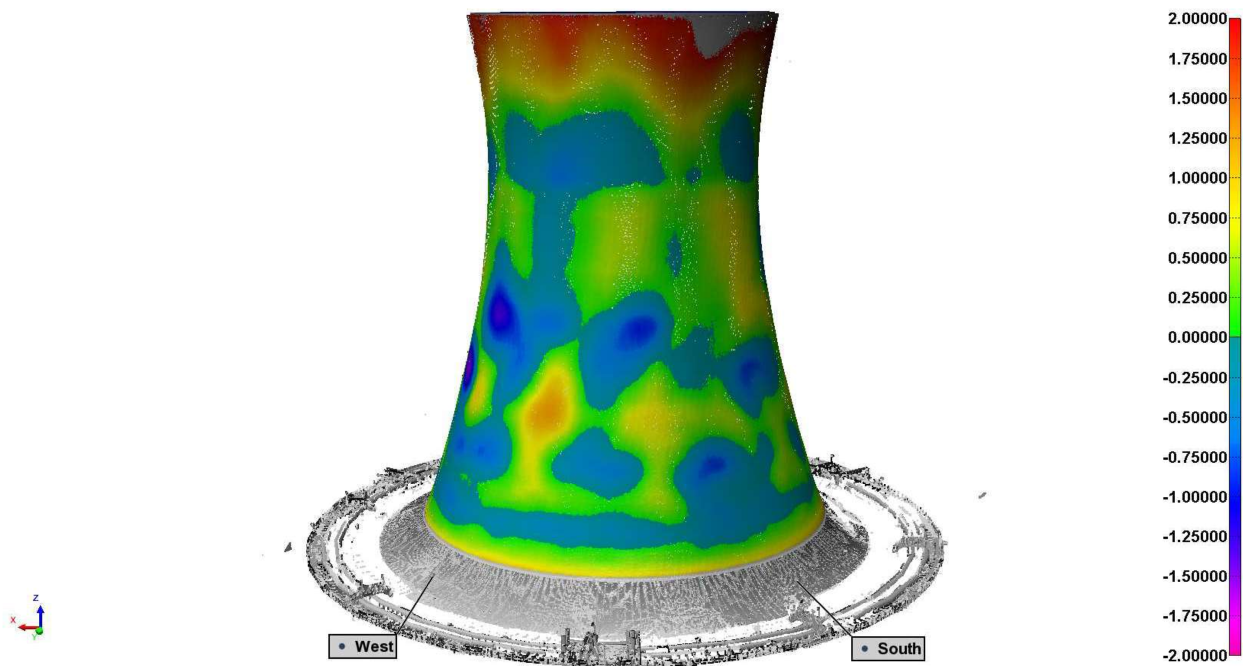

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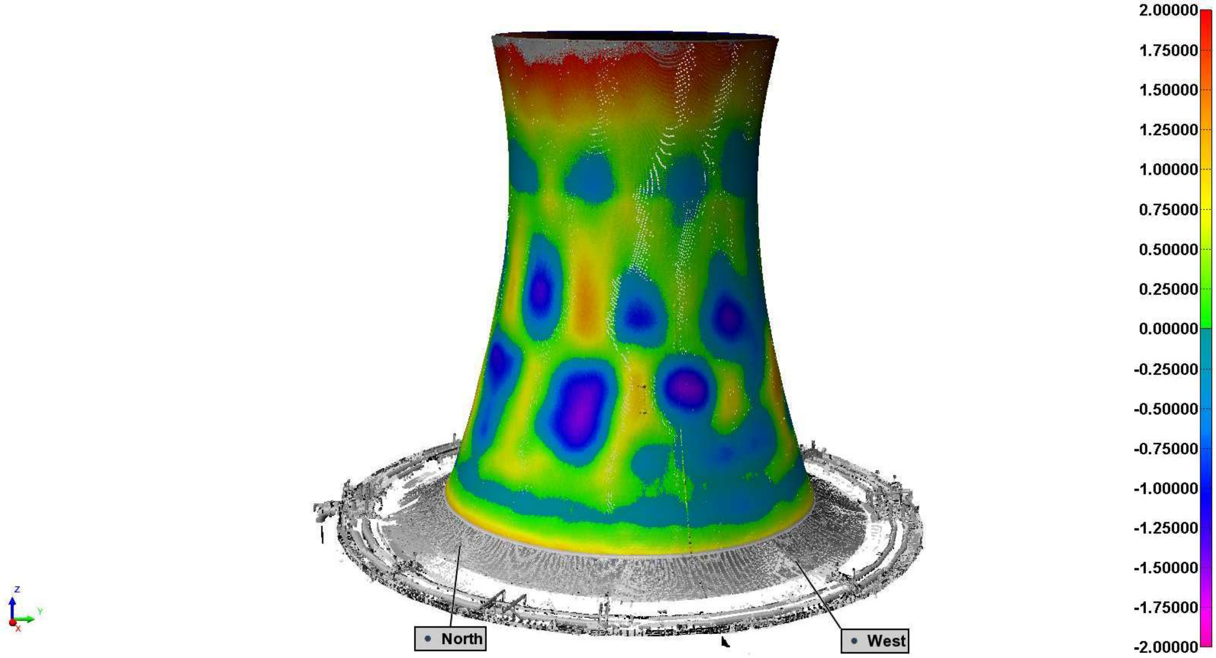

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10597 Chester Rd
Cincinnati, OH 45215
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Cooling Tower
Scan to Scan Comparison

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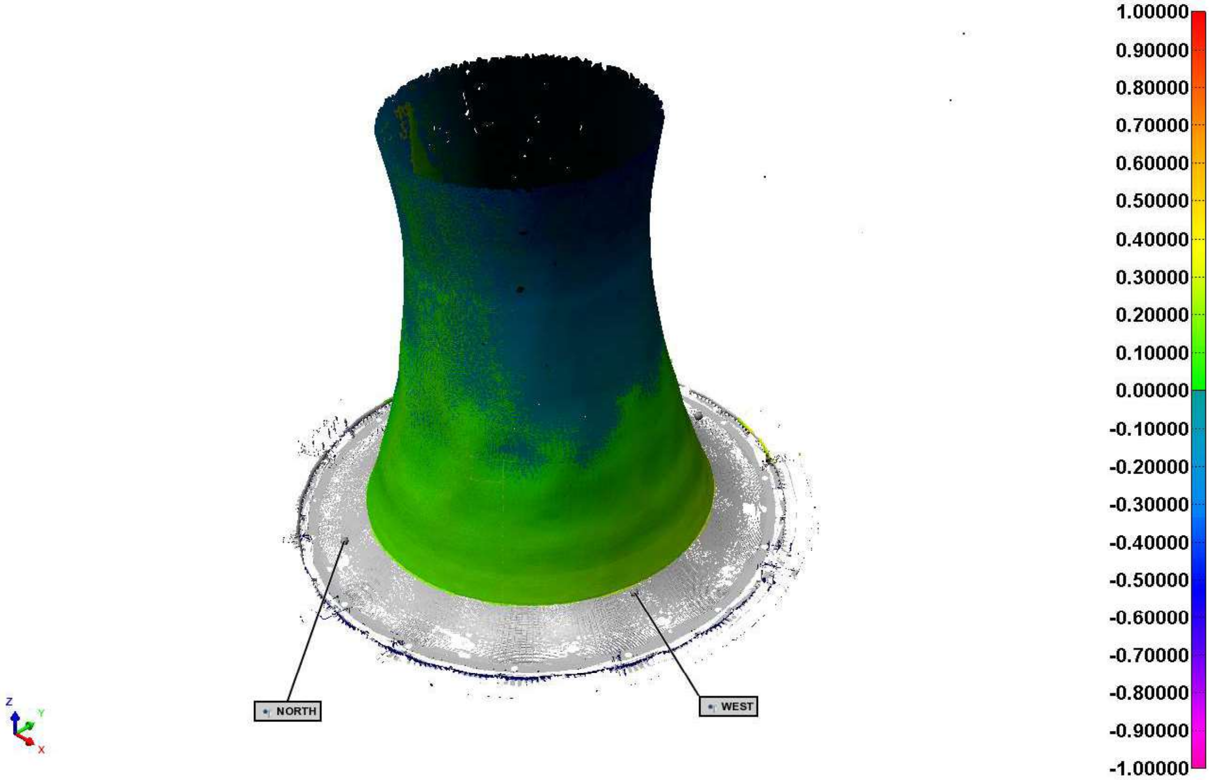

