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COMMANDER
NAVY REGION HAWAII
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Ser N45/00401
AUG 16 2021

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Environmental Management Division
Solid and Hazardous Waste Branch
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SUBJECT: RESPONSE TO THE ENVIRONMENTAL PROTECTION AGENCY AND DEPARTMENT OF HEALTH "PRELIMINARY REVIEW AND REQUEST FOR REVISED OR SUPPLEMENTAL SCOPE OF WORK" LETTER REGARDING THE U.S. NAVY AND DEFENSE LOGISTIC AGENCY DECISION ON NEED FOR AND SCOPE OF MODIFIED CORROSION AND METAL FATIGUE PRACTICES EXECUTION PLAN, RED HILL BULK FUEL STORAGE FACILITY ADMINISTRATIVE ORDER ON CONSENT SECTION 5.4

Dear Ms. Carvalho and Ms. Kwan:

Enclosed is the Administrative Order on Consent Section 5.4 Execution Plan Decision on Need for and Scope of Modified Corrosion and Metal Fatigue Practices Amendment 1 document in response to the Environmental Protection Agency (EPA) and Department of Health (DOH) "Preliminary Review and Request for Revised or Supplemental Scope of Work" letter dated 10 May 2021. The enclosed Amendment 1 Execution Plan document specifically addresses topics outlined in the letter and includes supplemental content to incorporate comments received from the EPA and DOH during the 10 June 2021 meeting.

This Amendment 1 Execution Plan provides additional details, describes supplemental deliverables, and schedules numerous meetings in order to bring further transparency in the data collection and evaluation processes. Specific information is provided regarding interim products that will be developed and status meetings scheduled for each deliverable. Schedule activities have been clarified so parties understand the EPA and DOH deliverable review durations are not constrained by Navy and Defense Logistics Agency (DLA), who will continue to execute the plan. The Amendment 1 Execution Plan identifies robust resources, means, and methods that

5750
Ser N45/00401
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define the expertise Navy and DLA will use to develop each deliverable. A process that will be used to consider all of the information and findings from the various documents is provided in detail.

If you have any questions, please contact Mr. Donald Panthen, Red Hill Program Director, at (808) 473-4148 or by email at donald.panthen@navy.mil.

Sincerely,

J. G. MEYER
Captain, CEC, U.S. Navy
By direction

Enclosure: 1. Administrative Order on Consent Section 5.4 Execution Plan Decision letter of 10 May 2021.

Administrative Order on Consent
In the Matter of Red Hill Bulk Fuel Storage Facility
EPA Docket No: RCRA 7003-R9-2015-01
DOH Docket No: 15-UST-EA-01

Section 5.4
EXECUTION PLAN
Decision on Need for and Scope of Modified Corrosion and Metal Fatigue Practices

AMENDMENT #1

Prepared by:
NAVFAC EXWC

DATE: 16 August 2021

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EXECUTIVE SUMMARY

The purpose of AOC Section 5.4 is to improve the current inspection process as stated in the AOC SOW Section 2.4 Tank, Inspection, Repair and Maintenance (TIRM) Decision Document, dated 24 April 2017. The agreed upon goal, by the Regulatory Agencies (RAs) and Navy/DLA (Defense Logistics Agency) for an improved TIRM process, is to achieve no release during a service interval between Clean, Inspect, and Repair (CIR) events. Improvements will focus on significant and practicable opportunities to increase confidence in achieving the TIRM performance goal.

This Navy/DLA execution plan for the preparation of Work Products responds to RA letters regarding previous work and deliverables under AOC Section 5.3. The Navy will provide Work Products that will consist of additional research, studies, data analysis, market information, testing, investigations, and recommendations. The intent of the Work Products is to clarify, explain, amplify, and present new information both in furtherance of responses related to AOC Section 5.3 as well as implementation of AOC Section 5.4.

The objective of these studies and investigations is to evaluate potential improvements to the current tank inspection and repair processes. Any such improvements, along with all the other work and analyses the Navy is performing, can help decrease the risks and further the goal of preventing a release during a service interval. Improvements that will be incorporated into the TIRM process will increase confidence in achieving this goal.

Several Work Products will be developed as described in this AOC SOW Section 5.4 Execution Plan. The Regulatory Agencies will have an opportunity to collaborate with the Navy/DLA during development of statements of work and during review of preliminary and final submittals. The concurrence of the recommendations provided in the initial Work Products will be incorporated into subsequent Work Products. The final Work Product - TIRM Update Report – will meet the objectives to improve the TIRM process.

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Table of Contents

List of Attachments

ACRONYMS AND ABBREVIATIONS

ACI	American Concrete Institute
AOC	Administrative Order on Consent
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
AST	Above ground Storage Tank
BAPT	Best Available Practicable Technology
CV	Curriculum Vitae
DLA	Defense Logistics Agency
DTRR	Destructive Testing Results Report
HCL	Hawaii Corrosion Laboratory
LFET	Low Frequency Electromagnetic Technique
MFE	Magnetic Flux Examination
NAVFAC EXWC	Naval Facilities Engineering and Expeditionary Warfare Center
NDE	Non-Destructive Examination
PAUT	Phase Array Ultrasonic Testing
PLCA	Preliminary Concrete Assessment Report
PLCA	Preliminary Liner Corrosion Assessment Report
RAs	Regulatory Agencies
RHBFSF	Red Hill Bulk Fuel Storage Facility
SME	Subject Matter Expert
SOW	Scope of Work
TBD	To be determined
TIRM	Tank, Inspection, Repair and Maintenance
TUA	Tank Upgrade Alternative
UH	University of Hawaii
UST	Underground Storage Tank
UT	Ultrasonic Testing

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1.0 INTRODUCTION

1.1 Background

The Navy/DLA submitted the Corrosion and Metal Fatigue Practices, Destructive Testing Results Report (DTRR) to the RAs on July 7, 2019 to satisfy the requirements in Section 5.3.3 of the Red Hill Administrative Order on Consent (AOC). On March 16, 2020, the RAs disapproved the DTRR and stated they "do not concur that the NDE results are validated, both by Destructive Testing and thorough, case-by-case analysis." The RAs further stated that additional work should include both 1) effort to improve the non-destructive testing protocol as generally envisioned in Section 5.4 of the AOC SOW, and 2) further destructive testing to address deficiencies and evaluate proposed improvements to non-destructive examination protocol.

Following the disapproval letter, discussions between the Navy/DLA and the RAs resolved many of the differences in interpretation. The Navy/DLA submitted a letter on June 2, 2020 to the RAs which agreed that additional information to substantiate the DTRR conclusions was warranted. RAs accepted the DTRR on July 7, 2020 under an agreement in which work under AOC Section 5.3.3 was satisfied and the Navy/DLA would work to "identify and implement practicable improvements to the NDE process with the specific goal of defining performance objectives that are protective of human health and the environment." Thus, the requirements to initiate AOC SOW Section 5.4 were met. AOC SOW Section 5.4 states that work is to address "needs for further evaluation, development, or implementation of practices to control corrosion or metal fatigue."

1.2 Section 5.4 Scoping Meetings

Three scoping meetings were held between the Navy/DLA and the RAs to agree upon an outline for the scope of work under AOC Section 5.4: (1) July 13, 2020, (2) August 11, 2020, and (3) September 1, 2020. Attachment A is the final Scope of Work outline presented to the RAs on September 1, 2020.

1.3 Execution Plan

The Navy/DLA incorporated the Scope of Work outline into ten Work Products. The Work Products are distinct and incorporate all topics in the Scope of Work Outline provided in Attachment A. The outline includes the topics RAs stated must be investigated in order to receive approval for AOC SOW Section 5.4. Development of the Work Products will include research, studies, data analysis, market information, testing, investigations, and recommendations.

The numbers in parenthesis following elements of each Work Product correspond to numbering in the Scope of Work outline. The Navy/DLA will provide statements of work developed for each Work Product to RAs for review and comment. Contract statements of work are procurement sensitive privileged information. RAs are prohibited from disclosure of the content in accordance with the Federal Acquisition Regulation and signed non-disclosure agreements.

1.4 Content

As required by the RAs, Work Product contents will address the following categories.

1) Technology – including specific non-destructive examination (NDE) technology and procedures constrained by practical limitations.
2) Human Factors (implementation of technology) – the overall TIRM process relies on human performance. What can be done to limit or mitigate human factor errors?
3) Repair Threshold / Process / Criteria – Evaluate current practice to determine if changes are warranted to account for new information such as destructive testing and analysis of NDE technology.
4) Slowing / Stopping Corrosion – Considering NDE data, destructive testing, concrete and corrosion studies, and other studies, what can be done (if anything) to slow or stop corrosion?
5) NDE Comparison – How does Balanced-Field Electromagnetic Technique NDE compare with non-electronic (vacuum testing or magnetic flux exclusion) methods to verify weld joint integrity?

1.5 Schedule

The approximate schedule for the completion of the work is provided for each Work Product. The schedules are based on Navy/DLA resources and realistic timeframes. However, these schedules are dependent on RAs review/comment durations and may be extended by several months. An overall estimated schedule for the entire effort, without RA review/comment durations, is provided in Attachment B.

A significant amount of additional content was requested by the RAs during Section 5.4 Scoping meetings. The development of some Work Products is based on results of antecedent reports and analysis. Other information will require original, publication-grade research. Therefore, there will be multiple Work Products for RAs to review.

It is anticipated that limited preliminary Work Product(s) may be available as within six months of approval of this plan. Due to the amount of testing, research, report writing, and dependencies between the Work Products, the overall plan will require 2 to 2-1/2 years to execute. The schedule will not be updated during the duration of the work contained in this Execution Plan, except during the meetings and workshops for each Work Product.

1.6 Flow Chart

As required by the RAs, Attachment C is a flow chart which provides the planned structure of the development of the Work Products, how development of Work Products will feed into development of other work, and how work will result in the final TIRM improvement processes and a completion report. The flow chart incorporates reviews and meetings/workshops for all of the statements of work, and preliminary and final submittals for each Work Product. The flow chart in conjunction with the schedule provides the overall approach in obtaining the collaboration and acceptance of the Work Products that will meet requirements of AOC SOW Section 5.4.

2.0 WORK PRODUCT #1 – NAVY/DLA INTERPRETATION OF THE COUPON RESULTS

2.1 Purpose

- The purpose of this Work Product is for a corrosion Subject Matter Expert (SME) to provide consulting services to interpret laboratory testing of steel coupons previously conducted by Navy/DLA, and to provide additional information and clarification in response to the RAs interpretations and statements received in a letter dated March 16, 2020.
- The Outline below lists the data and information that will be analyzed further in this Work Product.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

2.2 Outline

1.

2.3 Schedule

- May 2022
- Refer to paragraph 1.5 above and Attachment B.

2.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for review and comment. In order to remain on schedule, comments are required within three weeks after the Work Product is sent to Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:

a. Preliminary
b. Final

- The Review meeting will be scheduled with the Regulatory Agencies approximately two weeks after the Work Product is sent to the Regulators.

2.5 Contracts and Subject Matter Experts

- Technical expertise for the preparation of this Work Product is being provided by:
  a. TBD – Contract is not awarded.
- The Statement of Work for the development of this Work Product will provide the requirements for the technical experts.

2.6 Peer Review

The "Interpretation of the Coupon Results Work Product" will have Peer Review by Navy/DLA SME's. The Navy/DLA SME's will perform the technical and editorial review of all preliminary and final submittals. The Navy/DLA SME's will be selected for this effort based on the requirement of the Work Product. For this Work Product, an engineer or metallurgist who has not previously reviewed AOC SOW Section 5.4 Documents might provide a Peer Review. The qualifications of the individual selected to perform the Peer Review will be provided to the RAs.

3.0 WORK PRODUCT #2 – PRELIMINARY LINER CORROSION ASSESSMENT REPORT (PLCA)

3.1 Purpose

- The RAs stated in their letter dated 16 Mar 2020:
  - A belief the Navy is underestimating corrosion rates for Tank 14 and should reassess corrosion rates used in calculating minimum remaining thickness under TIRM.
  - The potential cause for increasing corrosion rates creates concern for potential corrosion of embedded reinforcement in the concrete.
- This Work Product will consist of an effort to consolidate all existing tank corrosion and condition information into a report. The primary objective is to review existing tank inspection corrosion data and produce a preliminary report addressing steel liner corrosion.
- The result of this Work Product will be used during the development of Work Product #10 - Overall Corrosion Assessment Report, and any deficiencies of previous inspection processes will be identified and incorporated into Work Products #7 – Inspection Data, LFET, and Step 2 Analysis Report and #9 – TIRM Update Report.
- The Work Product will address the topics listed below in the Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- The Statement of Work for this Work Product is included as Attachment D.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

3.2 Outline

1. Potential for Increased Rates of Corrosion
   - 1.1. Method by which Corrosion Rate is calculated (4.1)
   - 1.2. Using extreme value rates to establish Minimum Remaining Thickness (4.2)
   - 1.3. Environmental and chemical conditions affecting rates (4.4)
   - 1.4. Potential causes for corrosion (4.6)
   - 1.5. Potential corrosion impact from use of old verses new carbon steel Patch Plates (4.9)
     - 1.5.1. Potential Galvanic corrosion between new patch plate and old carbon steel liner (4.9.1)

2. Potential for weld stress due to crevice corrosion in the gap between the steel liner and a new patch plate. (4.9.2)
   - 2.1 Address crevice corrosion in fillet-welded patch plates on ASTs and how this is applicable for Red Hill and USTs in general.

3. Rainfall effects on Red Hill metal liners (4.7)

4. Factor of Safety (5.2)
   - Comparison with other industries (API, ASME, ASCE, ASNT, etc.)

5. Corrosion Rates (5.3)

- Address extreme value (e.g., timber lodged behind plate) vs uniform rate
- Comparison of corrosion rate model used at Red Hill with API standards
- Reevaluate the repair threshold and associated factor of safety to account for inaccuracies in NDE, corrosion rates, and possible delays in repair cycles.

3.3 Schedule

- December 2021
- Refer to paragraph 1.5 above and Attachment B.

3.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Preliminary
  b. Final
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

3.5 Contracts and Subject Matter Experts

- Technical expertise for the preparation of this Work Product is being provided by:
  a. Solomon Resources, Inc.
  b. Wiss, Janney, Elstner Associates
- The Qualifications for the consultants are provided in Attachments E and F.
- The Statement of Work for the development of this Work Product provides the requirements for the technical experts.

3.6 Peer Review

The "Preliminary Liner Corrosion Assessment Report" will have Peer Review by Navy/DLA SME's. The Navy/DLA SME's will perform the technical and editorial review of all preliminary and final submittals. The Navy/DLA SME's will be selected for this effort based on the requirement of the Work Product. For this Work Product, an engineer or metallurgist who has not previously reviewed AOC SOW Section 5.4 Documents might provide a Peer Review. The qualifications of the individual selected to perform the Peer Review will be provided to the RAs.

4.0 WORK PRODUCT #3 – PRELIMINARY CONCRETE ASSESSMENT REPORT

4.1 Purpose

- Empirical evidence of the Red Hill Bulk Fuel Storage Facility (RHBFSF) demonstrate the concrete is in good condition. Further information about the quality and durability of the RHBFSF concrete, and the potential for corrosion in the reinforcement is needed. The basis for this information is an analysis of mechanical, physical, and material properties. Due to characteristics of the facility and the potential for deleterious consequences of ad hoc destructive testing, a deliberate approach that will mitigate damage to the infrastructure is necessary.
- The result of this Work Product will be used during the development of Work Product #10 - Overall Corrosion Assessment Report.
- The Work Product will address the topics listed in the below Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

4.2 Outline

1. Conduct additional analyses on the condition of the concrete structure and embedded reinforcing steel. (5.4)
    - Study existing concrete pursuant to principles of American Concrete Institute (ACI) 364-1R- 19 Guide for Assessment of Concrete Structures Before Rehabilitation
    - Cores might include embedded reinforcing steel
    - Physical, chemical, and mechanical properties of the concrete will be studied
    - Statement of Work for this Study is included as Attachment G. Paragraph 1.2.1 provides the Assessment Plan overview and the intent for this study.