Scan to Scan Comparison (Best Fit Alignment) with +1.00ft color scale range. Note that positive deviations mean the 8/09/18 scan data is above the 1/13/17 scan surface and negative deviations mean the 8/09/18 scan data is below the 1/13/17scan surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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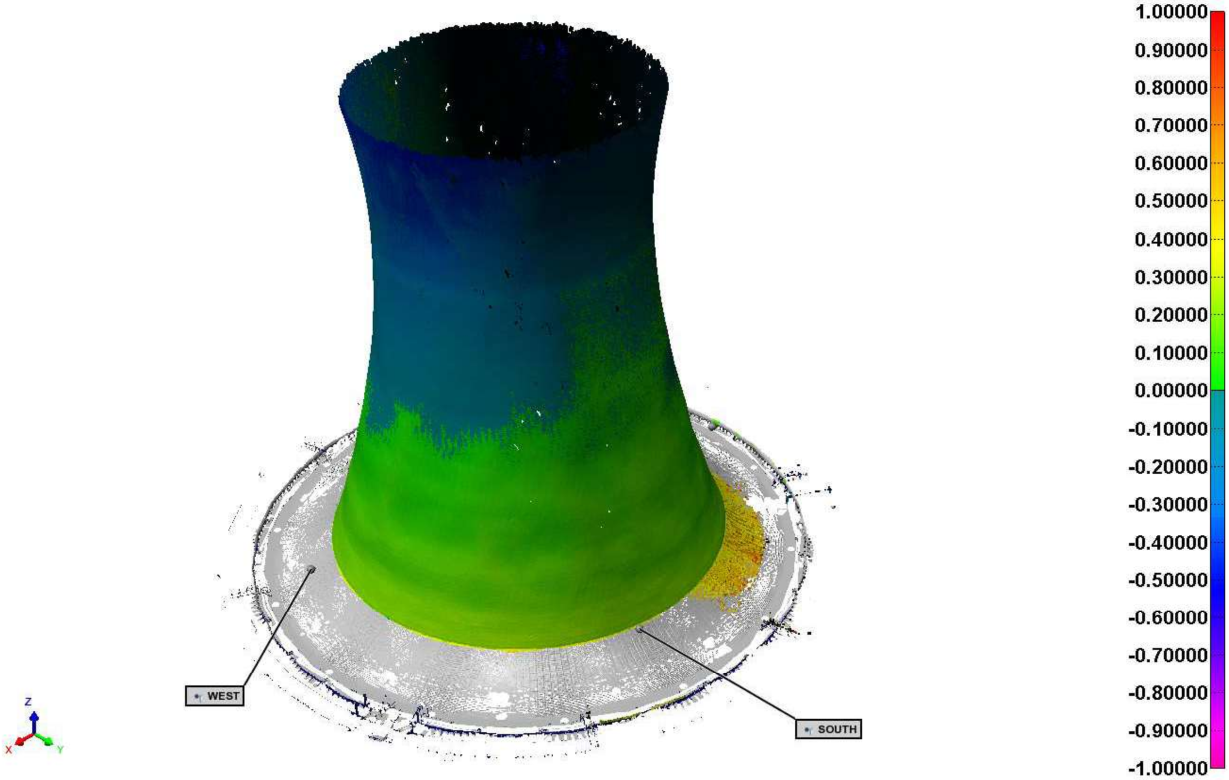

Scan to Scan Comparison (Best Fit Alignment) with ±1.00ft color scale range. Note that positive deviations mean the 8/09/18 scan data is above the 1/13/17 scan surface and negative deviations mean the 8/09/18 scan data is below the 1/13/17scan surface. Areas shown in grey represent areas of the scan that are either outside of the scale area shown or areas in which no data was collected and are not compared.

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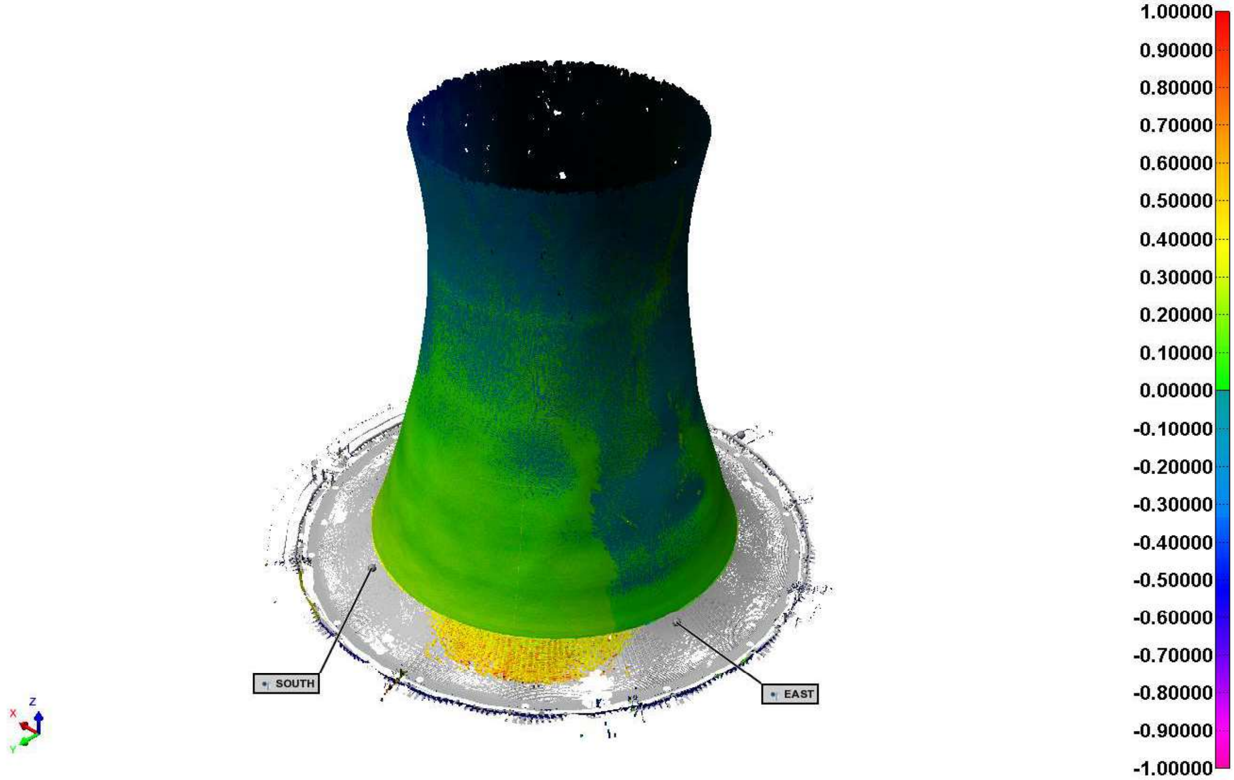

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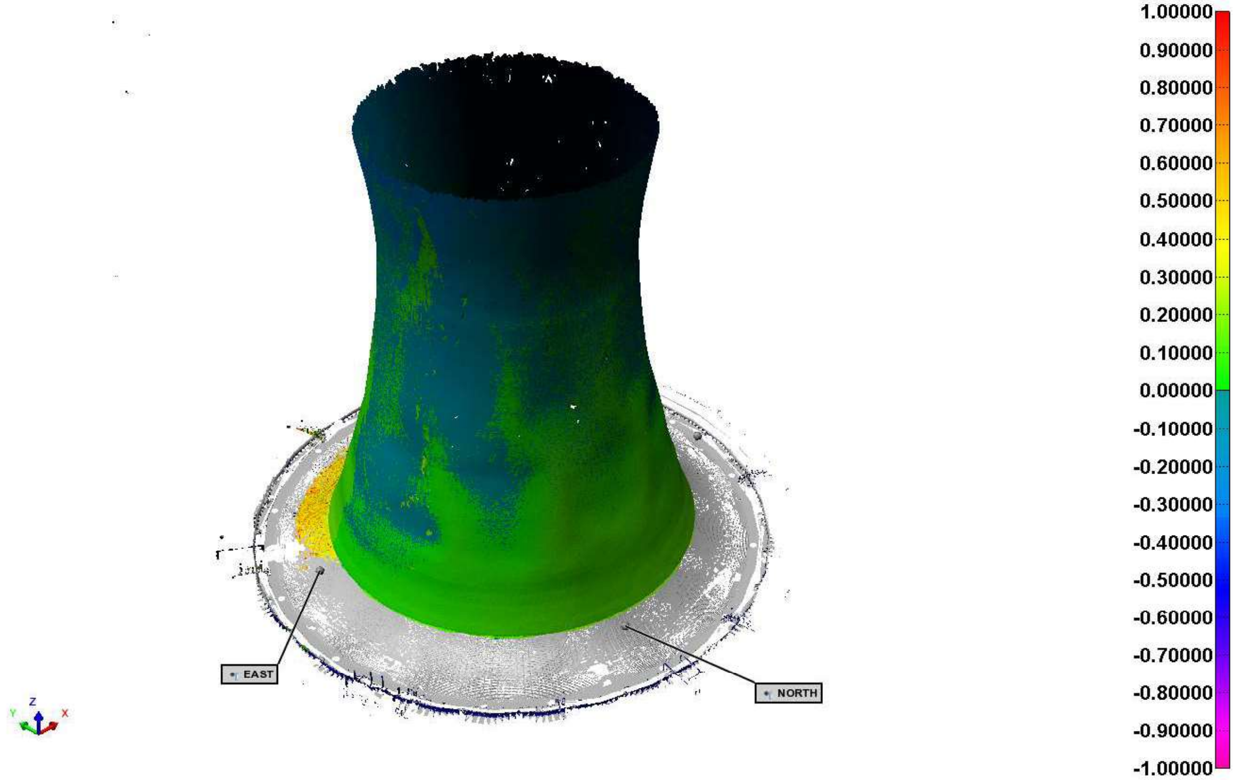

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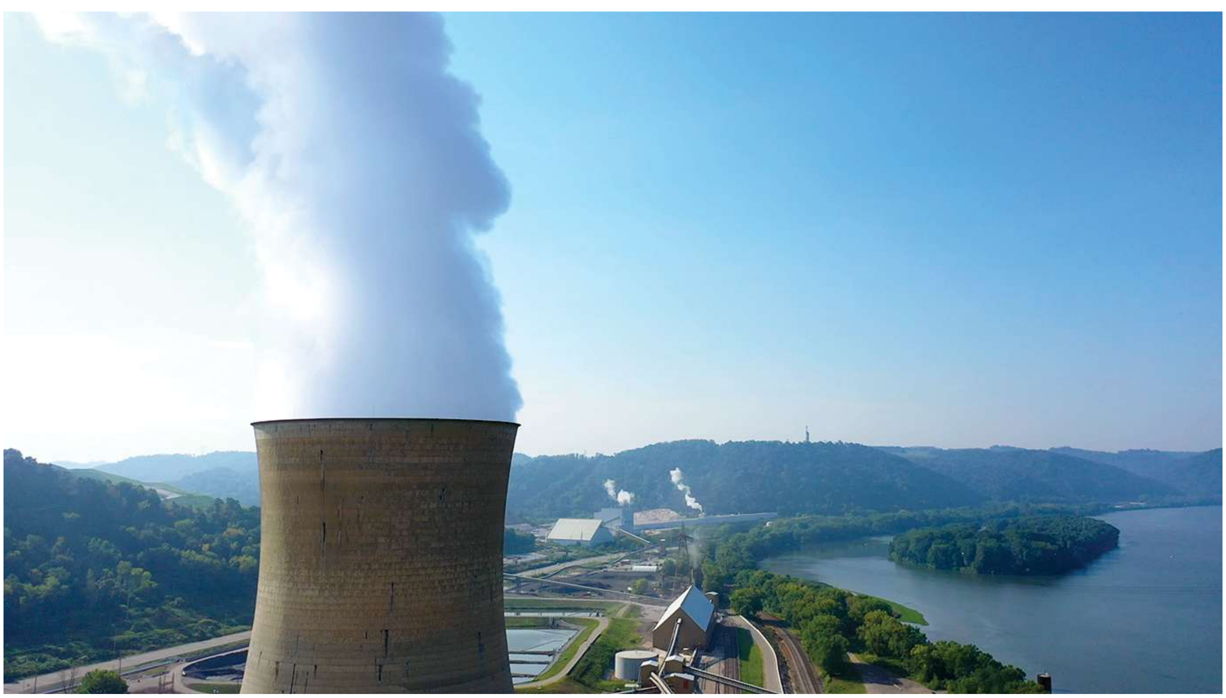
Los Angeles,
CA 90291

80 E Rich Street, Suite 600,
Columbus, OH 43215

5 route du Pérollier,
69570 Dardilly - France

External visual inspection of the MITCHELL's UNIT 2 Cooling Tower



Revision History

Version	Date	Author	Modifications
1.0	2019-10-15	Sterblue	Initial version

1. Scope

This document deals with the visual and photogrammetric inspection of the shell of Mitchell Unit 2 cooling tower.
This document aims at giving the map of defects, their characteristics and some statistics about the shell.

This report is completed by appendices:

- Appendix 1 presents examples of major defects found on the shell
- Appendix 2 presents the table of defects
- Appendix 3 presents the map of defects
- Appendix 4 presents the map of defects with falling risk overlaying the orthophotography
- Appendix 5 presents the map of defects with orthophotography (low resolution)
- Appendix 6 present the map of defects overlaying the orthophotography
- Appendix 7 present the map of defects overlaying the distortions map

The orthophotography, distortion and defects maps are available on the shared google drive with a viewer and an interactive file. Excel files listing all of the defects and their XYZ coordinates can be found on this shared drive, the photos of each defect can also be found on the Sterblue Cloud.

2. Deliverables

This report along with the other deliverables will be made available via Google Drive. The deliverables are:

- Inspection Report
- Inspection Presentation
- Appendices
- Orthopicture covering all defects - Shape files
- 3D image of the cooling tower with defects

3. General points

Tools:
The photos were taken from 14 august to 16 august 2019. All the photos were shot by a UAV with a 24 megapixel camera (DJI X7 on a matrice 210 RTK v2 UAV).

Weather:
Cloudy with some sun.

Context of processing:
All the necessary image processing steps for creating the orthophotography were done at Sites and Sterblue offices in France.
The theoretical model of the shell was created using the document “Mitchell U2 CT Shell Dwg 13 _ 14.pdf”

Units:

The US survey foot is used for the lengths, surfaces and 3D coordinates.
1 US ft = 1200/3937 meter = 0.30480061 meter
The inch is used for the opening of cracks.
12 in = 1 ft ; 1 in = 0.0833 ft = 25.4mm

Coordinate system (as per "MTU2CT August 2019.xlsx"):
All the 3D data are known in the NAD83 / West Virginia North (EPSG: 26861) coordinate system.
The scaling error of this coordinate system is less than 0.2 inch on the 300 ft of this structure.

References:
The following points were used to place the 3D model in the NAD83 / West Virginia North coordinate system.

Point	East - X (us ft)	North - Y (us ft)	Elevation - Z (us ft)
NW_1	1598249.908	487003.725	832.212
NW_2	1598236.744	486987.915	834.681
NW_3	1598217.204	486958.935	834.783
NW_4	1598231.232	486992.632	810.594
SW_1	1598277.623	486833.758	830.661
SW_2	1598300.885	486833.525	845.758
SW_3	1598321.431	486829.932	827.007
SW_4	1598299.384	486823.318	806.755
SW_5	1598300.795	486829.289	827.001

Coordinates of the references (05 august 2019)

4. Data acquisition and treatments

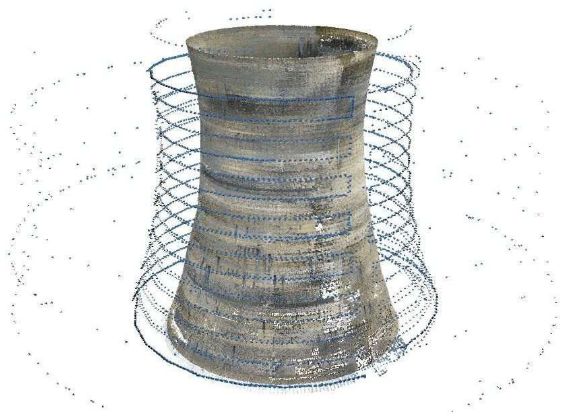
4.1. UAV flights

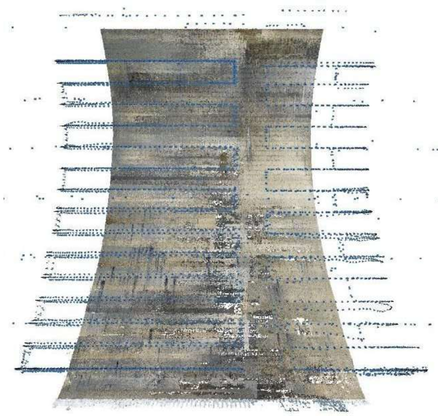
2 types of flights were performed:
- 164 ft (50 m) for overview and photogrammetric structure. Pixel size (GSD): 0.16 in (4 mm),
- 43 ft (13 m) for inspection. Pixel size (GSD): 0.04 in (1 mm).

These flights produced 594 photos (164 ft flights) and 7236 photos (43 ft flight) respectively.
A photogrammetric process gives 3D alignment of these photos and 3D reconstruction of the tower as a point cloud and 3D mesh.

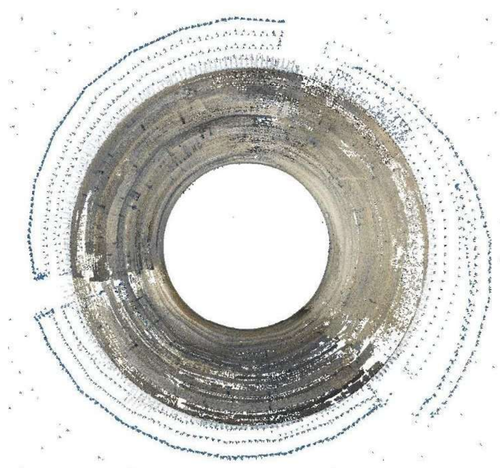
4.2. Camera alignment

The following captures show the position of the photos at 164 ft and 43 ft.





Perspective view from the cameras positions – Left view from the cameras positions



View from the top from the cameras positions

4.3. Georeferencing of 3D model

The points NW1 to NW4 and SW1 to SW5, known in the coordinate system NAD83 / West Virginia North has been picked on the tower. These references help to place and scale the 3D model into this coordinate system.

The points are not well placed: they are just on the South of the tower and on the North-West, on a single level : 807 to 845 us ft. For a proper coordinate system definition, it is preferable to have points on the full circle of the structure and from bottom to top.