4.3 Schedule

- February 2022
- Refer to paragraph 1.5 above and Attachment B.

4.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
    a. Preliminary
    b. Final
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

4.5 Contracts and Subject Matter Experts

- Technical expertise for the preparation of this Work Product is being provided by:

a. Solomon Resources, Inc.
b. CTL Group
c. Dr. J David Rogers

- The qualifications for the consultants are provided in Attachments E and H
- The Statement of Work for the development of this Work Product provides the requirements for the technical experts.
- Attachment I is UFGS Section 02 25 16.00 20 which is referred to in the Statement of Work.

4.6 Peer Review

The "Preliminary Concrete Assessment Report Work Product" will have Peer Review by Navy/DLA SME's. The Navy/DLA SME's will perform the technical and editorial review of all preliminary and final submittals. The Navy/DLA SME's will be selected for this effort based on the requirement of the Work Product. For this Work Product, an engineer who has not previously reviewed AOC SOW Section 5.4 Documents might provide a Peer Review. The qualifications of the engineer or metallurgist selected to perform the Peer Review will be provided to the RAs.

5.0 WORK PRODUCT #4 – INSPECT AND REPAIR PROTOCOLS PROJECT FOR RED HILL UNDERGROUND STORAGE TANKS

5.1 Purpose

- The RAs stated a belief the Navy is underestimating corrosion rates for Tank 14 and should reassess corrosion rates used in calculating minimum remaining thickness under TIRM.
- The Work Product will address the topics listed in the below Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- Inspection and Repair Protocols are being examined by the University of Hawaii to determine if other methods are practical and can be considered improvements.
- University of Hawaii's proposal for this Work Product is included as Attachment J.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

5.2 Outline

1. University of Hawaii (UH) Study - The Hawaii Corrosion Laboratory (HCL), Department of Mechanical Engineering proposes to 1) elucidate the limits of nondestructive evaluation on severely corroded steel panels with adherent corrosion products, 2) develop protocol to measure in situ corrosion rates of steel panels that can be used for the Red Hill USTs, and 3) evaluate repair and patch protocols to prevent premature failures. (4.3)

2. Peer Review of Report (Corrosion Consultant)

5.3 Schedule

- July 2022
- Based on UH schedule
- Refer to paragraph 1.5 above and Attachment B.

5.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Final
  b. Final + Peer Review Work Products
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

5.5 Principal Investigator

- Technical expertise for the preparation of this Work Product is being provided by:
  a. Dr. Lloyd Hihara, University of Hawaii at Manoa

5.6 Peer Review

- The “Inspect and Repair Protocols Project for Red Hill Underground Storage Tanks Work Product” will have an independent peer review. It is anticipated that there will not be any preliminary submittals provided by the University of Hawaii to the Navy/DLA during the development of this Work Product. Therefore, the Navy/DLA will not be able to provide any reviews of the preliminary submittals. An independent peer review and critical analysis of the report will be performed on the report.
- It is anticipated that this peer review will be performed by Wiss, Janney, Elstner Associates. Wiss, Janney, Elstner Associates is also the technical expert for the “Preliminary Liner Corrosion Assessment Report” and the “Overall Corrosion Assessment Report.”

6.0 WORK PRODUCT #5 – CONCRETE TANK DEGRADATION INSPECTION AND RETROFIT

6.1 Purpose

- The RAs stated a belief that the potential cause for increasing corrosion rates creates concern for potential corrosion of embedded reinforcement in the concrete.
- The Work Product will address the topics listed in the below Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- University of Hawaii's proposal for this Work Product is included as Attachment K.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

6.2 Outline

1. UH Study - The objectives of this portion (secondary containment-corrosion in concrete) of the project are to 1) identify the locations and extent of cracking/degradation of the concrete and steel structure surrounding the oil tanks, 2) understand the causes and mechanism of the concrete and steel degradation based on chemical and mineralogical analysis, and 3) propose appropriate retrofitting technologies and strategies. (4.5)

2. Peer review of report – Concrete Consultant

6.3 Schedule

- August 2022
- Based on UH schedule
- Refer to paragraph 1.5 above and Attachment B.

6.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Final
  b. Final + Peer Review Work Products
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

6.5 Principal Investigator

- Technical expertise for the preparation of this Work Product is being provided by:
  a. Dr. Lin Shen, University of Hawaii at Manoa

6.6 Peer Review

- The "Concrete Tank Degradation Inspection and Retrofit Work Product" will have an independent peer review. It is anticipated that there will not be any preliminary submittals

provided by the University of Hawaii to the Navy/DLA during the development of this Work Product. Therefore, the Navy/DLA will not be able to provide any reviews of the preliminary submittals. An independent peer review and critical analysis of the report will provide validation and the integrity of the report.

- It is anticipated that this peer review will be performed by Dr. J. David Rogers. Dr. Rogers is also the technical expert for the "Preliminary Concrete Assessment Report."

7.0 WORK PRODUCT #6 – ELEMENT, PHASE, AND OXIDATION STATE MAPPING OF RED HILL UST CORROSION BY ADVANCED MICROSCOPY METHODS

7.1 Purpose

- Assess the possibility of distinguishing historic from contemporary corrosion episodes via "tracer" element and oxidation state distributions that may reveal episodic corrosion history
- The Work Product will address the topics listed in the below Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- University of Hawaii's proposal for this Work Product is included as Attachment L.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

7.2 Outline

1. UH Study - Laboratory study to attempt to distinguish between recent and historic corrosion. The Advanced Electron Microscopy Center at UH will perform element, phase, and oxidation state mapping and analysis of coupons extracted from out-of-service Red Hill USTs, and in close collaboration with Task 2, laboratory-generated corrosion samples, as they are produced. These analyses will be carried out in a focused-ion-beam scanning electron microscope and a scanning transmission electron microscope using electron imaging, energy dispersive X-ray spectroscopy and electron energy loss spectroscopy to visualize structure, morphology, and corrosion product phases and distributions. (5.3.5)

2. Peer review of report by corrosion consultant

7.3 Schedule

- May 2022
- Based on UH schedule
- Refer to paragraph 1.5 above and Attachment B.

7.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Final
  b. Final + Peer Review Work Products
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

7.5 Principal Investigator

- Technical expertise for the preparation of this Work Product is being provided by:
  a. Dr. Hope Ishii, University of Hawaii at Manoa

7.6 Peer Review

- The "Element, Phase, And Oxidation State Mapping of Red Hill UST Corrosion by Advanced Microscopy Methods" will have an independent peer review. It is anticipated that there will not be any preliminary submittals provided by the University of Hawaii to the Navy/DLA during the development of this Work Product. Therefore, the Navy/DLA will not be able to provide any reviews of the preliminary submittals. An independent peer review and critical analysis of the report will provide validation and the integrity of the report.
- It is anticipated that this peer review will be performed by Wiss, Janney, Elstner Associates. Wiss, Janney, Elstner Associates is also the technical expert for the Preliminary Liner Corrosion Assessment Report and the Overall Corrosion Assessment Report.

8.0 WORK PRODUCT #7 – INSPECTION DATA, LFET, AND STEP 2 ANALYSIS REPORT

8.1 Purpose

- The following topics were developed during discussions with the RAs during previous Scoping meetings from 4 June 2020 to 11 August 2020. These topics will be addressed, analyzed, and discussed thoroughly by Navy/DLA. The Navy/DLA will provide this information and documentation to the RAs as they are developed.
- The Work Product will address the topics listed in the below Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

8.2 Outline

8.3 Schedule

- December 2022
- Delayed 18 months due to the pandemic. The Navy was not allowed in the Laboratory to create the corrosion on the test plates.
- Refer to paragraph 1.5 above and Attachment B.

8.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Preliminary
  b. Final
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

8.5 Contracts and Experts

- Technical expertise for the preparation of this Work Product is being provided by:
  a. Solomon Resources, Inc.
  b. Charles Annis, P.E
  c. TBD for additional work for this Work Product
- The qualifications for the consultants are provided in Attachment E.
- The Statement of Work for the development of this Work Product provides the requirements for the technical experts.

8.6 Peer Review

The "Inspection Data, LFET, And Step 2 Analysis Report Work Product" will have Peer Review by Navy/DLA SME's. The Navy/DLA SME's will perform the technical and editorial review of all preliminary and final submittals. The Navy/DLA SME's will be selected for this effort based on the requirement of the Work Product. For this Work Product, SMEs might select another engineer to perform a Peer Review. The individual will have several years of experience in storage tank inspection. The qualifications of the individual selected to perform the Peer Review will be provided to the RAs.

9.0 WORK PRODUCT #8 – ROBOTIC INSPECTION REPORT

9.1 Purpose

- Analyze the technology of robotic inspections and compare to a previously performed inspection using manual methods.
- The Work Product will address the topics listed in the below Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

9.2 Outline

9.3 Schedule

- August 2022
- Dependent on schedule of tank availability.
- Refer to paragraph 1.5 above and Attachment B.

9.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Preliminary
  b. Final
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

9.5 Contracts and Experts

- Technical expertise for the preparation of this Work Product is being provided by:
  a. TBD – Contract is not awarded.
- The Statement of Work for the development of this Work Product will provide the requirements for the technical experts.

9.6 Peer Review

The "Robotic Inspection Report Work Product" will have Peer Review by Navy/DLA SME's. The Navy/DLA SME's will perform the technical and editorial review of all preliminary and final submittals. The Navy/DLA SME's will be selected for this effort based on the requirement of the Work Product. For this Work Product, an engineer who has not previously reviewed AOC SOW

Section 5.4 Documents might provide a Peer Review. The individual will have several years of experience in storage tank inspection. The qualifications of the individual selected to perform the Peer Review will be provided to the RAs.

10.0 WORK PRODUCT #9 – TIRM UPDATE REPORT

10.1 Purpose

- The results of the above initiatives will be incorporated into an update to the TIRM Report.
- The Work Product will address the topics listed in the below Outline in response to the RAs statements and as requested by the RAs during the Scoping meetings as listed in Attachment A.
- The Statement of Work for this Work Product has not been developed.
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

10.2 Outline

1. Data Entry and Documentation (5.7)
    - Refine process to eliminate entry errors (5.7.1)
    - Eliminate intermediate steps in data handling (5.7.2)
    - Screening for outlier data (5.7.3)

2. Auditing of Quality Control Program (5.8)
    - Spot checks (metal loss) using Contractor NDE (5.8.1)
    - Spot checks (metal loss) using 3rd party NDE (5.8.2)
    - Spot checks (metal loss) using destructive means (5.8.3)
    - Spot checks of Quality Control documentation (5.8.4)
    - Negative Performance Incentives (rework, removal of personnel, rejection of work) (5.8.5)
    - Acceptance sampling plan (Develop after "Inspection Data, LFET, and Step 2 Analysis Report") (5.8.6)

3. Changes to Quality Assurance Procedures (6.3)

4. Tank Inspection Specification (6.2)
    - Specs, drawings, etc. (6.2.1)
    - Qualification of Inspectors (6.2.2)
    - Testing procedures (6.2.3)
    - Reporting procedures (6.2.4)
    - Audit coupons (6.2.5)

5. Tank Repair Specification (6.2)

6. Removal of telltales (4.8)

10.3 Schedule

- May 2023- Dependent on other studies and testing
- Refer to paragraph 1.5 above and Attachment B.

10.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Review meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Preliminary
  b. Final
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

10.5 Subject Matter Experts

- Technical expertise for the preparation of this Work Product is being provided by:
  a. TBD – Will be developed by NAVFAC EXWC engineers

10.6 Peer Review

The "TIRM Update Report Work Product" will have Peer Review by Navy/DLA SME's. The Navy/DLA SME's will perform the technical and editorial review of all preliminary and final submittals. The Navy/DLA SME's will be selected for this effort based on the requirement of the Work Product. For this Work Product, an engineer experienced in storage tank inspection might provide another review. The qualifications of the individual selected to perform Peer Review will be provided to the RAs.

11.0 WORK PRODUCT #10 - OVERALL CORROSION ASSESSMENT REPORT (OCA) (6.1)

11.1 Purpose

- The Overall Corrosion Assessment Report will amalgamate the Preliminary Concrete Assessment Report (Work Product #3) and the Preliminary Liner Corrosion Assessment Report (PLCA) (Work Product #2) into a unified synopsis of corrosion in the Red Hill storage tanks. (6.1)
- Refer to paragraph 12.3 below and Attachment C for a description of how this Work Product will be incorporated into the overall purpose of Red Hill AOC SOW Section 5.4.

11.2 Outline

1. Report on results

11.3 Schedule

- March 2023
- Dependent on other studies and testing
- Refer to paragraph 1.5 above and Attachment B.

11.4 Deliverables to the Regulatory Agencies and Review Meetings

- The following deliverables will be provided to the Regulatory Agencies for their review and comments. In order to remain on schedule, the comments will be required to be provided within three weeks after the Work Product is sent to the Regulators.
- Status meetings will be scheduled to provide a synopsis of the deliverable with the Regulator Agencies for the following deliverables during the development of the Work Product:
  a. Preliminary
  b. Final
- The Review meeting will be scheduled with the Regulatory Agencies approximately 2 weeks after the Work Product is sent to the Regulators.

11.5 Contracts and Experts

- Technical expertise for the preparation of this Work Product is being provided by:
  a. Solomon Resources, Inc.
  b. Wiss, Janney, Elstner Associates
- The Qualifications for the consultants are provided in Attachments E and F.
- The Statement of Work for the development of this Work Product provides the requirements for the technical experts.

11.6 Peer Review

The "Overall Corrosion Assessment Report Work Product" will have Peer Review by Navy/DLA SME's. The Navy/DLA SME's will perform the technical and editorial review of all preliminary and final submittals. The Navy/DLA SME's will be selected for this effort based on the requirement of the Work Product.

12. PROCESS THAT WILL BE USED TO CONSIDER ALL OF THE INFORMATION AND FINDINGS FROM THE VARIOUS WORK PRODUCTS

12.1 Selection of Best Available Practicable Technology (BAPT) for the TIRM Improvement process:

The objective of developing these Work Products is to research the following main topics, technologies and practices in order to select the BAPT for the TIRM Improvement process:

- Corrosion rates
- Concrete condition
- Non-destructive testing
- 2-step process
- Data Entry
- Quality Assurance
- Quality Control

12.2 Process of Work Product Development

The Work Products will be developed by the following steps:

1. Develop the Statement of Work for the specific Work Product. This Statement of Work consists of:
    a. Purpose
    b. Background
    c. Goals and Objectives
    d. Technical Requirements
    e. Qualifications of SME
    f. Task Requirements
    g. Submittal Requirements
        - Note that a Work Plan is not a submittal, since the Statement of Work provides the requirement of the Work to be performed. If a Contractor submits a Work Plan, it may invalidate the requirements stated in the Negotiated Statement of Work.
    h. Schedule
    i. General Requirements
    j. Meetings
    k. Period of Performance
    l. Government Points of Contacts
2. Award Contract
    a. Request Contractor's proposal
    b. Receive Contractor's proposal (technical and cost)
    c. Negotiate contractor's proposal (technical and cost)
    d. Obtain funding
    e. Award Contract
3. Contract Execution
    a. Kick-off meeting
    b. Monitor schedule

c. Review submittals per Statement of Work
d. Review & Progress meetings per Statement of Work

12.3 Planned Work Product Development

1) Attachment C is a Flow Chart showing the planned structure of the development of the Work Products and how the development of the Work Products will flow into the development of other Work Products, and resulting in the final TIRM Improvement processes. The narrative below is a description of this planned structure.
2) Work Products #1 thru #6
   - Work Product #1 – This Work Product will provide additional technical data with supported documentation that will clarify some of the statements made in the DTRR report and the RA's response letter and Attachments. The purpose of this Work Product is to set the baseline for the mutual understanding of the additional studies, research, and Work Products as outlined in this Execution Plan.
   - Work Products #2 and #3 – These Work Products will provide supported documentation of the current condition of the tank liner and concrete. The Statements of Work for Documents #2, and 3 have been developed, and the task orders have awarded, and the submittals are being prepared by the Contractor. These Statements of Work are included as Attachments D and G.
   - Work Products #4, #5, and #6 – These Work Products will provide additional documentation of the current condition of the tank liner and concrete. The Proposals submitted by University of Hawaii for Work Products #4, #5, and #6 have been developed. These proposals are included as Attachments J, K, and L.