3D positions of the references

The table shows the errors made on these points while trying to georeference the 3D model

	Coordinates (us ft)			Error (us ft)			
Point	East - X	North - Y	Elevation - Z	X	Y	Z	3D
NW_1	1598249.908	487003.725	832.212	0.010	0.008	0.001	0.013
NW_2	1598236.744	486987.915	834.681	0.012	-0.009	-0.001	0.015
NW_3	1598217.204	486958.935	834.783	-0.063	0.002	0.012	0.064
NW_4	1598231.232	486992.632	810.594	0.037	-0.019	-0.004	0.042
SW_1	1598277.623	486833.758	830.661	-0.030	0.002	0.015	0.034
SW_2	1598300.885	486833.525	845.758	0.011	0.024	0.008	0.028
SW_3	1598321.431	486829.932	827.007	0.007	-0.001	-0.021	0.022
SW_4	1598299.384	486823.318	806.755	0.032	-0.015	-0.009	0.036
SW_5	1598300.795	486829.289	827.001	-0.016	0.008	-0.001	0.018
			Std dev (us ft)	0.031	0.013	0.011	0.016

These errors are very good all things considered, but that's because the 9 reference points are divided into two groups (NW & SW), with all the points in relatively close proximity of each other in these two groups. We might have bigger errors on the parts without references, up to 0.3 ft.
The 3D coordinates (GPS) of the UAV cannot be used for this georeferencing because it needs to place the base antenna on a point on the ground that is measured with good accuracy (0.03 ft).

4.4. Point cloud and 3D model

After aligning the camera and georeferencing the tower, a point cloud can be generated, made up of 200 million 3D points (colored), and a triangular mesh can be generated. After generating these 3D data, the mesh texture can be generated
The mesh is composed of 1 million triangles.

3D point cloud (colored)

3D mesh of triangles (left: not textured) – right: textured

These data sets are delivered on the google drive as a *.las file for the point cloud and a *.obj file for the 3D textured mesh.
Units are US ft and coordinate system is NAD83 / West Virginia North.

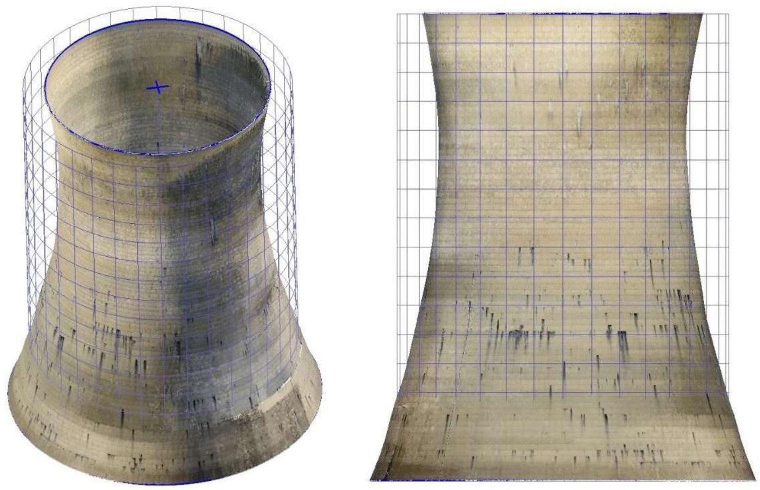
4.5. Orthophotography

The textured 3D model was unwrapped following a cylindrical model. The parameters of the cylinder are:

- Center:

- East (X) = 1 598 307.24 US ft
- North (Y) = 486 925.65 US ft
- Radius: 107.645 US ft
- Cut : North
- Unwrap rotation : natural view from outside

4.5.1. Cylindrical projection



Cylinder used for the data unwrapping

Cylindrical unwrapping N - W - S - E - N (left to right)

This projection on the cylinder and unwrapping leads to some scaling error on lengths which is corrected in the database by computing the 3D coordinates of the defects on the shell and re-computing the lengths.

4.5.2. Orthophoto resolution

3 orthophotos have been generated:

- 1 pixel = 0.04 in (1 mm) for the parts with highly detailed images with a flight at 43 ft (13m)
- 1 pixel = 0.08 in (2 mm) for the parts with standard images with a flight at 43 ft (13m)
- 1 pixel = 0.16 in (4 mm) for the parts covered with with a flight at 164 ft (50m)

The 0.04 in (1mm) grid with not blurred photos enables to see the cracks starting with an opening 3 to 5 time smaller than 1 pixel: cracks with an opening of 0.008-0.012 in (0.2-0.3 mm).
The 0.08 in (2mm) grid with not blurred photos enables to see the cracks starting with an opening 3 to 5 time smaller than 1 pixel: cracks with an opening of 0.016-0.024 in (0.4-0.6 mm).

The 0.16 in (4mm) grid was helpful to see in some areas not covered with highly detailed images and standard images from the 43 ft (13m) flights.

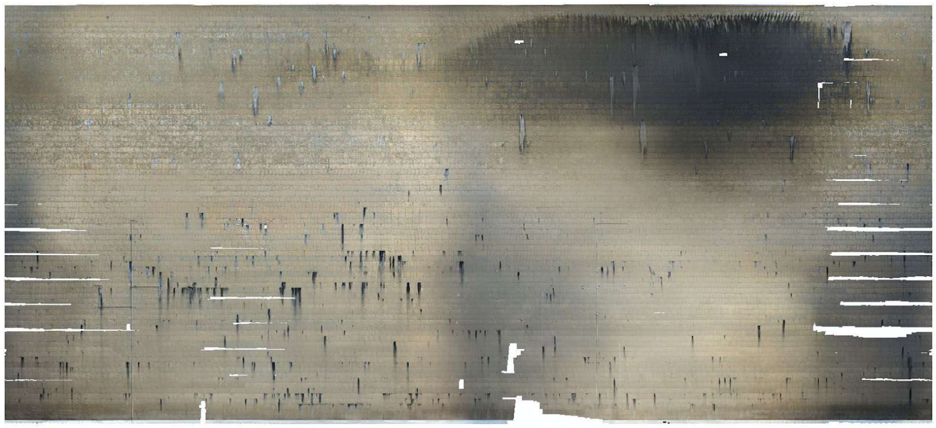
Units of the orthophotos are US survey feet.

The orthophotos are georeferenced on an X,Y flat coordinate system. For this cylindrical projection:

- X= circonference position. X is between 0 US ft (0°) to 676.35 US ft (360°)
- Y= elevation, from 735.63 US ft (bottom of the shell) to 1038.42 US ft (top of the shell)

One single file with these 3 orthophotos overlaying gives the better of each image: the 0.04in image is on top of the 0.08in image which is on top of the 0.16in image.

1 pixel = 0.16 in (4 mm)



1 pixel = 0.08 in (2 mm) with standard images

1 pixel = 0.04 in (1 mm) – Ultra sharp images

The white stripes are explained by a vertical overlap which was too small or absent. This lead to having zones which were pictured but from further away only.

4.5.3. Orthophoto visualisation

The orthophotography is delivered as a *.tiff file, linked to its georeferencing file (.tfw). It can be read with any GIS software (ArcGis, Qgis, Mapinfo,…).

An html viewer is given on the google drive to easily view the orthophotography without the defects and without measurements.

5. Inspection characteristics

From the orthophotography, a visual inspection was made to find all the defects of the shell. Cracks with an opening of more than 0.03 in (0.8 mm) were highlighted. Corrosion, concrete spit, seepage, unsticking or visible steel are drawn/highlighted if visible.

According to their geometric characteristics, the defects can be recorded as:

- linear defects (for example cracks),
- surface defects (for example crazing area),
- punctual defects (for example corrosion punctures).

5.1. Defects id

Each defect has a single number (id) which is written on the map and can be used to find the type and features.

5.2. Defects types

The following list includes identified and coded defect types:

- FI: cracks
- CO: corrosions
- SU: seepages
- DC: unstickings
- DX: miscellaneous defects not covered by the types above

5.3. Defects secondary feature(s)

A defect's secondary feature is a physical feature that completes defect type classification and is coded as follows:

- EF: efflorescence
- EP: concrete spit
- SU: seepage
- FA: crazing
- DC: unsticking
- AA: visible steel
- TR: rust trace
- NC: honeycombing
- REP: repair
- AU: other

A defect may be allocated with one, two or even no secondary features.

5.4. Defects location

- RB: concrete rework,
- JO: joint,
- NV: rib,
- RC: falling risk.

5.5. Defects measured features

Measured features describe defect characteristics that may be quantified using a numerical value:

- position (X, Y, Z) (ft),
- length (ft),
- average opening (in), for cracks,
- surface area (ft^2), if the defect is a surface,
- orientation : 0° is vertical, 90° is horizontal, between 15° and 75°,it is inclined.

5.6. Evolution

For a second inspection of the wall in the future, a second orthophotography overlaying exactly the first one will enable us to give the evolution of the defects. These names would be used in this case:

- CRE: New defect
- EVO: Evolutionary defect
- NEV: No evolution
- FUS: Defect merged with another one (name of this defect in the remark)
- FUSF: defect that has been merged with a FUS defect and then deleted.
- SUP: defect deleted
- REP: defect deleted because it has been repaired
- NOB: no observation (because no image of this area)

5.7. Defects snapshots

One or several color shots characterize each defect. They are saved in digital format (jpeg). The name of the file is the defect id.

5.8. Accuracy for photogrammetric inspection

The expected performance as a result of the measurement distance are as follows:

- detected cracks: opening average above 0.008-0.012 in (0.2-0.3 mm),
- defect location precision in the XYZ coordinate system: 0.8 in (2 cm),
- defects length: accuracy 2 in (5 cm).

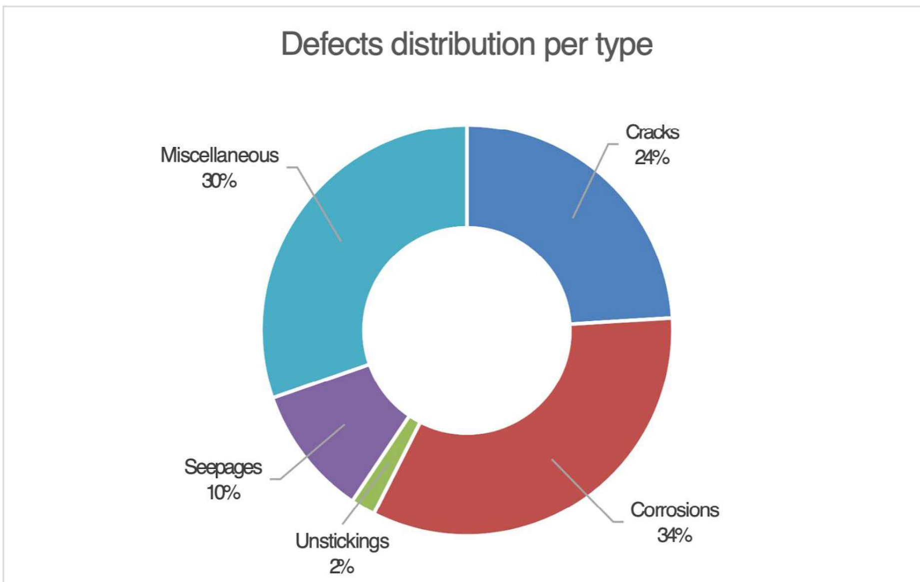
Even if we are able to see the 0.008-0.012 in (0.2-0.3 mm) cracks, the cracks are drawn/highlighted if their opening is above 0.03 in (0.8 mm).

6. General results

The following tables give some statistical results of inspection.

6.1. Defects distribution per type

	Family of defects					
	Cracks	Corrosions	Unstickings	Seepages	Miscellaneous	Total
	FI	CO	DC	SU	DX	
Number of defects	1393	1939	112	594	1759	**5797**
Cumulative length (ft)	8911.80	68.31	106.48	2196.98	5398.99	**16682.58**

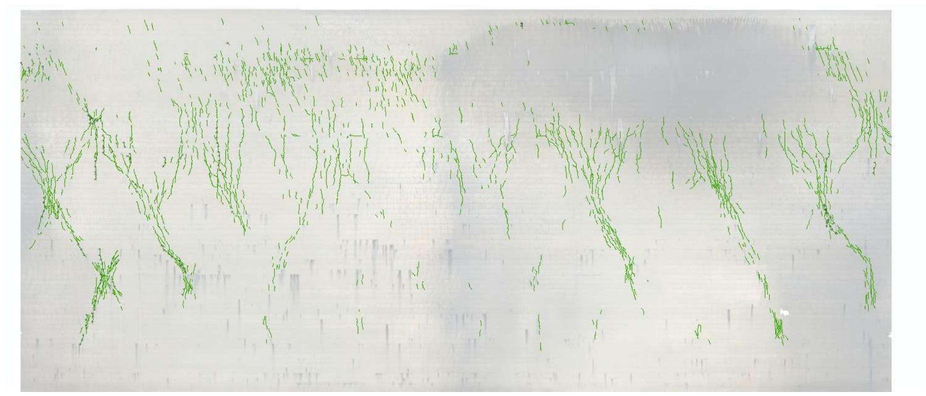


The majority of defects are cracks (1393), miscellaneous defects (1759) and corrosions (1939). Most of the miscellaneous defects are efflorescence with no seepage. When an efflorescence has water seepage, it is classified as a seepage with efflorescence.

The cumulative length is very important: 16682.58 ft. The cracks above 0.8mm (0.03 in) have a cumulative length of 8911.80 ft. This value would be much more important if the cracks above 0.3mm (0.01 in) were included.

6.2. Cracks

There are a lot of cracks and the cumulative length is important. Moreover, the cracks with an opening under 0.03 in (0.8mm) were not drawn. The following capture shows the distribution of cracks on the entire shell:



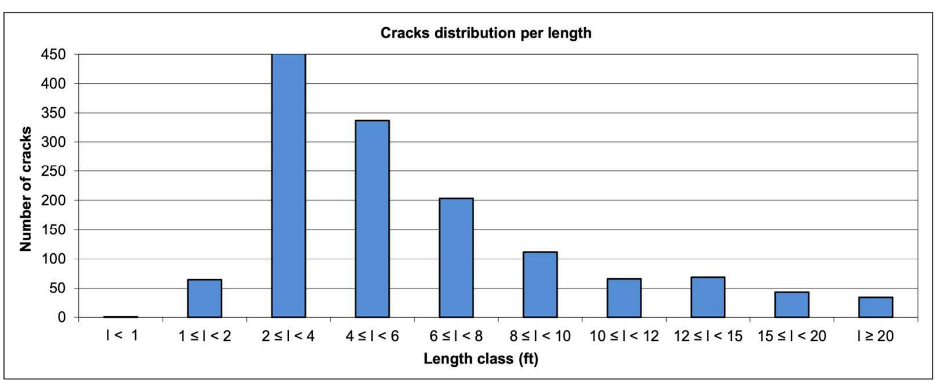
Distribution of cracks N - W - S - E - N

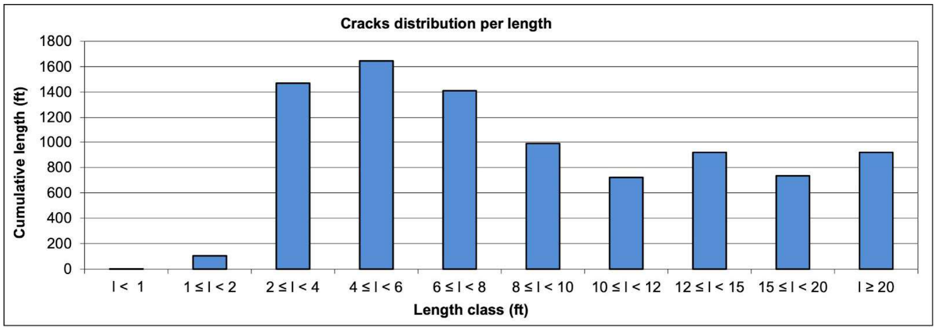
We can see a distribution in X or Y from 45 ft above the bottom of the shell to 260 ft.
In the geometrical analysis part, we can see these cracks are following the distortions.

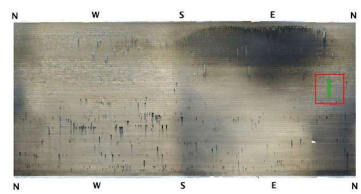
6.2.1. Cracks distribution and histogram per length classification

Length class (ft)	l < 1	1 ≤ l < 2	2 ≤ l < 4	4 ≤ l < 6	6 ≤ l < 8	8 ≤ l < 10	10 ≤ l < 12	12 ≤ l < 15	15 ≤ l < 20	l ≥ 20
Number	1	65	463	337	203	112	66	69	43	34
Cumulative length (ft)	0.988	103.43	1470.77	1644.22	1411.17	988.85	721.32	918.34	734.34	918.36

Most of the cracks are between 1 & 10 ft, but we can find 34 cracks with a length of more than 20 ft.
A lot of cracks are ready to merge and create a single very long crack.