3) Upon completion of Work Products #1 thru #6, the Navy/DLA and the RA's will have a full understanding of the current condition of the facility. This understanding will be the basis of the development of the remaining Work Products.

4) A Face-to-Face Workshop will be held following the completion of Work Products #1 thru #6. This Workshop will allow the Government SMEs and RAs' SMEs to present briefings that discuss the preparation and results of the Work Products. Following the briefings, the Navy/DLA and the RAs will collaborate to discuss the Statement of Work task and submittals requirements for Work Products #7 and #8, and #9.

5) Work Product #10 will be developed after the completion of Work Products #2 and #3. The results from Work Products #4, #5, and #6 and the Face-to-Face Workshop will also be incorporated into this Work Product. The Statement of Work has been prepared and the task order has been awarded. The Statement of Work is included as Attachment D.

6) The Navy/DLA will provide Statements of Work developed for Work Products #7, #8, and #9 to the Regulators for their review and comment prior to step 2 in paragraph 12.2 above. As the Statements of Work are Source-Selection Privileged information, the RAs will cannot disclose any of the content in accordance with the signed Non-disclosure statements. The RAs can publish all final documents (redacted), submitted by the Regional Engineer, Navy Region Hawaii. The schedule for the award of these task orders will be dependent on the

response time from the RAs to provide comments. Face-to-Face Workshops or Conference Calls between the Navy/DLA and the RAs, and their SMEs will be conducted to discuss the Statements of Work. The discussions will lead to a final agreed-to Statement of Work.

6) Work Products #7, #8, and #9 will be developed with lagged starts.
   - Work Product #7 will investigate and test several NDE methods, and the process in which the NDE is to be used in the field in order to obtain the BAPT and practices. The Statement of Work for this Work Product has not been prepared.
   - Work Product #8 will investigate the capability of using Robotic Inspection tools. Note that the robot is a delivery system, so the type of NDE that is used will be based on the outcome of Work Product #7. A draft Statement of Work for this Work Product has been prepared, but the project is on-hold pending the availability of the selected Bulk Underground Storage Tank in the United States.
   - Work Product #9 will incorporate the results of Work Products #7, #8, and #10 to update the performance requirements that are included in the execution of the Tank Inspection and Repair contracts. The Statement of Work for this Work Product has not been prepared.

7) Interim reviews will be conducted upon the receipt of results of the preliminary and final reports of Work Products #7, #8, and #9. The preliminary reports will be labeled "Draft, Pre-Decisional, Do Not Cite or Quote, For Discussion Purposes Only." Following the reviews, Face-to-Face Workshops or Conference Calls between the Navy/DLA and the RAs, and their SMEs will be conducted. The discussions will lead to a final document that all parties will understand the background and technical issues that were considered during the preparation of the document. This collaboration will lead to agreed-to Work Products. The final documents will be releasable, but may require redaction.

8) During the completion of the Work Products, the Navy/DLA will prepare a Completion Report which will summarize all the Work Products, the agreed upon results, and the processes that will be executed for future TIRM execution.

12.4 Workshop and Collaboration Process

- The Workshop and Collaboration meetings will consider how each Work Product interrelates with other the Work Products as each are being developed, completed, and incorporated into the follow-on Work Products.
- These discussions will be centered in determining the best available practicable technology (BAPT) in executing the TIRM process as stated in paragraph 12.1 above.
- The Navy/DLA manages the Fuel Tank Clean, Inspect, and Repair program for Naval Fuel storage tanks. UFC 3-460-03, which is an approved tri-service and DLA document, provides the requirements for the inspection intervals and the requirements for repairs to meet these inspection intervals. This document is used as a requirement for the Red Hill TIRM process. If any of the requirements in this document cannot be met with the improved Red Hill TIRM process, then the Service Headquarters will be advised and an approval for exemption to the UFC 3-460-03 will be required.
- The TIRM Improvement processes will be based on the most current approved Tank Upgrade Alternative tank system and the other approved TUA risk mitigation measures.

- If in the future, the TUA is updated, the TIRM procedures will be updated at that time.

12.5 The overarching objective of the AOC SOW Section 5.4 is to provide improvements to the current TIRM process. These studies, testing, and documentation described within this Execution Plan will determine the BAPT for the TIRM process. The BAPT will include the management systems for the Contractor's quality control and the Navy/DLA's quality assurance during the inspection and repair, the 2-step process for verification of inspection, data entry, and the human process during the execution of the TIRM process. These studies will assess corrosion rates used to manage inspection intervals and repair thresholds. Revised tank inspection and tank repair specifications will implement updated performance standards. The improvements to the TIRM process will decrease risks and promulgate the goal of preventing a release during a service interval.

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ATTACHMENT A
AOC Section 5.4 Scope of Work Outline (1 September 2020)

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AOC SECTION 5.4 SCOPE OF WORK OUTLINE (1 September 2020)

1. Interpretation of the Coupon Results
   PURPOSE: The RAs interpretation of the Destructive Testing Report was that there were two (2) False Positives and two (2) False Negatives. The Navy/DLA will address the following topics in response to the RAs interpretation.

2. Deficiencies in Data Collected
   PURPOSE: The RAs stated that Navy's laboratory analysis did not or was unable to identify the thinnest portion of each plate which made the destructive testing exercise and its analysis incomplete. The Navy/DLA will address the following topics in response to the RAs statement.

3. Uncertainty Regarding NDE Accuracy
   PURPOSE: The RAs stated there is insufficient correlation between NDE and the laboratory measurements. The Navy/DLA will address the following topics in response to the RAs statement.

4. Potential for Increased Rates of Corrosion
   PURPOSE: The RAs stated a belief the Navy is underestimating corrosion rates for Tank 14 and should reassess corrosion rates used in calculating minimum remaining thickness under TIRM. Also, it was stated the potential cause for increasing corrosion rates creates concern for potential corrosion of embedded reinforcement in the concrete. The Navy/DLA will address the following topics in response to the RAs statement.
   - 4.1. Method by which Corrosion Rate is calculated
     - 4.1.1. Evaluate potential causes for corrosion and possible actions to reduce corrosion rates, if possible.
   - 4.2. Using extreme value vs uniform to establish Minimum Remaining Thickness
   - 4.3. Dr. Hihara's theory concerning metal liner
   - 4.4. Environmental and chemical conditions affecting rates

4.5. Dr. Hihara's theory concerning reinforced concrete
4.6. Potential causes for corrosion
4.7. Rainfall effects on metal liner
4.8. Removal of telltales
4.9. Potential corrosion impact from use of old verses new carbon steel Patch Plates
4.9.1. Potential Galvanic corrosion between new patch plate and old carbon steel liner
4.9.2. Potential for weld stress due to crevice corrosion in the gap between the steel liner and a new patch plate

5. Recommendations for Moving Forward

PURPOSE: The following topics were developed during discussions with the RAs during previous Scoping meetings from 4 June 2020 to 11 August 2020. These topics will be addressed, analyzed, and discussed thoroughly by Navy/DLA. The Navy/DLA will provide this information and documentation to the RAs as they are developed.

5.2. Factor of Safety
5.2.1. Comparison with other Industries (API, ASME, ASCE, etc.)
5.3. Corrosion Rates
5.3.1. Address extreme value (e.g., timber lodged behind plate) vs uniform rate
5.3.2. Comparison to API 650 tank steel bottom
5.3.3. Reevaluate the repair threshold and associated factor of safety to account for inaccuracies in NDE, corrosion rates, and possible delays in repair cycles.
5.3.4. Analysis of Inspection Data (modeling, regression, comparative, quantitative)
5.3.5. Laboratory study to attempt to distinguish between recent and historic corrosion
5.4. Conduct additional analyses on the condition of the concrete structure and embedded reinforcing steel.
5.4.1. Study existing concrete pursuant to principles of ACI 364-1R
5.4.2. Cores might include embedded reinforcing steel
5.4.3. Physical, chemical, and mechanical properties of the concrete will be studied

5.5.6.1. Evaluate probe calibrations variance between horizontal calibration plate verses vertical calibration plate.

5.7. Data Entry and Documentation
- 5.7.1. Refine process to eliminate entry errors
- 5.7.2. Eliminate intermediate steps in data handling
- 5.7.3. Screening for outlier data

5.8. Auditing of Quality Control Program
- 5.8.1. Spot checks (metal loss) using KTR NDE
- 5.8.2. Spot checks (metal loss) using 3rd party NDE
- 5.8.3. Spot checks (metal loss) using destructive means
- 5.8.4. Spot checks of QC documentation
- 5.8.5. Negative Performance Incentives (rework, removal of personnel, rejection of work)
- 5.8.6. Acceptance sampling plan

6. Validation of Initiatives

PURPOSE: The results of the above five (5) initiatives will be incorporated into the following topics:

6.1. Report on results

6.2. Implement Changes to Specifications
- 6.2.1. Specs, drawings, etc. that they give to the contractors. Those are what we should be reviewing.
- 6.2.2. Qualification of Inspectors
- 6.2.3. Testing procedures
- 6.2.4. Reporting procedures
- 6.2.5. Audit coupons

6.3. Changes to Quality Assurance procedures

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ATTACHMENT B
Schedule

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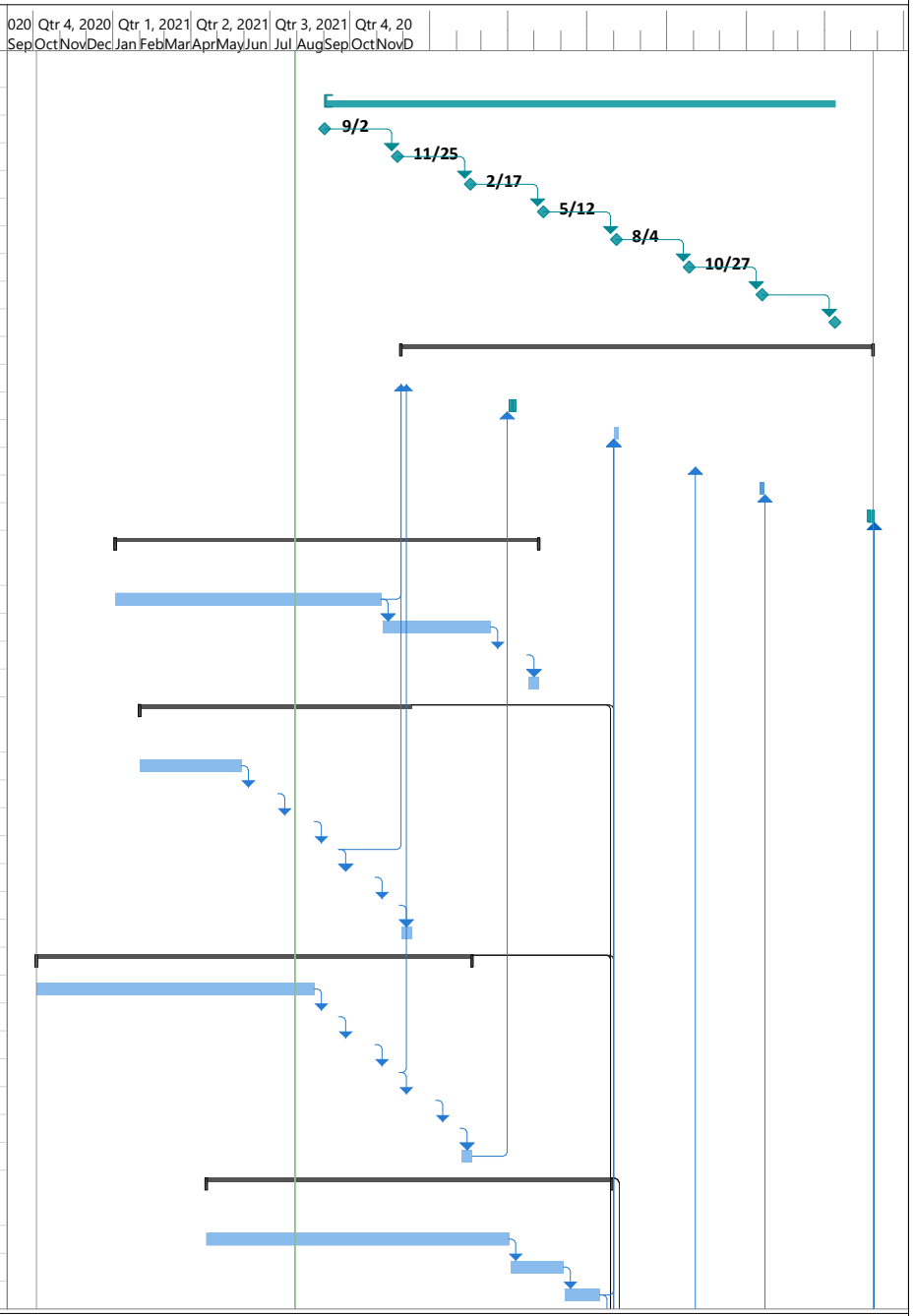
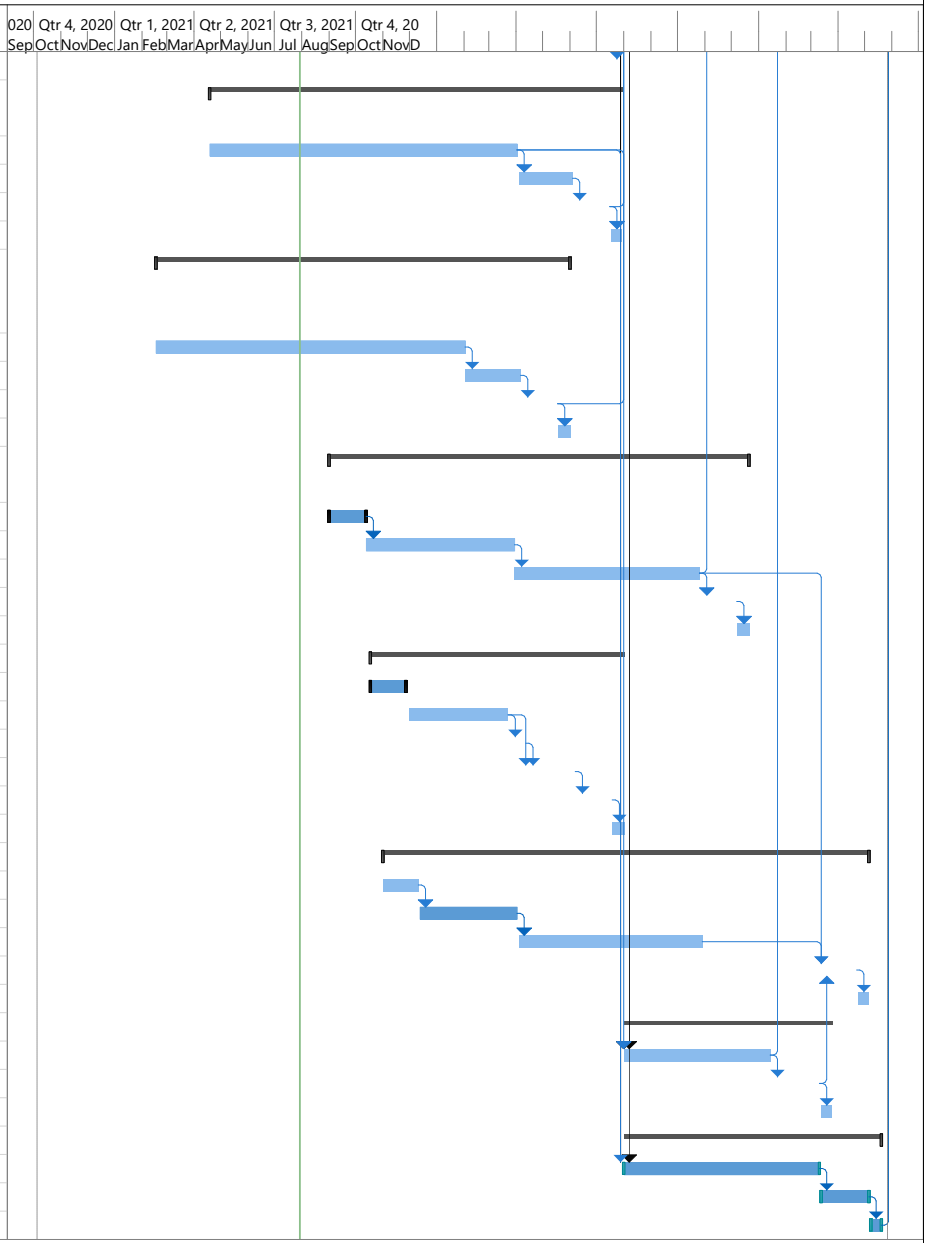
ID	Task Name	Duration	Start	Finish
1	**Section 5.4 Schedule**			
2	**Quarterly Update Meetings**		**Thu 9/2/21**	
3	Meeting 1 - Kickoff	0 days	Thu 9/2/21	Thu 9/2/21
4	Meeting 2	0 days	Thu 11/25/21	Thu 11/25/21
5	Meeting 3 -	0 days	Thu 2/17/22	Thu 2/17/22
6	Meeting 4	0 days	Thu 5/12/22	Thu 5/12/22
7	Meeting 5	0 days	Thu 8/4/22	Thu 8/4/22
8	Meeting 6	0 days	Thu 10/27/22	Thu 10/27/22
9	Meeting 7	0 days	Thu 1/19/23	Thu 1/19/23
10	Meeting 8	0 days	Thu 4/13/23	Thu 4/13/23
11	**Document Reviews Meetings with RA's**	**390 days**	**Mon 11/29/21**	**Fri 5/26/23**
12	Meeting 1 - Face to Face	5 days	Mon 11/29/21	Fri 12/3/21
13	Meeting 2 - Face to Face	5 days	Mon 4/4/22	Fri 4/8/22
14	Meeting 3 - Face to Face	5 days	Mon 8/1/22	Fri 8/5/22
15	Meeting 4 - Face to Face	5 days	Wed 10/26/22	Tue 11/1/22
16	Meeting 5 - Face to Face	5 days	Mon 1/16/23	Fri 1/20/23
17	Meeting 6 - Face to Face	5 days	Mon 5/22/23	Fri 5/26/23
18	**1 - Navy/DLA Interpretation of the Coupon Results**	**350 days**	**Mon 1/4/21**	**Fri 5/6/22**
19	Award Contract	220 days	Mon 1/4/21	Fri 11/5/21
20	Contractor develop Report	90 days	Mon 11/8/21	Fri 3/11/22
21	Government Review	30 days	Mon 3/14/22	Fri 4/22/22
22	Prepare Document for Distribution	10 days	Mon 4/25/22	Fri 5/6/22
23	**2 - Preliminary Liner Corrosion Assesment Report**	**225 days**	**Mon 2/1/21**	**Fri 12/10/21**
24	Corrosion Consultant Develop Preliminary Report	85 days	Mon 2/1/21	Fri 5/28/21
25	Government Review	30 days	Mon 5/31/21	Fri 7/9/21
26	Corrosion Consultant Develop Final Draft Report	30 days	Mon 7/12/21	Fri 8/20/21
27	Government Review	20 days	Mon 8/23/21	Fri 9/17/21
28	Corrosion Consultant Develop Final PLCA Report	30 days	Mon 9/20/21	Fri 10/29/21
29	Government Review	20 days	Mon 11/1/21	Fri 11/26/21
30	Prepare Document for Distribution	10 days	Mon 11/29/21	Fri 12/10/21
31	**3 - Preliminary Concrete Assessment Report**	**360 days**	**Mon 10/5/20**	**Fri 2/18/22**
32	Concrete Consultant Develop Report	230 days	Mon 10/5/20	Fri 8/20/21
33	Government Review	20 days	Mon 8/23/21	Fri 9/17/21
34	Concrete Consultant Develop Final Draft Report	30 days	Mon 9/20/21	Fri 10/29/21
35	Government Review	20 days	Mon 11/1/21	Fri 11/26/21
36	Concrete Consultant Develop Final Report	30 days	Mon 11/29/21	Fri 1/7/22
37	Government Review	20 days	Mon 1/10/22	Fri 2/4/22
38	Prepare Document for Distribution	10 days	Mon 2/7/22	Fri 2/18/22
39	**4 - Inspect and Repair Protocols Project for Red Hill Underground Storage Tanks**	**335 days**	**Mon 4/19/21**	**Fri 7/29/22**
40	UH Develop Report	250 days	Mon 4/19/21	Fri 4/1/22
41	Peer Review	45 days	Mon 4/4/22	Fri 6/3/22
42	Government Review	30 days	Mon 6/6/22	Fri 7/15/22