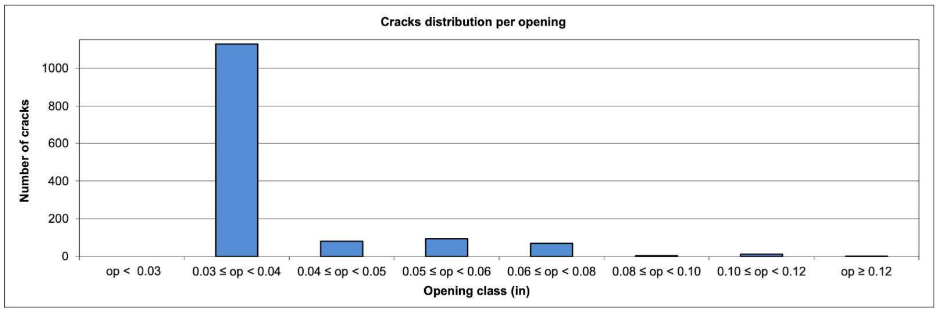


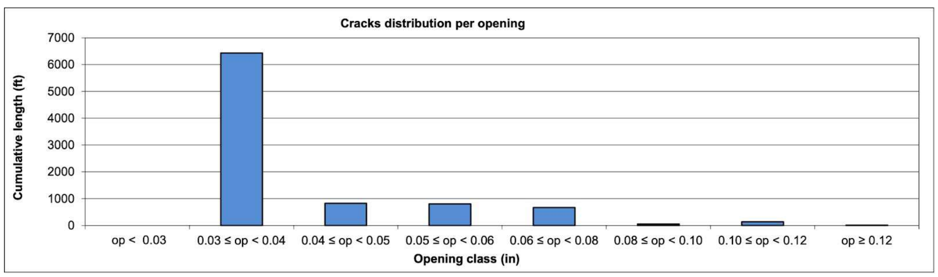


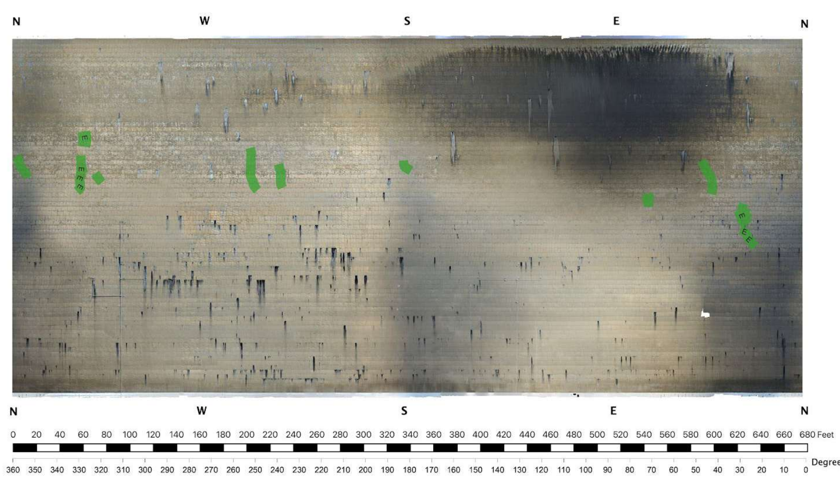
Above, can be seen a closeup of the longest crack, along with its location in relation to the structure.

6.2.2. Cracks distribution and histogram per opening classification

Opening class (in)	op < 0.03	0.03 ≤ op < 0.04	0.04 ≤ op < 0.05	0.05 ≤ op < 0.06	0.06 ≤ op < 0.08	0.08 ≤ op < 0.10	0.10 ≤ op < 0.12	op ≥ 0.12
Number	-	1128	81	94	70	5	13	2
Cumulative length (ft)	-	6426.09	822.00	800.09	667.77	52.44	137.23	6.18







15 widest cracks have been highlighted in the geographical layout.

Closeup of widest crack along with georeference

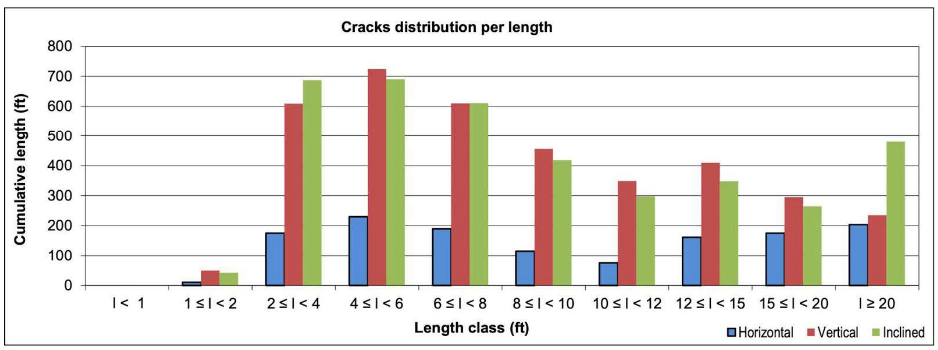
Closeup of second widest crack along with georeference

6.2.3. Cracks distribution per orientation

A crack is horizontal if its angle between the start point and end point is less than 15 degrees; it is vertical if it is more than 75 degrees; others are inclined.

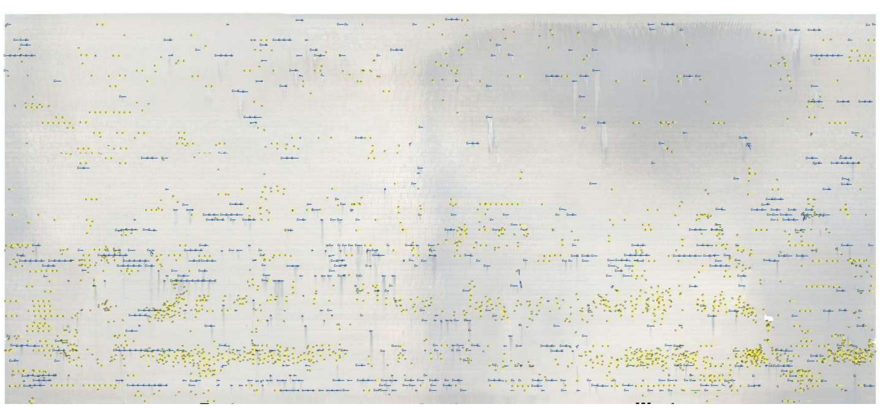
	Length class (ft)	l < 1	1 ≤ l < 2	2 ≤ l < 4	4 ≤ l < 6	6 ≤ l < 8	8 ≤ l < 10	10 ≤ l < 12	12 ≤ l < 15	15 ≤ l < 20	l ≥ 20
Cumulative length (ft)	Horizontal	0	11	175	230	190	115	75	161	175	203
	Vertical	1	50	609	724	610	455	349	409	295	235
	Inclined	0	43	687	690	611	418	297	348	264	480

Most of the cracks are vertical and inclined.



6.3. Seepage and efflorescence

There is a high number of incidents of seepage and efflorescence. Crack openings cannot be seen for those defects.
The following capture shows the distribution of the seepage and efflorescence:



Distribution of seepage and efflorescence N - W - S - E - N (left to right)

Most of the seepage defects are horizontal. An efflorescence with seepage is classified as seepage because the water leak is more important than an efflorescence. Most of the seepage defects are on the lower half of the cooling tower.

The efflorescence defects are most of time small cracks with traces of efflorescence , but we are not able to see the opening of the crack. A lot of efflorescence defects are vertical or inclined and placed between 20 and 95 ft from the bottom of the shell.

6.4. Holes and falling risk

6.4.1. Hole

Two holes have been detected:

- 97 ft from the bottom of the shell, on the East side. Vapor inside the cooling tower can be seen, along with the steel. The width is 4 ft and the height is 1ft. (defect n°887)

Hole (4 ft width x 1 ft height)

- 194 ft from the bottom of the shell, on the West side. The width is 0.14 ft and the height is 0.28 ft. (defect n°2608)

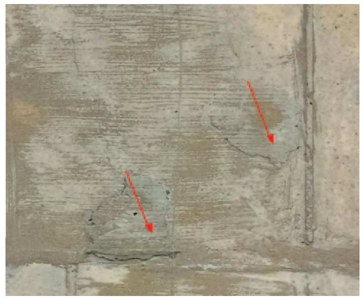
Hole (0.14 ft width x 0.28 ft height)

6.4.2. Defects with falling risk

66 falling risks were detected. Most of them can kill a man and most of them are ready to fall.
All of them are unstickings : 20 points, 6 lines and 40 surfaces. The difference between points, lines and surfaces is the size of the defect: the defects of less than 0.3 ft in width or height are drawn as points.
The following map gives the location of all of these falling risks. The majority of these defects are above 200 ft from the bottom of the shell.

Defects with falling risk N - W - S - E - N

The following captures shows all these defects ready to fall:









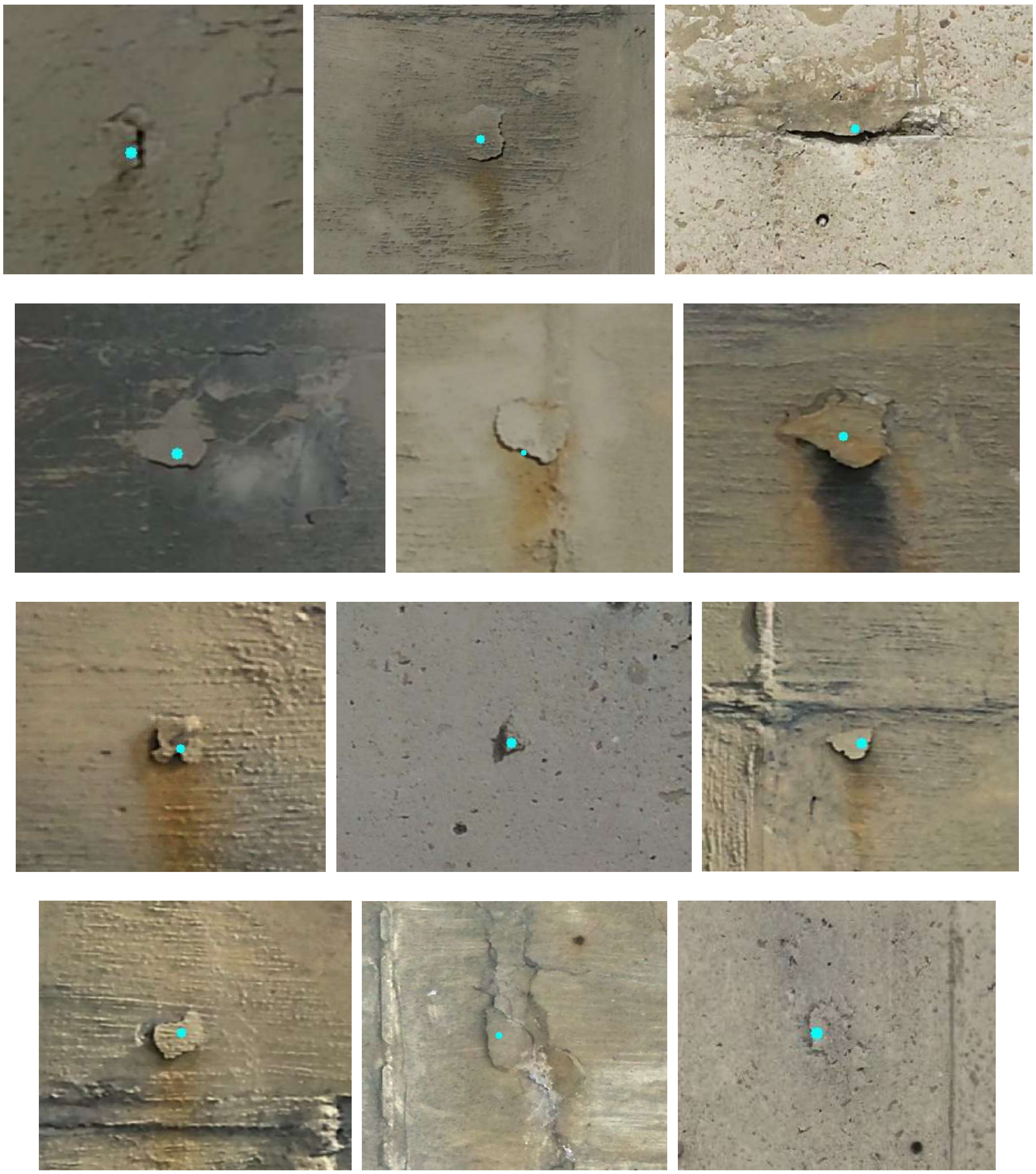










Defects with falling risk

7. Inspection synthesis

- Total number of defects: 5797
- Cumulative length of cracks: 8911.80 ft
- Cumulative length of corrosions (visible steels): 68.31 ft
- Surface: ≈17069m² = 183 728 ft²
- Number of defects per surface unit: 0.0315 def/ft²
- Length of cracks per surface unit: 0.050 ft/ft²
- Length of corrosions (visible steels) per surface unit: 0.00036 ft/ft²

8. Distortion analysis

8.1. Theoretical model

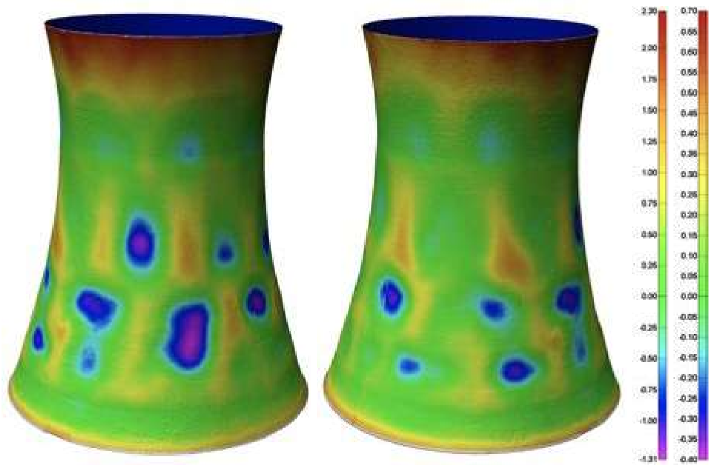
The theoretical model was built from the document "Mitchell U2 CT Shell Dwg 13 _ 14.pdf" with the help of drawings and the equation of the hyperbolic curve.

8.2. Comparison and unwrapping

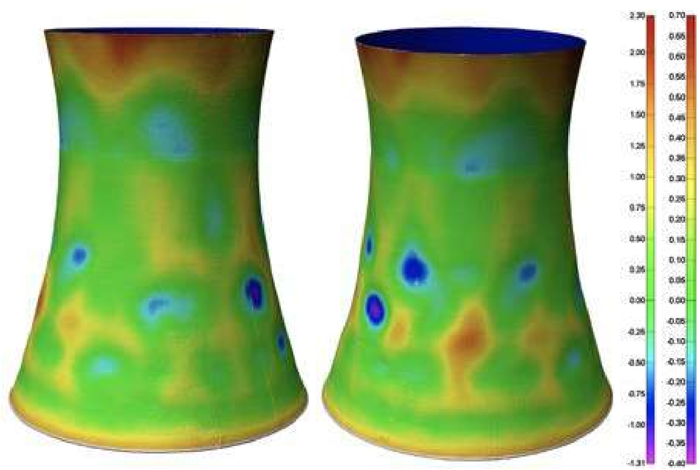
The theoretical model can be compared to the real model once both models were aligned in the same coordinate system. The alignment process was performed by using the altitude of the bottom, top and neck of the shell.
The comparison gives distances between the two surfaces. These distances are color coded:

- Green for no distortions
- Hot color (yellow, red) for outside distortions
- Cold colors (blue) for inside distortions

The scaling is not symmetrical: the maximum outside measured distortion is +0.7m and the minimum inside distortion is -0.4m.

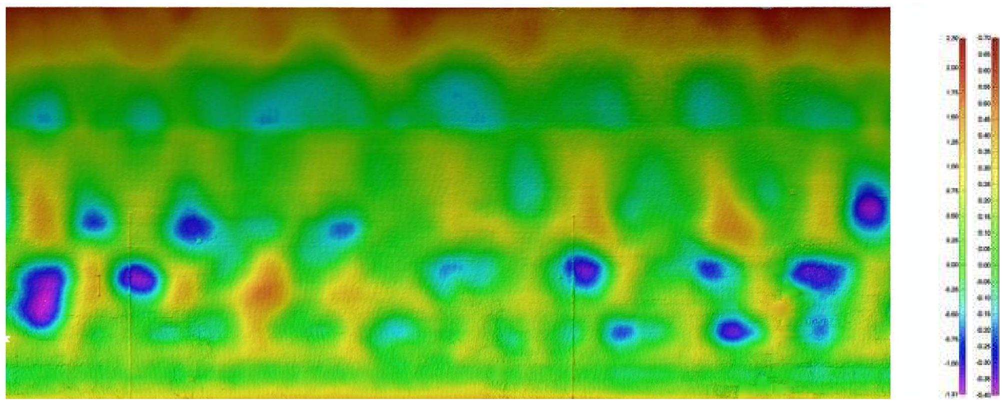


Views from North and East (scale in foot (left) and meters (right))



Views from South and West (scale in foot (left) and meters (right))

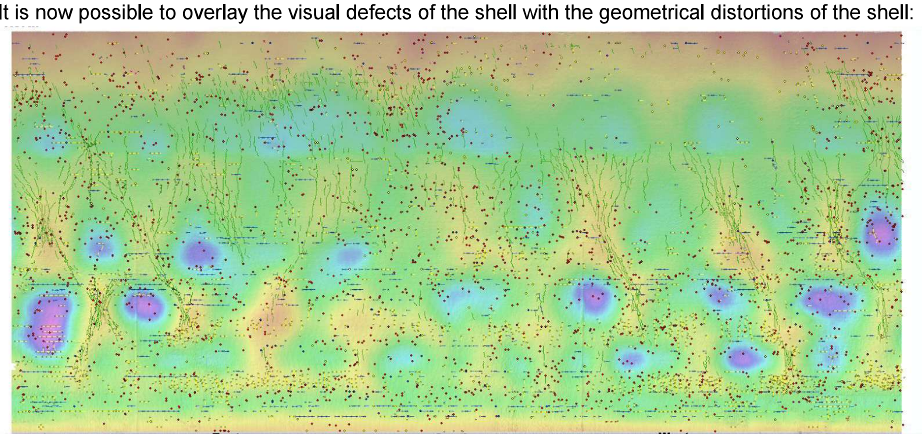
It is possible to unwrap these distortions in the same way the orthophotography was developed:



Cylindrical unwrapping of the distortions (scale in foot (left) and meters (right))
N - W - S - E - N

8.3. Defect overlaying

It is now possible to overlay the visual defects of the shell with the geometrical distortions of the shell:



N - W - S - E - N

The correlation is very high between defects and distortions. Most of the cracks are located at the summit of the external distortions (bumps). Most of the efflorescences are also on summit of external distortions (bumps): Bottom East, West and North of the shell.