ID	Task Name	Duration	Start	Finish
43	Prepare Document for Distribution	10 days	Mon 7/18/22	Fri 7/29/22
44	**5 - Concrete Tank Degradation Inspection and Retrofit**	**335 days**	**Mon 4/19/21**	**Fri 7/29/22**
45	UH Develop Report	250 days	Mon 4/19/21	Fri 4/1/22
46	Peer Review	45 days	Mon 4/4/22	Fri 6/3/22
47	Government Review	30 days	Mon 6/6/22	Fri 7/15/22
48	Prepare Document for Distribution	10 days	Mon 7/18/22	Fri 7/29/22
49	**6 - Element, Phase, and Oxidation State Mapping of Red Hill UST Corrosion by Advanced Microscopy Methods**	**335 days**	**Wed 2/17/21**	**Tue 5/31/22**
50	UH Develop Report	250 days	Wed 2/17/21	Tue 2/1/22
51	Peer Review	45 days	Wed 2/2/22	Tue 4/5/22
52	Government Review	30 days	Wed 4/6/22	Tue 5/17/22
53	Prepare Document for Distribution	10 days	Wed 5/18/22	Tue 5/31/22
54	**7 – Inspection Data, LFET, and Step 2 Analysis Report**	**340 days**	**Wed 9/1/21**	**Tue 12/20/22**
55	Prepare Statement of Work	30 days	Wed 9/1/21	Tue 10/12/21
56	Award Contract	120 days	Wed 10/13/21	Tue 3/29/22
57	Contractor develop Report	150 days	Wed 3/30/22	Tue 10/25/22
58	Government Review	30 days	Wed 10/26/22	Tue 12/6/22
59	Prepare Document for Distribution	10 days	Wed 12/7/22	Tue 12/20/22
60	**8 – Robotic Inspection Report**	**206 days**	**Mon 10/18/21**	**Mon 8/1/22**
61	Prepare Statement of Work	30 days	Mon 10/18/21	Fri 11/26/21
62	Award Contract	80 days	Wed 12/1/21	Tue 3/22/22
63	Perform Inspection	14 days	Wed 3/23/22	Mon 4/11/22
64	Contractor develop Report	40 days	Tue 4/12/22	Mon 6/6/22
65	Government Review	30 days	Tue 6/7/22	Mon 7/18/22
66	Prepare Document for Distribution	10 days	Tue 7/19/22	Mon 8/1/22
67	**9 – TIRM Update Report**	**395 days**	**Mon 11/1/21**	**Fri 5/5/23**
68	Prepare Statement of Work	30 days	Mon 11/1/21	Fri 12/10/21
69	Award Contract	80 days	Mon 12/13/21	Fri 4/1/22
70	Develop Report	150 days	Mon 4/4/22	Fri 10/28/22
71	Government Review	30 days	Mon 3/13/23	Fri 4/21/23
72	Prepare Document for Distribution	10 days	Mon 4/24/23	Fri 5/5/23
73	**10 – Overall Corrosion Assessment Report**	**170 days**	**Mon 8/1/22**	**Fri 3/24/23**
74	Corrosion Consultant Develop Report	120 days	Mon 8/1/22	Fri 1/13/23
75	Government Review	40 days	Mon 1/16/23	Fri 3/10/23
76	Prepare Document for Distribution	10 days	Mon 3/13/23	Fri 3/24/23
77	**11 - Completion Report**	**210 days**	**Mon 8/1/22**	**Fri 5/19/23**
78	Development of Summary Documentation	160 days	Mon 8/1/22	Fri 3/10/23
79	Government Review	40 days	Mon 3/13/23	Fri 5/5/23
80	Prepare Document for Distribution	10 days	Mon 5/8/23	Fri 5/19/23