9. Structural analysis

The technical advice below was based solely on the inspection data, no other input data was analyzed.

This cooling tower is in poor structural condition.

The defects identified on the structure illustrate both the pathology of materials (concrete spalling, corrosion, reinforcement swelling cracks) and also a mechanical malfunction (cracks at 45 ° and significant distortions in the lower part of the structure). As a reminder, the threshold for detection of cracks was 0.8 mm, which is considered as a high value for a reinforced concrete structure exposed to the elements. From the point of view of the structural strength, crack openings of more than 1.8 mm have been found (especially in the areas of 45° cracks), their severity is difficult to estimate without more information, but they probably correspond to a plasticization of reinforcement in these areas.

The superposition of the disorder mapping with the deformations measured in relation to the theoretical drawings makes it possible to correctly identify the 45° cracks in the elongation zones (in red / orange on the map). The generalized character of the distortions tends to eliminate the hypothesis of differential ground settlement to explain these disorders.

The photographic coverage shows that often the concrete coating is weak, which explains the cracks that follow the steel reinforcements, efflorescence and the many instances of visible reinforcements.
It is unlikely that these implementation defects are the only origin of the "mechanical" defects (inclined cracks), indeed, it would mean that the losses of sections of the reinforcement are generalized.

The origin of the defects observed on the structure is probably twofold:
- Design defect with insufficient reinforcements, which does not guarantee the structural strength of the structure over time,
- Implementation defects and aging of the structure which leads to numerous disorders (cracks, corrosion, etc.) which accentuates the mechanical disorders.

In addition concerning security, many disorders have been identified with the risk of falling concrete, these disorders have to be treated or access to the bottom of the cooling tower must be prohibited.

The question of the exploitation of the structure and its reinforcement must arise in the very short term.
A complete assessment must be carried out including:
- Analysis of design data (plans, calculation notes, etc.),
- The analysis of the history of the work (inspection, exploitation),
- The realization of in situ measurements to characterize the reinforcement, the geometry, the characteristics of the concrete, etc.
- The modeling of the cooling tower on the basis of these data,
- The establishment and implementation of reinforcement / repair recommendations.

Meanwhile a regular inspection should be conducted to confirm the absence of degradation of the structures condition.
Sterblue recommends regular inspection intervals of no more than 3 - 6 months.

10. Data

The following data is available in the google drive shared folder:
- Table of defects and table of defects with 3D coordinates of all the points
- Image capture of defects (*.jpg file). Name of the file = id of the defect

- PDF of mappings
- *.tiff file of the orthophotography (0.04in, 0.08in, 0.16in and assembly) compatible with GIS software
- Viewer KRpano for the orthophotography
- Point cloud as *.las file
- 3D textured model as *.OBJ file

11. Flight analysis and experience feedback

3 flight trajectories were carried out. It could be done in just 2. The RTK base should be placed on a point known in XYZ on the ground, and these 3D coordinates should be written in the base software to get the precise location of each photo. If the base is placed on two or 3 points on the ground, we should know the exact location of these 3 points (and height above the ground of the antenna).

Some photos have been shot with ISO 800. This level of ISO is not too high, but an option in the camera have blurred the photos, maybe to remove the noise. This option should be deactivated to get the highest resolution of these images. Images at ISO 800 have been downsized at 50% to get a sharp pixel of 0.08in (2mm) instead of a blurred pixel of 0.04in (1mm).

The software has been updated to optimize the trajectory for future inspections in order to have:

- 50% of overlapping on the vertical axis
- 70% of overlapping on the horizontal axis
- Overlap between the 3 trajectories

The flight at 164ft (50m) could be replaced by a flight at a shorter distance with a wider lens (25 mm) and/or a photo coverage from the ground.

12. Conclusion

This report has presented the visual inspection of the MITCHELL'S UNIT 2 cooling tower with images captured with a UAV and automatic flights.

The data provided on the google drive share folder define a visual archive of the shell on 16th of August 2019. It does not define an accurate geometry archive because of the lack of 3D references.

It is possible to combine this data with a future photo coverage of the tower to give an accurate evolution of the defects on the tower.

This cooling tower is in poor structural condition. Many disorders have been identified with the risk of falling concrete, these disorders have to be treated or access to the bottom of the cooling tower must be prohibited.

Appendix 1

Example of major defects

Defect n°	Zone	Elevation
3779	S-SE	1012.48 ft
Type	**Length**	**Opening**
Unsticking with falling risk	0.61 ft²	-

Defect n°	Zone	Elevation
4	N	751.10 ft
Type	**Length**	**Opening**
Concrete spit	-	-

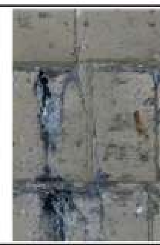
Defect n°	Zone	Elevation
2723	SW	799.63 ft
Type	**Length**	**Opening**
Corrosion	-	-

Defect n°	Zone	Elevation
2725	S	859.51 m
Type	**Length**	**Opening**
Seepage	3.12 ft	-

Defect n°	Zone	Elevation
2874	SW	766.51 ft
Type	**Length**	**Opening**
Seepage	-	-

Defect n°	Zone	Elevation
2979	E-SE	1031.44
Type	**Length**	**Opening**
Corrosion - visible steel	2.02 ft	-

Defect n°	Zone	Elevation
763	E	771.46 ft
Type	**Length**	**Opening**
Efflorescence	2.03 ft	-



Defect n°	Zone	Elevation
5341	N-NW	885.31 ft
Type	**Length**	**Opening**
Crack with efflorescence	3.85 ft	0.16 in

Defect n°	Zone	Elevation
1553	E-NE	942.91 ft
Type	**Length**	**Opening**
Efflorescence on concrete rew o	1.73 ft	-

Defect n°	Zone	Elevation
4995	W-NW	900.17 ft
Type	**Length**	**Opening**
Crack	3.52 ft	0.12 in

Defect n°	Zone	Elevation
5304	N-NW	870.86
Type	**Length**	**Opening**
Seepage	-	-

Defect n°	Zone	Elevation
853	E-NE	840.84
Type	**Length**	**Opening**
Crack	2.69 ft	0.08

Appendix 2 to 7

(delivered on the shared drive)

Appendix 2: table of defects
Appendix 3: map of defects
Appendix 4: map of defects with falling risk overlaying the orthophotography
Appendix 5: map of defects overlaying the orthophotography
Appendix 6: map of distortions
Appendix 7: map of defects overlaying the distortions

R 19 LY 3239

Los Angeles,
CA 90291

80 E Rich Street, Suite 600,
Columbus, OH 43215

5 route du Pérollier,
69570 Dardilly - France

Appendix 2 - Table of defects

Inspection characteristics

From the orthophotography, a visual inspection was made to find all the defects of the shell. Cracks with an opening of more than 0.03 in (0.8 mm) were highlighted. Corrosion, concrete spit, seepage, unsticking or visible steel are drawn/highlighted if visible.

According to their geometric characteristics, the defects can be recorded as:

- linear defects (for example cracks),
- surface defects (for example crazing area),
- punctual defects (for example corrosion punctures).

Defects id

Each defect has a single number (id) which is written on the map and can be used to find the type and features.

Defects types

The following list includes identified and coded defect types:

- FI: cracks
- CO: corrosions
- SU: seepages
- DC: unstickings
- DX: miscellaneous defects not covered by the types above

Defects secondary feature(s)

A defect's secondary feature is a physical feature that completes defect type classification and is coded as follows:

- EF: efflorescence
- EP: concrete spit
- SU: seepage
- FA: crazing
- DC: unsticking
- AA: visible steel
- TR: rust trace
- NC: honeycombing
- REP: repair
- AU: other

A defect may be allocated with one, two or even no secondary features.

Defects location

- RB: concrete rework,
- JO: joint,
- NV: rib,
- RC: falling risk.

Defects measured features

Measured features describe defect characteristics that may be quantified using a numerical value:

- position (X, Y, Z) (ft),
- length (ft),
- average opening (in), for cracks,
- surface area (ft^2), if the defect is a surface,
- orientation : 0° is vertical, 90° is horizontal, between 15° and 75°,it is inclined.

Evolution

For a second inspection of the wall in the future, a second orthophotography overlaying exactly the first one will enable us to give the evolution of the defects. These names would be used in this case:

- CRE: New defect
- EVO: Evolutionary defect
- NEV: No evolution
- FUS: Defect merged with another one (name of this defect in the remark)
- FUSF: defect that has been merged with a FUS defect and then deleted.
- SUP: defect deleted
- REP: defect deleted because it has been repaired
- NOB: no observation (because no image of this area)

Defects snapshots

One or several color shots characterize each defect. They are saved in digital format (jpeg). The name of the file is the defect id.

Accuracy for photogrammetric inspection

The expected performance as a result of the measurement distance are as follows:

- detected cracks: opening average above 0.008-0.012 in (0.2-0.3 mm),
- defect location precision in the XYZ coordinate system: 0.8 in (2 cm),
- defects length: accuracy 2 in (5 cm).

Even if we are able to see the 0.008-0.012 in (0.2-0.3 mm) cracks, the cracks are drawn/highlighted if their opening is above 0.03 in (0.8 mm).