ATTACHMENT C
Work Products Development Flowchart

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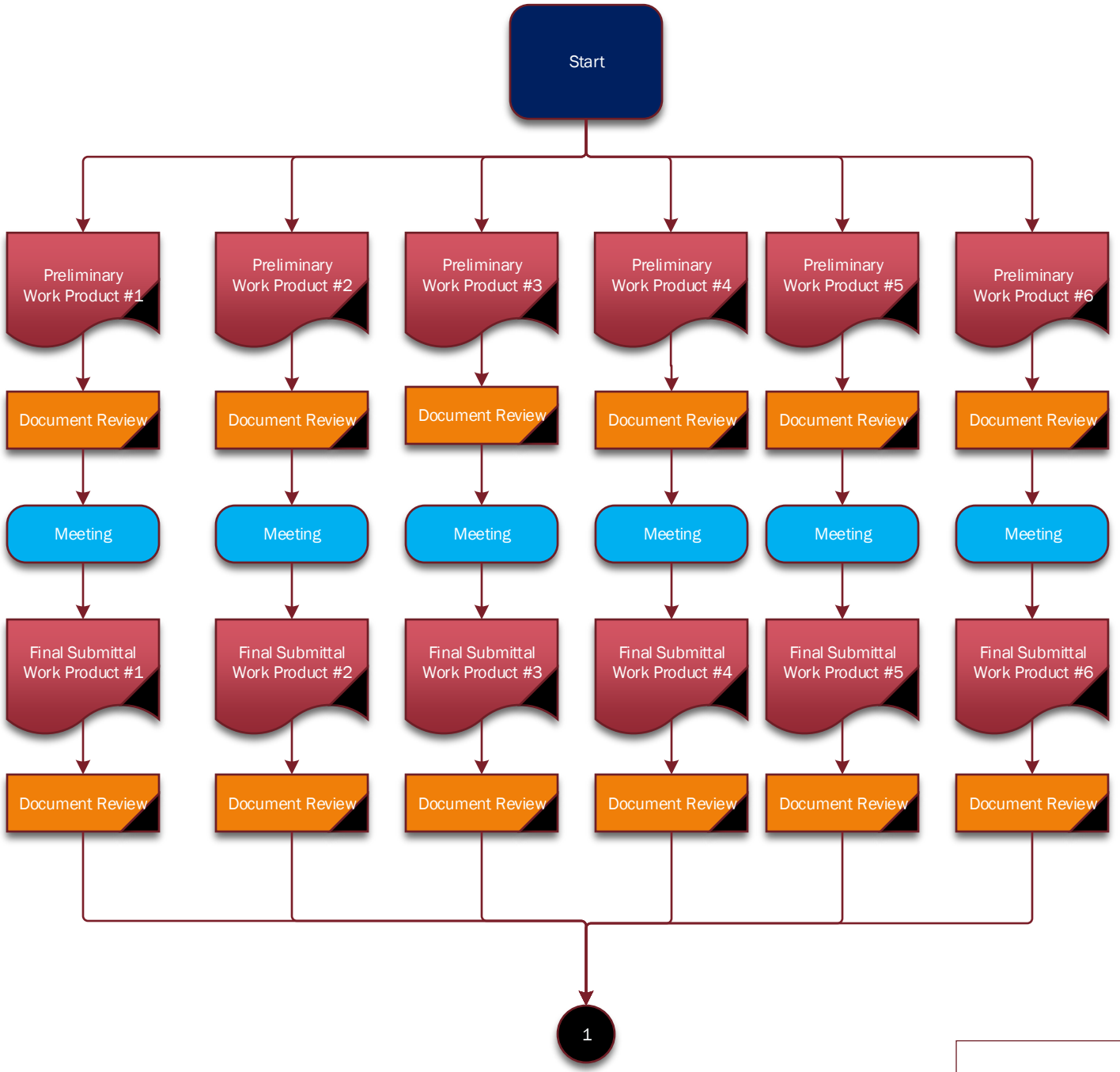
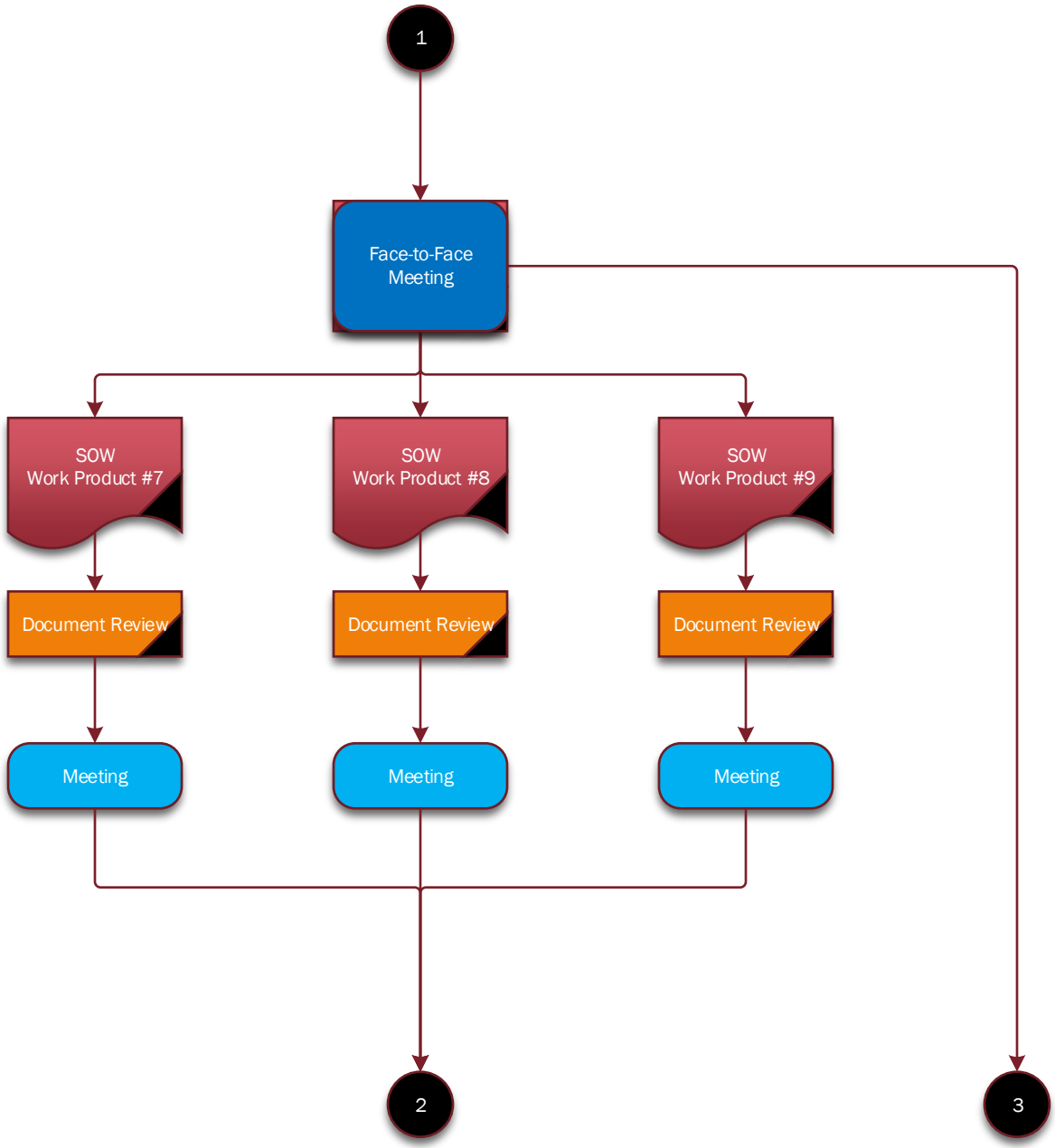
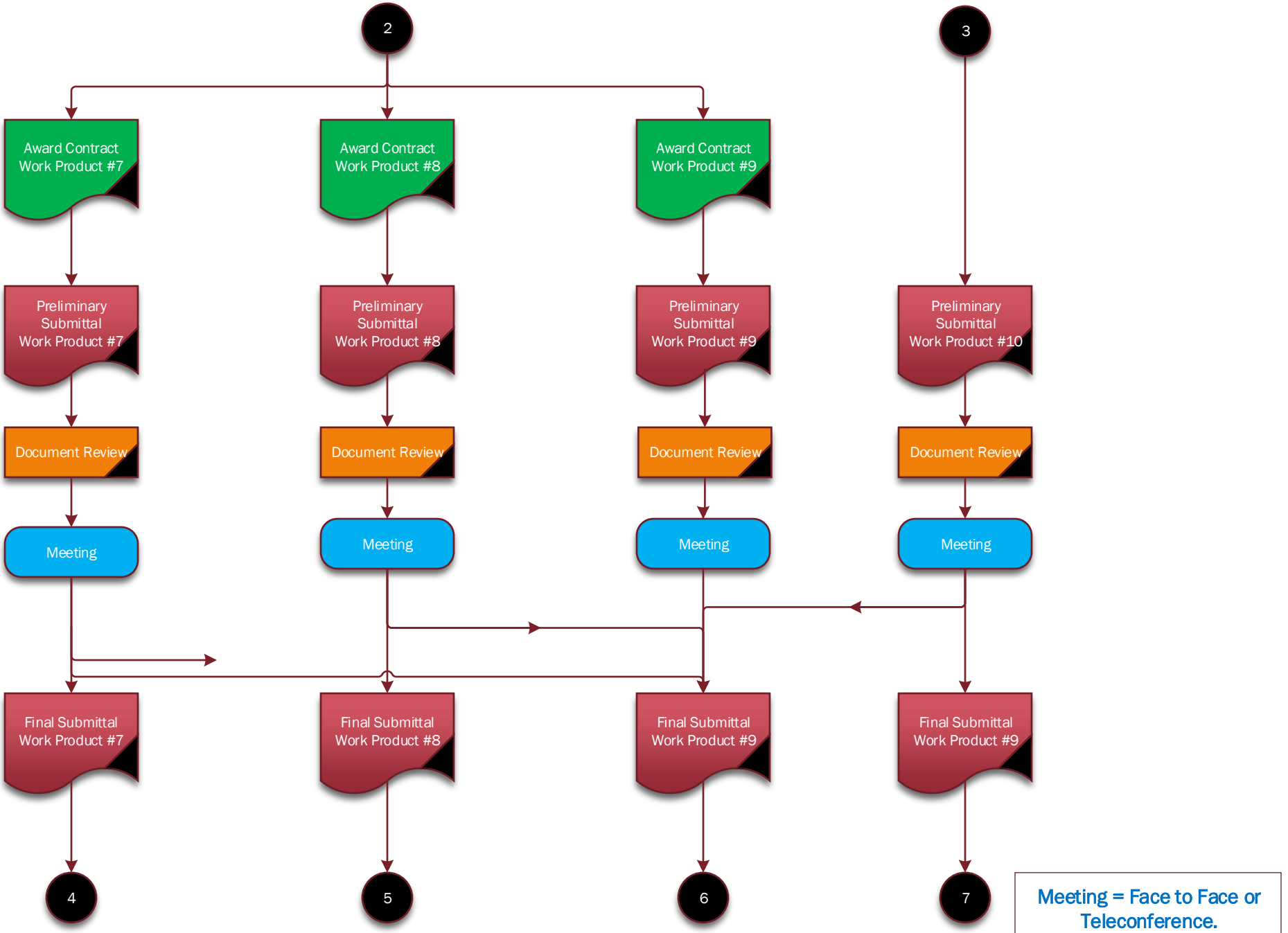
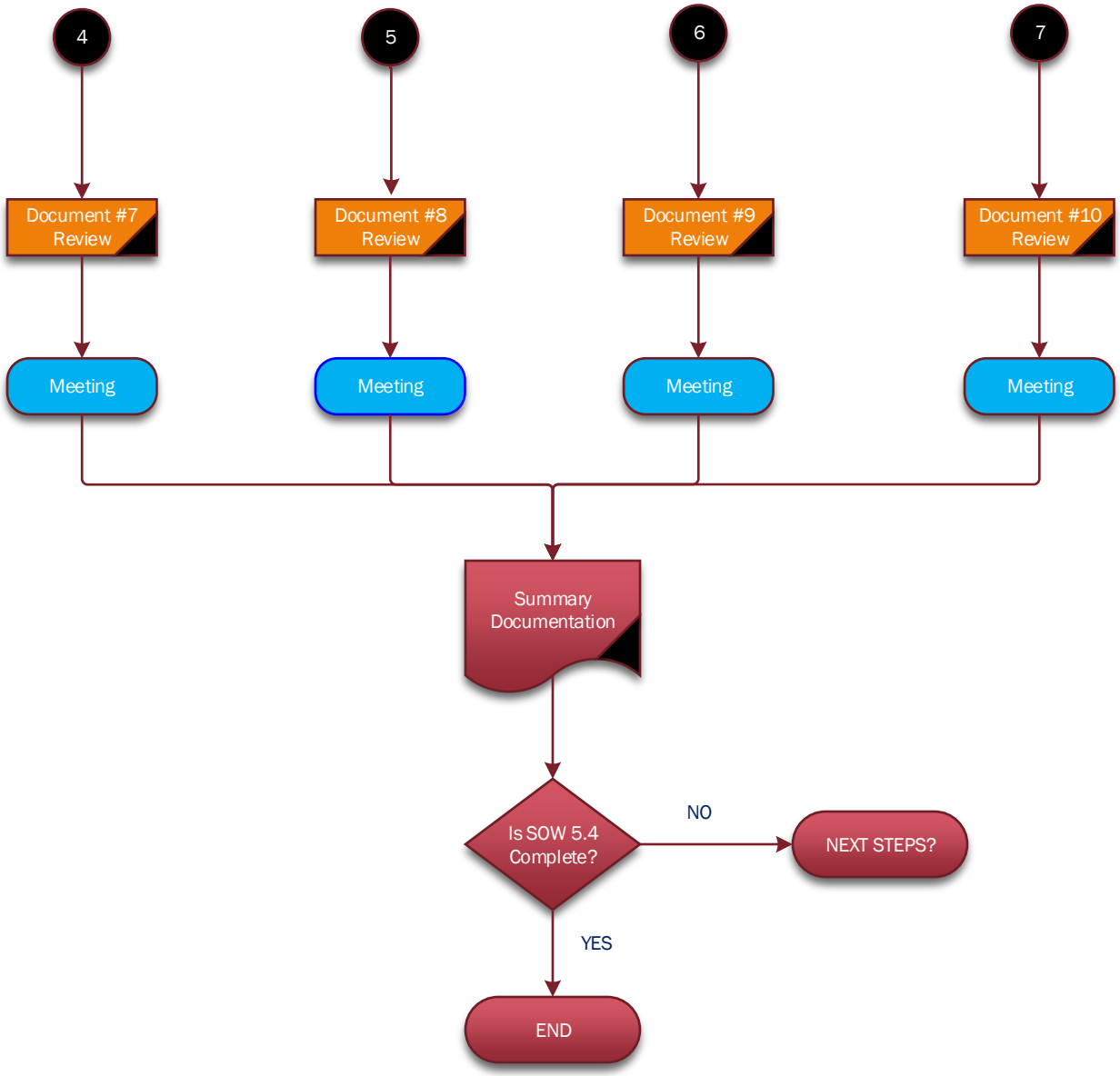


Meeting = Face to Face or Teleconference. Concurrence, Agreements & Decisions



Meeting = Face to Face or Teleconference.
Concurrence, Agreements & Decisions


2
3
Award Contract Work Product #7
Award Contract Work Product #8
Award Contract Work Product #9
Preliminary Submittal Work Product #7
Preliminary Submittal Work Product #8
Preliminary Submittal Work Product #9
Preliminary Submittal Work Product #10
Document Review
Document Review
Document Review
Document Review
Meeting
Meeting
Meeting
Meeting
Final Submittal Work Product #7
Final Submittal Work Product #8
Final Submittal Work Product #9
Final Submittal Work Product #9
4
5
6
7
Meeting = Face to Face or Teleconference. Concurrence, Agreements & Decisions



Meeting = Face to Face or Teleconference. Concurrence, Agreements & Decisions

ATTACHMENT D
Contract Statement of Work – Provide Red Hill Corrosion Assessment

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CONTRACT STATEMENT OF WORK

Project Title: Provide Red Hill Corrosion Assessment
Contract No: N39430-19-D-2170
Task Order: TBD
WON: 1674309
Contractor: Solomon Resources, LLC.
ACQR: 5810655

SOW HISTORY

Version	Date	Description
Basic Award	01 Jul 2020	Original Scope

Date: 01 Jul 2020
Submitted By: Frank Kern

Contents

1 NEED

Technology to screen the steel tank liners at the Red Hill Bulk Fuel Storage Facility (RHBFSF) for backside corrosion has been used at the Facility since circa 2006. Condition reports have been produced as part of individual tank inspection and repair evolutions. A facility-wide effort to consolidate tank corrosion and condition information into a facility-wide report has not been undertaken.

1.1 Background

During construction of the RHBFSF, twenty mined vertical cavities were lined with butt-welded carbon steel. The liners were used as forms when reinforced concrete with thickness ranging from 2 to 5 feet was placed. At the conclusion of construction, each tank was leak-tested with water and repairs were made based on the test results. Further information is available in GFI Attachment 5 Brief Background Red Hill Tank Construction.

The liners were coated with a thin film urethane epoxy between 1960-1970. Empirical data suggest the epoxy coating has been effective at preventing product-side corrosion.

During routine inspection and electromagnetic corrosion screening done on some tanks since 2006, areas of backside corrosion have been found and repaired. The standard for repair is a modified API Std 653 approach.

During tank filling at the conclusion of a routine repair evolution in 2014, a release took place. The subsequent investigation determined the underlying cause of the release was poor workmanship and unrepaired gas test holes installed by the repair contractor. As a result of the release, Navy entered into an administrative order with Regulatory Agencies (RA). Work products of this Statement of Work will be used in concert with others to further Navy efforts to satisfy requirements of the administrative order.

1.2 Goals and Objectives

The goals of this project are to receive preliminary reports that will better inform Navy and DLA. The primary objective is to review corrosion data and produce a preliminary report addressing steel liner corrosion. Secondary objectives are to provide Subject Matter Expert (SME) Consultant services in the form of review and analysis of expert documents, participation in stakeholder and public meetings, testimony before regulatory agencies regarding the assessment, and briefing Navy and DLA leadership. The tertiary objective is to produce an overall corrosion assessment report.

2 REQUIREMENTS

In order to meet project goals, this SOW contains requirements to review reports by others, analyze data with a consultant SME, produce a preliminary liner corrosion assessment report, and produce an overall corrosion assessment report. The source data and reports, analysis, and report are non-disclosable. Individuals involved will be required to sign a statement of non-disclosure.

Provide means and methods to execute this SOW. Provide appropriate subcontractor support from qualified companies, consultant(s), and specialists to execute this SOW. Provide and distribute submittals in accordance with Table S.

2.1 Corrosion Subject Matter Expert

Provide the services of a corrosion subject matter expert (SME) consultant qualified by education and experience to perform expert services of storage tank corrosion assessment. Minimum education is a doctorate in engineering or closely related field. Relevant experience in corrosion assessment and evaluation of large concrete structures is required. Submit SME Consultant resume for Govt approval.

Contractor and subcontractor employee(s) shall conduct themselves in a proper, efficient, courteous, and businesslike manner. Coordination and cooperation with others is a key element to success, and is required. The Contracting Officer may require the contractor remove from the work any individual the Govt reasonably determines is uncooperative, unqualified, fails to satisfactorily perform work, is careless, objectionable, contrary to public interest, or acts inconsistent with the best interests of National Security.

2.2 Task 1 Preliminary Liner Corrosion Assessment

All notes, data, comments, recommendations, specifications, and other documents collected and produced as part of this contract are property of the Govt. These data or images shall not be used, in whole or part, published or unpublished, in any technical or non-technical presentation, or otherwise released by the contractor without prior written approval of the Contracting Officer.

2.2.1 Preliminary Nature of Assessment

Metal thickness data are not available for each storage tank liner at Red Hill. In addition, some reports contain sparse data. For those reasons the assessment will be produced as preliminary and subject to change should further data become available.

2.2.2 Literature Review

Perform a review of literature relevant to carbon steel plates in intimate or close contact with concrete substrate. Consider (Petti, et al. 2011) and (Tuutti, 1982). Assess methods of corrosion rate determination in industry standards API 570 and 653. Review relevant Red Hill construction records which document tank design and construction. Assume electronic review of thirty vintage, hand-drafted Arch D as-built drawings.

2.2.3 Analysis of Inspection Records

Provide SME consultant analysis of the corrosion data per individual tank and as part of the entire facility. Perform data manipulation as-needed to inform the analysis. Review thickness data and analysis performed by the tank inspectors. Propose a meaningful basis for establishing and reporting rates, if different from current practice. Segregate data and analysis into categories of product-side and backside corrosion. Assume quantitative data are available for analysis in six reports, each containing approximately 25-relevant pages and a large spreadsheet. Assume qualitative data are available in four reports, each containing approximately 50-relevant pages.

2.2.4 Preliminary Liner Corrosion Assessment Report

Produce a preliminary liner corrosion assessment (PLCA) report. Overall objectives of the preliminary report are below.

a. Compare and contrast the science of storage tank bottom corrosion versus the methods of corrosion rate assessment in API Standards 653 and 570

b. Summarize the literature and science of corrosion of steel plates in contact with concrete, as it relates to conditions at Red Hill

c. Discuss estimates of liner corrosion rates

d. Recommendations to change in practice of corrosion rate determination

Provide a preliminary report which meets objectives, and contains commentary and analysis. Provide the PLCA Report at three levels of completion.

2.2.4.1 Draft PLCA

The Draft Report is an outline format containing placeholders for all elements of analyses. Populate the draft report with completed results. Analysis that is still in-progress might not be included in the draft. The Draft Report is progress-type with a level of completion expected to be 75%

2.2.4.2 Prefinal PLCA

The Prefinal Report contains all analysis and incorporates Govt and Subject Matter Expert (SME) comments.

2.2.4.3 Final PLCA

The level of completion of the Final Report is ready for publication and incorporates Govt and SME comments.

2.2.5 Electronic Meetings and Phone Calls

Provide SME consultant attendance and participation in technical, quality, and status meetings with the GTT. Meetings will be conducted only an as-needed basis. Assume periodicity ranges from once every two weeks to once per month. Duration is not expected to exceed 1 hour each. Assume electronic means are commercial web conferencing (Zoom, Google, Skype, Microsoft) without video capability.

2.3 Task 2 SME Consultant Work

2.3.1 External Report Analysis

It is expected external experts will produce documents and reports pertaining to RHBFSF corrosion. Provide peer review and critical analysis of the reports. The initial audience for the review and analysis is the GTT. However, expect discussion of external documents and reports to be a topic during electronic or onsite meetings with external stakeholders. Quantity of external document and report reviews is given in Table 2.1. Assume each report or document requires 6 hours for review and analysis.

Table 2.1 External Report Review

Type	Quantity (ea)
Corrosion or Practices Report	5

2.3.2 Third Party Review Response

Review and commentary on the PLCA will take place by external third parties and RA. Expect rounds of reviews to take place at any level of completion. Some review comments might not require a report revision and will only require a response to comments. In response to the third party and RA review comments, provide SME Consultant analysis and report deliverables per Table 2.2. Assume each effort requires 4 hours of time.

Table 2.2 Third Party Review Responses

Work Item	Quantity (ea)
Analysis	6

Review and Respond to Comments	5
Report Supplement	2

2.3.3 Appearance and Participation at Public and Regulatory Agency Meetings

Provide SME consultant participation in onsite and electronic public, Govt, and RA meetings. Assume electronic meetings are telephonic or commercial web conferencing (Zoom, Google, Skype, Microsoft). Using these means, video conferencing may take place with voice supplemented with pdf screen presentation as backup. See paragraph Mobilizations for onsite meeting requirements.

Meetings with RA will involve interaction, commentary, and criticism from forensic and specialty consultants representing their respective clients. Sworn testimony to the RA in support of the preliminary corrosion assessment report is expected. Meetings with public will involve direct interaction with individuals and organizations representing the complete range of technical knowledge and experience.

Provide SME Consultant electronic meeting participation per Table 2.3. See paragraph Work Hours for time of day requirements.

Table 2.3 Electronic Meeting Participation Schedule

Type of Involvement	Quantity of Meetings	Hours (per meeting)
Participation, Govt Only	6	2
Participation, Govt + RA + Public	2	6

2.3.4 Mobilizations

Provide SME consultant mobilizations to support the corrosion assessment as well as participate in onsite Govt, RA, and public meetings. Assume onsite meetings take place in Honolulu. Assume each mobilization requires five days (two travel days, three work days). Quantity and purpose of mobilizations is per the Table 2.4.

Table 2.4 Mobilization Schedule

Type of Participation	Quantity (ea)
Onsite Govt Meeting	1
Onsite RA Meeting	1

2.4 Task 3 Overall Corrosion Assessment

Preparation of a preliminary concrete assessment report (concrete report) is underway by others. The report will assess the quality and durability of RHBFSF reinforced concrete. Provide SME services to review the concrete report and be familiar with its principal findings. Formulate an Overall Corrosion Assessment (OCA) which amalgamates the concrete report and the PLCA into a unified synopsis of corrosion in the Red Hill storage tanks.

Assume the concrete report contents will not be available for inclusion until June 2021. The COR will advise of more specific delivery information once available. Assume relevant portions of the concrete report do not exceed 100-pages.

2.4.1 Overall Corrosion Assessment Report

Produce an OCA report based on the PLCA and the concrete report. Contents of the report are principal findings, conclusions, and opinions contained in both the concrete report and the PLCA report. The audience for the OCA report is Navy and DLA leadership and the general public.

Utilize the services of a technical writer to tailor the report to the audience. Make use of illustrative graphics and professional editing to ensure fundamental concepts are easily understood by non-technical individuals.

2.4.2 Prefinal OCA

The Prefinal OCA Report contains all analysis, graphics, and information. Produce the Prefinal Report no later than 90-days after receipt of information from the concrete assessment report.

2.4.3 Final OCA

The level of completion of the Final OCA Report is ready for publication and incorporates Govt comments.

2.5 Schedule

Within three weeks of award, provide a schedule which details performance of all work in this SOW. Use placeholder dates for the mobilizations. Build time into the schedule to receive the concrete report and perform Task 3 activities.

2.6 References

Petti, Jason P, Dan Naus, Richard E Weyers, Bryan A Erler, Neal S Berke, and Alberto Sagüés. 2011. *Nuclear Containment Steel Liner Corrosion Workshop: Final Summary and Recommendations Report.* Technical Report, Albuquerque: Sandia National Laboratories.

Tuutti, K. 1982. *Corrosion of Steel in Concrete.* Research Thesis, Stockholm: Swedish Cement and Concrete Research Institute.

3 GENERAL REQUIREMENTS

Comply with all federal, state, and local regulations. The term construction refers to any construction-type support activity which is required to execute this Statement of Work.

Coordinate planned work activities with the GTT. Report exceptions and deviations from this Statement of Work to the Contracting Officer. Only the Contracting Officer has the authority to authorize work or de-scope work elements of this Task Order.

3.1 Work Hours

Unless otherwise notified, SME Consultant meetings with Govt and RA will take place during normal business hours, Hawaii Standard Time. Meetings with the public are expected to take place between the hours of 1200 HST – 2100 HST.

3.2 No Waiver by the Government

The failure of the Govt in any one or more instances to insist upon strict performance to any of the terms of this contract or to exercise any option herein conferred shall not be construed as a waiver or

relinquishment to any extent of the right to assert or rely upon such terms or options on any future occasion.

3.3 Information Security

Security requirements apply to all contractors, subcontractors, and suppliers associated with this contract. In addition to special or extraordinary security requirements, comply with the following:

a. Do not publicly disclose information concerning any aspect of the design or services relating to this contract, without prior written approval of the Contracting Officer.

b. Do not disclose or cause to be disseminated information concerning the operations of the activity, operations of the activity's security, or information regarding the continuity of operations.

c. Do not disclose any information to any person not entitled to receive it. Failure to safeguard any classified information that may come to the Contractor or any person under his control, may subject the Contractor, his agents or employees to criminal liability under 18 U.S.C., Sections 793 and 798.

d. Direct to the Contracting Officer or Installation Security Officer for resolution all inquiries, comments or complaints arising from any matter observed, experienced, or learned as a result of or in connection with the performance of this contract, the resolution of which may require the dissemination of official information.

e. Coordinate photography with Installation requirements. Photo permit requests are processed by the Joint Base.

f. This effort will result in an aggregation of information which is sensitive and is protected from disclosure. A non-disclosure agreement will be required. Certain documents must be labeled privileged from disclosure.

Deviations from or violations of any of the provisions of this section, will, in addition to all other criminal and civil remedies provided by law, subject the Contractor to immediate termination for default and withdrawal of the Govt acceptance and approval of employment of the individuals involved.

3.4 Proprietary Rights

All field notes, drawings, photographs, specimens, specifications, findings, data, and documents collected and produced as part of this contract become property of the Govt. These data shall not be used, in whole or part, published or unpublished, as a part of any technical or non-technical presentation, or otherwise released by the Contractor without written approval of the Contracting Officer.

3.5 Installation Access

Submit request for access in accordance with DBIDS for JBPHH. Fulfill required background and fingerprint investigation information requests within one week of initiation. For workers already in possession of DBIDS access or a CAC, coordinate access requirements with the COR. For single-day access into Red Hill, it is not expected that all steps on the FLCPH badging flow chart will be required. Coordinate access requirements with the COR.

3.6 Safety and Occupational Health Requirements

Submit an abbreviated APP compliant with USACE EM 385-1-1 Appendix A. Submit matters of interpretation of standards to the COR for resolution before starting work. Where the requirements of this SOW, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply.

3.6.1 Accident Notification and Reports

For recordable injuries and illnesses, and property damage accidents resulting in at least $2,000 in damages, contractor shall:

a. Provide initial notification via telephone or email as soon as possible from the time of mishap.

b. Provide initial contractor Incident Reporting System (CIRS) report within 4-hours of mishap.

c. Conduct an accident investigation to establish the root cause(s) of the mishap.

d. Provide final CIRS report within five calendar days of mishap.

e. COR will provide forms or electronic system access for CIRS report.

Notify the Contracting Officer as soon as practical, but not later than four hours, after any accident meeting the definition of Recordable Injuries or Illnesses or High Visibility Accidents, property damage equal to or greater than $2,000, or any weight handling equipment accident. Include contractor name; contract title; type of contract; name of activity, installation or location where accident occurred; date and time of accident; names of personnel injured; extent of property damage, if any; extent of injury, if known, and brief description of accident (e.g., type of equipment being used, PPE used). Preserve the conditions and evidence on accident site until the Govt investigation team arrives and Govt investigation is conducted.

4 CONTRACT MEETINGS AND REPORTING

4.1 Kickoff Meeting / Teleconference

Upon Task Order award, within three weeks host a telephonic Kickoff Meeting with the GTT to establish the responsibilities of parties, to discuss the schedule, and to ensure mutual understanding of the scope. Prepare the meeting agenda. After opening remarks by the COR, lead the discussion of specific project requirements. Generate and submit meeting minutes for COR review and approval. This meeting shall occur prior to contractor personnel starting work.

4.2 Progress Meeting/Telcon

At various times, coordinate and host progress meetings with the GTT. The intent will be to discuss progress, quality, coordination, and mutual understanding. Meetings dates will be determined later. Assume they are telephonic. The COR will notify contractor when meetings are required. Prepare and submit brief minutes of the meetings per Table S.

5 PROPOSAL

5.1 Cost

Provide a detailed cost proposal for Tasks identified in Table 5.1 required to execute work in this SOW.

Table 5.1 Cost Proposal

Task 1 Preliminary Liner Corrosion Assessment	$
Task 2, SME Consultant Work	$
Task 3 Overall Corrosion Assessment (OCA)	$

Administrative Submittals	$

5.2 Technical

Provide proposal with succinct detail that demonstrates understanding and compliance with the principal means and methods. Identify proposed subcontractors. Provide a resume for the SME Consultant that demonstrates qualification and expertise.

6 OPTION ITEMS

In the event quantities of work are required in excess of what is in this SOW, Navy would like to establish unit prices for several Option Items. Should the work become necessary, unit prices will provide the basis for rapid execution of a change. Provide a fully burdened cost for optional work, using the referenced SOW paragraph as the basis for each Option Item, pursuant to the tables below. Option Item prices remain valid for the duration of the period of performance.

Only the Contracting Officer has the authority to authorize Option Item work. Do not proceed with any Option Item work unless the option has been exercised and the work is authorized by the Contracting Officer.

6.1 Option 1 - External Report Review and Analysis

Basis for the option work is paragraph External Report Analysis.

Table 6.1 Optional External Report Review

Type	Unit of Measure	Price
Corrosion or Practices Report	Each	$

6.2 Option 2 - Third Party Review Response

Basis for the option work is paragraph Third Party Review Response.

Table 6.2 Optional Third Party Review Responses

Work Item	Unit of Measure	Price
Analysis	Each	$
Review and Respond to Comments	Each	$
Report Supplement	Each	$

6.3 Option 3 - Electronic Meeting Participation

Basis for the option work is paragraph Appearance and Participation at Public and Regulatory Agency Meetings.

Table 6.3 Optional Electronic Meeting Participation

Type of Involvement	Unit of Measure	Price
Participation, Govt + RA + Public	Each Meeting	$

6.4 Option 4 - SME Consultant Mobilizations

Basis for the optional work is paragraph Mobilizations.

Table 6.4 Optional Mobilization

Type of Participation	Unit of Measure	Price
Onsite Meeting	Each	$

7 GOVERNMENT FURNISHED INFORMATION (GFI)

1. DBIDS for JBPHH
2. SECNAV 5512-1
3. FLCPH Badging Flow Charts
4. JB2 0-180
5. Brief Background Red Hill Tank Construction

8 PLACE OF PERFORMANCE

Joint Base Pearl Harbor Hickam, Honolulu, Hawaii.

9 PERIOD OF PERFORMANCE

The anticipated period of performance is 16 months from date of award.

10 PRIMARY POINTS OF CONTACT

Contracting Officer

Mr. Sal Vargas
NAVFAC EXWC Code ACQ72
1100 23rd Avenue, Building 1100, Port Hueneme, CA 93043-4347
(805) 982- 2565
salvador.r.vargas1@navy.mil

Government Technical Team

Project Manager

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Washington Navy Yard, DC 20374
DSN: 288-5196
Phone: (202) 433-5196

terri.regin@navy.mil

Project Engineer
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Port Hueneme, CA 9304DSN: 288-5196
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patrick.hauk@navy.mil

Design Manager, COR
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Port Hueneme, CA 93043
(805) 982- 2149
frank.kern@navy.mil

11 GLOSSARY

ACI	American Concrete Institute	EXWC	Engineering and Expeditionary Warfare Center
API	American Petroleum Institute	FLCPH	Fleet Logistics Center Pearl Harbor
ASCE	American Society of Civil Engineers	GTT	Government Technical Team
ASTM	American Society for Testing and Materials	Govt	Government
CAC	Common Access Card	GFI	Government Furnished Information
CD	Compact Disc	JBPHH	Joint Base Pearl Harbor Hickam
COR	Contracting Officer's Representative	KTR	Contractor
DBIDS	Defense Biometric Identification System	NAVFAC	Naval Facilities Engineering Command
DoD	Department of Defense	SEM	Scanning Electron Microscope
DLA	Defense Logistics Agency	SOW	Statement of Work
EDS	Energy-Dispersive X-ray Spectroscopy	USACE	US Army Corps of Engineers

END STATEMENT OF WORK

Table S Submittal List, Schedule, and Distribution

Submittal Description	Submittal Schedule			Distribution
	Initial	Govt. Review	Final	
Incident Reports	24 hrs after	-	-	EC
Project Schedule	3 WACA	1 week	-	EC
SME Consultant Resume	3 WACA	1 Week	-	EC
Safety Plan	3 WACA	2 weeks	1 WAGR	EC
Meeting Minutes	2 BD after	-	-	EC
Preliminary Liner Corrosion Assessment (PLCA) Report	1 WACO	1 Week	1 WAGR	EC
Overall Corrosion Assessment (OCA) Report	1 WACO	2 Week	2 WAGR	EC
External Report Review	1 WACO	1 Week	-	EC
Third Party Review Response	1 WACO	1 Week	-	EC

Legend / Notes:

WACA – Weeks after Contract Award
WACO – Weeks after Completion of Applicable Work
WAGR – Weeks after Govt Review
BD – Business Days
EC – Electronic Copy, subject to format / e-mail size requirements specified in the SOW
HC – Hard Copies, quantity four (4). Each hard copy shall include a CD/DVD insert including electronic copies of the report. contractor shall provide another eight (8) electronic copies of the report on CD/DVD
[1] – Weekly reports shall be e-mailed by 1000 local time of the first following business day

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ATTACHMENT E
SRLLC Qualifications

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The smallest failure may lead to costlier repairs in the future. We can help prevent that possibility.

Corrosion Protection, Together.

Solomon Resources, LLC
1001 Kamokila Blvd., Suite 125
Kapolei Bldg.,
Kapolei, HI 96707

Recipient
Street Address
City, ST ZIP Code

Tel (808) 450 2300
Cell (808) 358 2647
Michelle@SolomonResources. US

SOLOMON Resources, LLC

Solomon Resources, LLC

Products and Services

SOLOMON Resources, LLC

Solomon Resources, LLC is a woman-owned, small business, disadvantaged, SBA 8(a) certified company based in the State of Hawaii.

- DUNS No. 169731952
- CAGE No. 33EW5
- EIN 20-3119708
- Primary NAICS Code 611430

Coatings application documentation by quality assurance and inspection, to ensure adherence to specification approved by the owner.

Coatings failure analysis is done by engineering and laboratory analysis. Premature failures of protective coatings contribute to shortened life of equipment and structures.

Protective coatings need quality assurance, at all times.

The United States spend about 3% of its gross domestic products (GDP) on maintenance work to either replace or repair damaged structures and assets due to corrosion failure. Those costs have been minimized due to larger focus on quality assurance, ensuring that work is done right the first time. Quality assurance include creating effective specifications, inspection plans, use of proven products, and application inspection

Qualifications:

- ✓ NACE Certified Coatings Inspector – Peer
- ✓ NACE Protective Coatings Specialist
- ✓ ISO Auditor

What you offer:

- Corrosion & Coatings Consulting
- Coatings Inspection
- Coatings Specification Writing
- Protective Coatings Sales

Some Of Our Customers:

- US NAVFAC
- US Department of the Navy
- US Coast Guard
- Marine Contractors

ATTACHMENT F
WJE Qualifications

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CAPABILITY PROFILE

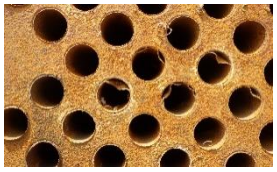
Metallurgical Engineering

- Pressure Vessel/Piping Design (VIII-1/2/3 + B31.3)
- Fitness-for-service (FFS)
- Fatigue and fracture analysis
- Nonlinear finite element analysis (FEA)
- Turnaround Support
- Heat treating evaluations
- Fire damage assessment
- Litigation support
- Failure analysis
- Forensic investigations
- Weld engineering
- Corrosion analysis and metallurgical upgrade consulting
- Rapid response services

The foundations of modern life require a constant, uninterrupted supply of energy and materials to ensure our society can flourish. In turn, the industries that supply these needs require constant maintenance and dedicated engineering support to perform their best. WJE's Metallurgy and Applied Mechanics division supports clients worldwide using our deep process industry experience to find engineering solutions to fitness for service concerns, design improvements, and effective repair options in a timely and professional manner.

WJE experts possess decades of experience in the design, analysis, and evaluation of all types of equipment found within the process industries. This expertise extends from pressurized equipment and piping systems to the structural supports and foundations for this equipment. Our team of engineers and materials scientists are dedicated to using industry best practices to address your most important pressure equipment concerns. To find a solution that fits your specific needs, we will rely on proven tools and methods, such as finite element analysis (FEA), fracture mechanics, field metallographic replication (FMR), and fitness-for-service (FFS).

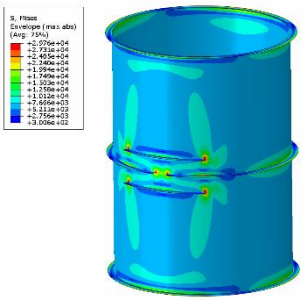
A multidisciplinary team is also available to assist owner/operators with the interaction of fixed equipment with the surrounding structural supports and equipment foundations. Our advanced in-house metallurgical and materials laboratories are ready to assist with a wide variety of materials characterization and testing to investigate and prevent equipment failures.

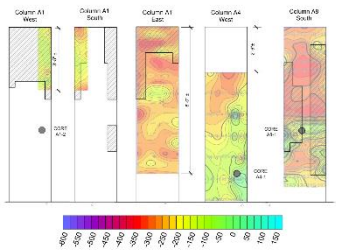


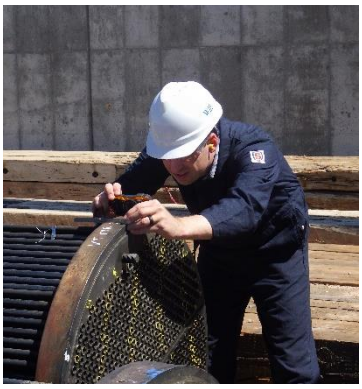
WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

CAPABILITY PROFILE

Metallurgical Engineering







REPRESENTATIVE PROJECTS

- A. Stucki Company - Moon Township, PA: AAR 2016 knuckle failure analysis
- Air Liquide Large Industries - Pasadena, TX: Metallurgical analysis of P-102 suction piping
- Apple Blossom Wind Farm - Bad Axe, MI: Forensic investigation
- CountryMark Refining - Mount Vernon, IN: Inspection plan support, fitness-for-service assessments, piping failure analysis, and on-site metallurgical turnaround support
- Energy Plant - Columbus, NE: Investigation of structure and pressure vessel collapse
- Lucite International - Beaumont, TX: On-site metallurgical turnaround support
- Odfjell Terminals - Houston, TX: Inspection of choline chloride tank weld corrosion
- Pharmaceutical Plant - Chicago, IL: Post-incident investigation of dryer for fire damage
- Polyethylene Plant - Port Allen, LA: New ASTM A53 pipe assessment
- Port of Houston - Houston, TX: Corrosion assessment program development
- Sinclair Wyoming Refining Company - Sinclair, WY: On-site turnaround support

WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

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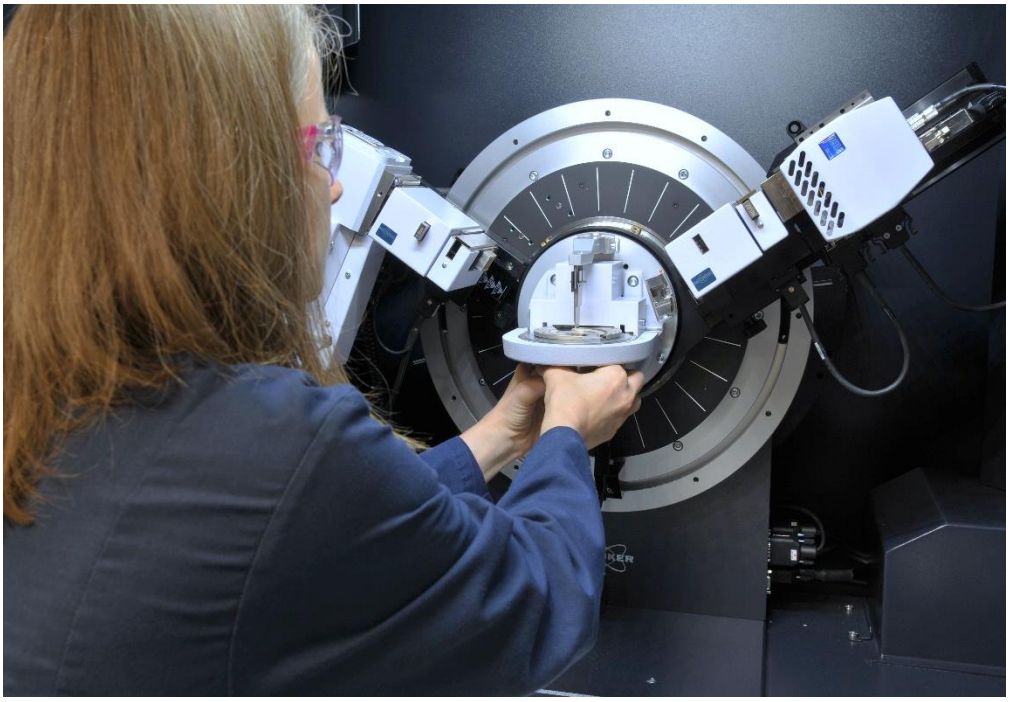
CAPABILITY PROFILE

Janney Technical Center

Materials and Structures Laboratory and Field Testing



- Materials Testing and Chemical Analysis
- Standardized (ASTM and other) and Specialty Testing
- Metallurgy
- Petrography
- Accelerated Weathering, Climate Control, and Freeze/Thaw Chambers
- Applied Research and Test Method Development
- Corrosion and Service Life Assessments
- Product Evaluation
- Cement, Concrete, Mortar, and Admixture Analysis
- Paints, Special Coatings, Waterproofing, Adhesives, and Sealants
- Glass Testing
- Structural Load and Fatigue Testing
- Field Instrumentation and Nondestructive Evaluation

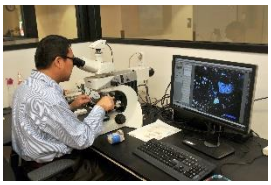
WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

WJE's Janney Technical Center (JTC) is named after WJE founder Jack Janney. Composed of both engineers and scientists, the JTC provides advanced testing and forensic capabilities to solve the most technically challenging problems related to structures, construction materials, and manufactured components. After half a century and more than 125,000 assignments, JTC engineers and materials scientists have successfully completed investigative, testing, and repair projects involving virtually every type of construction material, structural system, and architectural component.

The JTC's 70,000-square-foot state-of-the-art testing and applied research facility includes a full array of chemistry, petrography, metallurgy, concrete and mortar, corrosion, and structural testing laboratories as well as environmental exposure chambers.

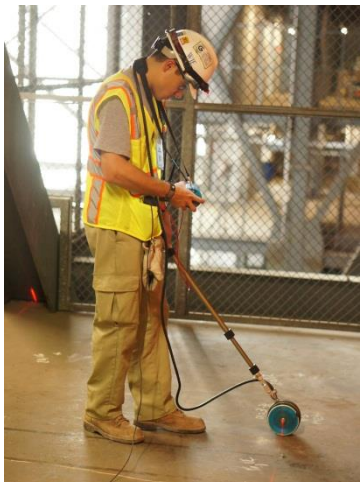
JTC personnel are recognized leaders in their fields and are active participants in standards development and industry organizations. Our multidisciplinary team of experienced scientists and engineers enables us to offer extensive testing and investigation capabilities to characterize materials, determine root causes of problems, and evaluate performance. The JTC performs tests to determine specification compliance, simulate performance under field conditions, understand failure mechanisms, generate fundamental engineering properties, and assess service life to meet the needs of various types of clients. Our services extend beyond our laboratories, and it is common for JTC personnel to take our expertise to the field and conduct specialized testing on-site.

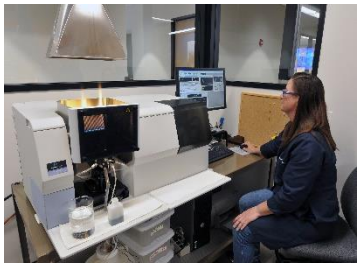
From the laboratory to the job site, from engineering to chemistry to physical sciences, JTC professionals develop and test new approaches and create innovative solutions for the built world.



CAPABILITY PROFILE

Janney Technical Center





WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

MATERIALS EVALUATION

- Physical Properties and Composition
- Durability Potential
- Corrosion Assessment
- Hygrothermal Properties

CHEMISTRY AND ANALYTICAL

- Atomic Absorption Spectroscopy (AA)
- Ion Chromatography (IC)
- Fourier Transform Infrared Spectroscopy (FTIR)
- Ultraviolet-Visible Spectroscopy (UV-VIS)
- X-Ray Fluorescence (XRF)
- X-Ray Diffraction (XRD)
- Gas Chromatography with Mass Spectrometry (GCMS)
- Differential Scanning Calorimetry (DSC)
- Thermogravimetric Analysis (TGA)
- Isothermal Conduction Calorimetry (ICC)

MICROSCOPY

- Petrography
- Metallography
- Fractography
- Scanning Electron Microscopy (SEM-EDS)

NONDESTRUCTIVE EVALUATION

- Acoustic Sounding
- Corrosion Potential and Rate Tests
- Ground Penetrating Radar (GPR)
- Ultrasonic Pulse Velocity
- Impact Echo, Impulse Response
- Ultrasonic Shear Wave
- Magnetic Particle Inspection
- Ultrasonic Flaw Detection
- Infrared Thermography (FLIR)
- Nuclear Gage Moisture Surveys
- High and Low Voltage Membrane
- Negative Pressure Uplift
- Air and Water Infiltration
- Unmanned Aerial Systems (Drones)

STRUCTURAL TESTING

- Load and Fatigue Testing
- Strain, Deflection, Rotation, and Movement Measurements
- Davit and Dedicated Anchorage Testing
- Strain Relief Method
- Bond and Adhesion Testing

MONITORING AND INSTRUMENTATION

- Vibrations and Acoustic Emission
- Temperature, Humidity, and Moisture Transmission

QUALITY PROGRAMS AND ACCREDITATIONS

- AASHTO Materials Reference Laboratory (AMRL)
- ASME NQA-1 Compliant Nuclear Quality Assurance Program
- California Authorized Laboratory for Testing Reinforcing Steel Splices
- Cast Stone Institute Testing Technician Certified Laboratory
- City of Los Angeles Approved Testing Agency
- Illinois DOT Approved Test Laboratory for Alkali-Silica Reactivity (ASR)
- ISO/IEC 17020:2012 *Conformity Assessment - Requirements for the Operation of Various Types of Bodies Performing Inspection* by the ANSI National Accreditation Board (ANAB)
- ISO/IEC 17025:2017 *General Requirements for the Competence of Testing and Calibration Laboratories* by the ANSI National Accreditation Board (ANAB)
- Massachusetts DOT Qualified Alkali-Silica Reactivity (ASR) Testing Laboratory
- Miami-Dade County Accredited Test Laboratory

STAFF CERTIFICATIONS

- American Concrete Institute (ACI)
  - Adhesive Anchor Installer
  - Aggregate Testing Technician - Level I
  - Cement Physical Tester
  - Concrete Field Testing Technician - Grade I
  - Concrete Flatwork Technician
  - Concrete Laboratory Testing Technician - Levels I and II
  - Concrete Strength Testing Technician
- American Society for Nondestructive Testing (ASNT)
  - Level I Thermographer
  - NDT Inspector - Levels II and III
  - NDT Magnetic Particle Testing- Level II
  - NDT Ultrasonic Technician - Levels I and II
- American Welding Society (AWS)
  - Certified Welder and Welding Operator
  - Certified Welding Engineer
  - Certified Welding Inspector
- Cast Stone Institute Quality Control Testing Technician
- International Concrete Repair Institute (ICRI) Concrete Slab Moisture Testing Technician
- Infrared Thermographer - Levels I and II
- National Association of Corrosion Engineers (NACE International)
  - Cathodic Protection - Levels CP 1, CP 2, and CP 3
  - Coating Inspector - CIP Levels 1 and 2
  - Corrosion Technician
- PTI Bonded Post-Tensioning Field Specialist - Level I
- Remote Pilot - Small Unmanned Aerial Systems (Drones)

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ATTACHMENT G

Contract Statement of Work – Access Reinforced Concrete Red Hill

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CONTRACT STATEMENT OF WORK

Project Title: Assess Reinforced Concrete Red Hill
Contract No: N39430-19-D-2170
Task Order: N3943020F4219
WON: 1675241
Contractor: Solomon Resources, LLC.
ACQR: TBD

SOW HISTORY

Version	Date	Description
Basic Award	23 Sep 2020	Original Scope
Mod	26 Oct 2020	Add efflorescence tests on 6 samples; ASTM C496 Tensile strength tests, Paragraph 2.2.4

Date: 09 Jul 2020
Submitted By: Frank Kern

Contents

1 NEED

The Red Hill Bulk Fuel Storage Facility (RHBFSF) was constructed with unique methods. Into mined vertical cavities, welded steel tank liners and steel reinforcement were installed. Using the liners as forms, concrete batched in an onsite plant was placed. The concrete was later prestressed by pressure grouting and the entire envelope was surrounded by a massive quantity of consolidation grouting.

Empirical evidence and a preliminary assessment of the RHBFSF demonstrate the concrete is in good condition. Further information about the quality and durability of the RHBFSF concrete, and the potential for corrosion in the reinforcement is needed. The basis for this information is an analysis of mechanical, physical, and material properties. Due to characteristics of the facility and the potential for deleterious consequences of ad hoc destructive testing, a deliberate approach that will mitigate damage to the infrastructure is necessary.

1.1 Background

During construction of the RHBFSF, an onsite batch plant was used to prepare the concrete as well as crush, classify, and convey aggregate. The source of the aggregate was the mining operation which produced cavities that became the adits, tunnels, and tanks. An exception to this process was Tanks 1-3 which used ready-mix concrete procured from a local supplier during construction.

A preliminary assessment of the concrete, consistent with ACI 364-1R was initiated in 2018. During that assessment, a review of pertinent design and construction documentation and relevant literature was performed, a visual examination of the condition of the concrete was conducted, an appraisement of the technical standard of care used during design and construction was made, and laboratory test results from material samples obtained by others were reviewed. Samples of powdered efflorescence were obtained from gunite surfaces for examination.

1.2 Goals and Objectives

The goals of this project are to expand on the previous assessment, issue a preliminary report, and better inform Navy and DLA. The primary objective is to acquire concrete samples, test them in a laboratory, analyze results, and produce a preliminary assessment report of the reinforced concrete. Secondary objectives are to provide Subject Matter Expert (SME) Consultant services in the form of review and analysis of expert documents, participation in stakeholder and public meetings, testimony before regulatory agencies regarding the assessment, and briefing Navy and DLA leadership.

1.2.1 Assessment Plan Overview

In accordance with guidance in USACE EM 1110-2-2002, this study is intended to further the preliminary assessment already initiated with laboratory tests and analyses of specimens of the RHBFSF concrete. Pursuant to principles of ASTM C823/C823M, the current working hypothesis is the concrete is in good condition. Thus, the need for the assessment is not due to concrete deterioration or a failure to perform to expectations. Rather, the intent is to provide information to be used, consistent with principles of ACI 364-1R, to broaden the base of knowledge about the reinforced concrete and further inform the hypothesis. Information about service life will be developed considering concepts in ACI 365.1R.

In order to characterize the reinforced concrete at the Facility, the plan is to acquire data that bracket conditions both geometrically (upper and lower) and temporally (early, middle, late). These data will be compared to similar-vintage specimens. Concrete specimens will be obtained from three tanks as well from a vent structure.

Tests followed by qualitative and quantitative analyses will be performed on the specimens in the following categories.

a. Physical Properties

b. Chemical Properties

c. Petrographic Properties

2 REQUIREMENTS

In order to meet project goals, this Statement of Work (SOW) contains requirements to obtain samples of concrete, procure laboratory testing and petrographic examination of the samples, analyze results by a consultant SME, and produce a concrete assessment report. The test program, data, results, analysis, and report (collectively: Test) are non-disclosable. Individuals involved will be required to sign a statement of non-disclosure.

Provide means and methods to execute this SOW which includes the Task Order Specifications. Provide appropriate subcontractor support from qualified companies, consultant(s), and specialists to execute this SOW. Provide and distribute submittals in accordance with Table S and Task Order Specifications.

2.1 Task 1 Concrete Sample Acquisition

Contractor and subcontractor employee(s) shall conduct themselves in a proper, efficient, courteous, and businesslike manner. Coordination and cooperation with others is a key element to success, and is required. The Contracting Officer may require the contractor remove from the work any individual the Govt reasonably determines is uncooperative, unqualified, fails to perform satisfactory work, is careless, objectionable, contrary to public interest, or acts inconsistent with the best interests of National Security.

2.1.1 Concrete Cores

Engage a qualified mechanical contractor experienced and badged for entry into RHBFSF. Remove and secure eight core samples of reinforced concrete in accordance with Section 02 25 16.00 20. Approximate size of each sample is a 6-inch diameter x 12-inch long cylinder. Obtain three samples from areas accessed by the upper tunnel, and three from areas accessed by the lower tunnel. Two cores will be obtained from an atmospheric vent structure on the exterior of the facility. Assume interior samples are horizontal, blind cores removed from below the manway plug and at the base of the product piping bulkhead in the respective cross-tunnels of Tanks 1, 5, and 19. Assume the exterior samples are horizontal, blind cores at locations accessible without scaffold. Govt will designate locations for each sample. Assume 1P 120V 15A electrical service is available within 100-feet of each interior core location, and use a portable generator on the exterior location. Assume the concrete is very hard with large, basalt aggregate. Cores are expected to cross at minimum #8 steel reinforcement.

2.1.2 Documentation

Record and provide core specimen removal information in accordance with Section 02 25 16.00 20. Use the Concrete Core Information Form included as GFI.

2.1.3 Repair of Concrete

Minimize the time between removal of a core and repair of the cavity. Protect the hole from contamination at all times. Repair the cavity in accordance with Section 02 25 16.00 20. Do not allow repair materials to be damaged or contaminated.

2.1.4 Core Handling, Preparation, and Shipping

Take and maintain custody of the core samples from time they are removed to the time they are delivered to the shipping company. Provide rugged watertight shipping cases pursuant to Section 02 25 16.00 20.

Use commercial transport with tracking and signature service to deliver the core specimens to the test laboratory. Handle, prepare, protect, pack, and ship the core specimens in accordance with Section 02 25 16.00 20. At the conclusion of testing and petrographic examinations, ship the mounted sections and the shipping cases containing fitted polyethylene foam to the Navy laboratory at the direction of the Contracting Officer Representative (COR).

2.2 Task 2 Laboratory Testing, Examination, and Reports

All test notes, data, photographs, specimens, sections, results, designs, comments, recommendations, specifications, and other documents collected and produced as part of this contract are property of the Govt. These data or images shall not be used, in whole or part, published or unpublished, in any technical or non-technical presentation, or otherwise released by the contractor without prior written approval of the Contracting Officer.

Provide sample preparation, laboratory testing, and report by an accredited laboratory to accomplish goals and objectives of this SOW and in accordance with Section 02 25 16.00 20. Analyze physical and chemical properties, and perform petrographic examination on the concrete specimens in two phases. Analyze chemical properties on six samples of powdered efflorescence which will be provided by Govt. Overall objectives of the laboratory testing and examination are below.

a. Provide the basis for SME analysis.

b. Determination of the condition of the concrete.

c. Determination of probable future performance of the concrete.

2.2.1 Laboratory Accreditation

Use an experienced laboratory accredited, in accordance with Section 02 25 16.0 20, by ISO 17025 for test methods to be performed.

2.2.2 Efflorescence Samples

Perform tests on the efflorescence samples and report their primary chemical constituents. They are expected to contain carbonates.

2.2.3 Phased Laboratory Examination

In Phase 1, perform and report a visual inspection and photo documentation of each specimens. Perform an initial petrographic examination to identify differences in the concrete, determine which are suitable for strength testing and which are suitable for other testing, and inform a recommended plan for the palette and sequence of physical, chemical, and petrographic tests on the specimens. Once determinations are made, schedule a Lab Test Plan meeting with the GTT and the SME Consultant to discuss the plan.

In Phase 2, execute the plan along with preliminary petrographic analysis to determine which specimens are most suited for ASTM C457 testing. Assess the quantity of SEM examinations recommended to be conducted.

2.2.3.1 Lab Test Plan Meeting

Purpose is to achieve concurrence between the Laboratory, the SME Consultant, and the Government technical team as to which tests will be conducted and the proposed order of testing. Duration is not expected to exceed 2 hours. Electronic means are commercial voice, or web conferencing (Zoom, Google, Skype, Microsoft) without video capability.

2.2.4 Physical Properties

Perform tests on the concrete specimens in accordance with Section 02 25 16.00 20. Test compressive

strength on specimens from early, middle, and late batch production categories. Test two samples and report results for splitting tensile strength (Brazilian) per ASTM C496.

2.2.5 Chemical Properties

Perform tests on the concrete specimens in accordance with Section 02 25 16.00 20. Test soluble chloride and sulfate concentration as a function of depth of concrete from the surface.

2.2.6 Petrographic Examination

Perform tests on the concrete specimens in accordance with Section 02 25 16.00 20 and ASTM C856. Prepare, mount, and polish thin sections from the surface and interior as needed to perform examination. Capture data from at least early, middle, and late batch production categories. Specific purposes of the petrographic examination are consistent with ASTM C856 Test Specimens from Actual Service, supplemented by judgement of the petrographer during Phase 1 examinations. The complexity and depth of the required petrographic study is consistent with Stage 3 Confirmatory Identification as well as elements of Stage 4 such as air-void sizes and aggregate proportions (Poole and Sims 2016).

Use phenolphthalein to determine pH as a function of depth. Verify extent of carbonation using thin sections.

Use petrographic and polarizing light microscopy in the examinations. Expect use of advanced examination techniques such as x-ray diffraction. Select samples for scanning electron microscope examination, assuming four are required. Assess for the presence of delayed ettringite.

2.2.7 Laboratory Report

Provide a report which contains results and analysis of the individual tests. Prepare a description by the petrographer of the observations and examinations made during the examinations, and interpretation of the findings insofar as they relate to goals and objectives of this SOW. Provide the laboratory report at three levels of completion.

2.2.7.1 Draft

The Draft Report is an outline format containing placeholders for all tests and analyses. Populate the draft report with completed test results. Testing that is still in-progress and the petrographic analysis might not be included in the draft. The Draft Report is progress-type with a level of completion expected to be 75%

2.2.7.2 Prefinal

The Prefinal Report contains all test results, petrographic analysis, and incorporates Govt and Subject Matter Expert (SME) comments.

2.2.7.3 Final

The level of completion of the Final Report is ready for publication and incorporates Govt and SME comments.

2.3 Task 3 SME Consultant Work

Provide the services of a Professional Civil Engineer qualified by education and experience to perform expert services of concrete assessment. Minimum education is a doctorate in geology or geological engineering. Relevant experience in assessment of large civil structures, Koolau basalt, and corrosion mechanisms in reinforced concrete is required. Submit SME Consultant resume for Govt approval.

2.3.1 Laboratory Report Analysis

Review and provide comments on the laboratory report and individual tests performed on the concrete

specimens. Expect laboratory report iterations of draft, prefinal, and final.

2.3.2 External SME Report Analysis

It is expected external experts will produce documents and reports pertaining to RHBFSF concrete. Provide peer review and critical analysis of the reports. The initial audience for the review and analysis is the GTT. However, expect discussion of external documents and reports to be a topic during electronic or onsite meetings with external stakeholders. Quantity of external document and report reviews is given in Table 2.1. Assume each report or document requires 6 hours for review and analysis.

Table 2.1 External Report Review

Type	Quantity (ea)
Technical Document	3
Corrosion or Repair Practices Report	2

2.3.3 Preliminary Nature of Assessment

Quantitative data are not available for all the concrete at Red Hill. In addition, the mix design is not known. For those reasons the assessment will be produced as preliminary and subject to change should further data become available.

2.3.4 Preliminary Concrete Assessment

Use the Preliminary Assessment initiated in 2018, the Laboratory Report, the literature, Red Hill storage tank construction and inspection records, and the petrographic analysis as the basis for a Preliminary Concrete Assessment Report. Compare, contrast, and characterize the Red Hill concrete environment with typical examples in the literature such as (Petti, et al. 2011), (P. K. Mehta 1988), (Ozaki and Sugata 1988), and (Tuutti, 1982). Consider adjectival classifications of environmental aggressivity provided in (Schiessel and Bakker 1988).

Informed by basis data, provide site-specific insight into concepts of residual service life considering (Tuutti, 1980) and (Andrade, Alonso and Gonzalez 1990), as well as durability considering (Samarin 1987), (Naus and Ellingwood 1986), and (Mehta and Monteiro 2006). Interpret chloride concentration results as they relate to durability and limitations inherent to the method.

Use the comparator cores as analogues to draw distinctions or similarities in materials or condition. Develop and discuss a preliminary performance analogue.

2.3.5 Preliminary Concrete Assessment Report

Use the services of a technical writer if necessary to prepare and format the report to the level required for publication. Below is an overview of expected elements in the preliminary report.

a. Identified performance issues or degradation mechanisms
b. Specimen to comparator analogue
c. Estimation of water to cement ratio
d. Characterization of the environment
e. Suitability of concrete for the environment
f. Quality of the concrete

g. Condition of the concrete

    1) Potential for ingress of corrosion inducing substances

h. Probable future performance of the concrete

i. Likelihood of performance impediments due to corrosion in the reinforcement

Plan three progress submittals and a record preliminary report as noted below.

2.3.5.1 Draft

The Draft Report is an outline format containing placeholders for all known elements. Populate the draft report with known test result information from the Laboratory Report. The level of completion of the Draft Report is expected to be 50%

2.3.5.2 Prefinal

The Prefinal Report contains fleshed-out analysis for all elements, complete test result information from the Laboratory Report, and incorporates Govt comments. Some conclusions and recommendations might be in draft. The level of completion of the Prefinal Report is expected to be 100%.

2.3.5.3 Final

The Final Report contains PreFinal contents expanded to full analysis for all elements, conclusions supported by data and graphics, and incorporates Govt comments. The level of completion of the Final Report is ready for publication and incorporates Govt comments. Final is the last Govt review.

2.3.5.4 For Record

The record report incorporates Govt comments and includes signed professional seal(s) and is the Preliminary Concrete Assessment Report.

2.3.5.5 Third Party Review Response

Review and commentary on the report will take place by external third parties and Regulatory Agencies (RA). Expect rounds of reviews to take place at any level of completion. Some review comments might not require a report revision and will only require a response to comments. In response to the third party and RA review comments, provide SME Consultant analysis and report deliverables per Table 2.2. Assume minor effort requires 4 hours, and substantial effort requires 12 hours of time.

Table 2.2 Third Party Review Responses

Work Item	Type	Quantity (ea)
Analysis	Minor	6
Analysis	Substantial	2
Review and Response to Comments	Minor	5
Review and Response to Comments	Substantial	2

Report Supplement	Minor	4
Report Supplement	Substantial	2

2.3.6 Electronic Meetings and Phone Calls

Provide SME consultant attendance and participation in technical, quality, and status meetings with the GTT. Meetings will be conducted only an as-needed basis. Assume periodicity ranges from once every two weeks to once per month. Duration is not expected to exceed 1 hour each. Assume electronic means are commercial web conferencing (Zoom, Google, Skype, Microsoft) without video capability.

2.3.7 Participation in Public and Regulatory Agency Meetings

Provide SME consultant participation in onsite and electronic public, Govt, and RA meetings. Assume electronic meetings are telephonic or commercial web conferencing (Zoom, Google, Skype, Microsoft). Using these means, video conferencing may take place with voice supplemented with pdf screen presentation as backup. See paragraph Mobilizations for onsite meeting requirements.

Meetings with RA will involve interaction, commentary, and criticism from forensic and specialty consultants representing their respective clients. Meetings with public will involve direct interaction with individuals and organizations representing the full range of technical knowledge and experience.

Provide SME Consultant electronic meeting participation per Table 2.3. See paragraph Work Hours for time of day requirements.

Table 2.3 Electronic Meeting Participation Schedule

Type of Involvement	Quantity of Meetings	Hours (per meeting)
Participation, Govt Only	6	2
Participation, Govt + RA	5	3
Participation, Govt + RA + Public	2	6
Presentation to Govt	2	3
Presentation to Govt + RA	2	3

2.3.8 Mobilizations

Provide SME consultant mobilizations to support the concrete assessment as well as participate in onsite Govt, RA, and public meetings. Assume onsite meetings take place in Honolulu. Assume each mobilization requires five days (two travel days, three work days). Quantity and purpose of mobilizations is per the Table 2.4.

Table 2.4 Mobilization Schedule

Type of Participation	Quantity (ea)
Concrete Review	1

Govt Meeting	2
RA Meeting	1
Public Meeting	1

2.4 Schedule

Within three weeks of award, provide a schedule which details performance of all work in this SOW. Use placeholder dates for the mobilizations. Other than the onsite concrete review, assume mobilizations take place at and after production of the Final Preliminary Concrete Assessment Report.

2.5 Informative References

Andrade, C, M.C. Alonso, and J.A. Gonzalez. 1990. "An Initial Effort to Use the Corroion Rate Measurements for Estimating Rebar Durability." *Corrosion Rates of Steel in Concrete.* Ann Arbor: American Society for Testing and Materials. 29-37.

Mehta, P K. 1988. "Durability of Concrete Exposed to Marine Environment - A Fresh Look." *Second International Conference on the Subject of Performance of Concrete in Marine Environment.* Detroit: American Concrete Institute. 1-29.

Mehta, P. Kumar, and Paulo J M Monteiro. 2006. *Concrete Microstructure, Properties, and Materials, 3rd Ed.* New York: McGraw-Hill.

Naus, D J, and B R Ellingwood. 1986. *Report on Aging of Nuclear Power Plant Reinforced Concrete Structures.* Technical Report, Oak Ridge: Oak Ridge National Laboratory.

Ozaki, S, and N Sugata. 1988. "Sixty-Year-Old Concrete in a Marine Environment." *Second International Conference on the Subject of Performance of Concrete in Marine Environment.* Detroit: American Cocrete Institute. 587-597.

Petti, Jason P, Dan Naus, Richard E Weyers, Bryan A Erler, Neal S Berke, and Alberto Sagüés. 2011. *Nuclear Containment Steel Liner Corrosion Workshop: Final Summary and Recommendations Report.* Technical Report, Albuquerque: Sandia National Laboratories.

Poole, Alan B, and Ian Sims. 2016. *Concrete Petrography, A Handbook of Investigative Techniques.* Boca Raton: CRC Press.

Samarin, Alek. 1987. "Methodology of Modeling for Concrete Durability SP 100-62." *Concrete Durability Katherine and Bryant Mather International Conference.* Detroit: American Concrete Institute. 1205-1225.

Schiessel, Peter, and R. Bakker. 1988. *RILEM Report 60-CSC Corrosion of Steel in Concrete.* RILEM Technical Committee 60-CSC, New York: Chapman and Hall.

Tuutti, K. 1982. *Corrosion of Steel in Concrete.* Research Thesis, Stockholm: Swedish Cement and Concrete Research Institute.

Tuutti, K. 1980. "Service Life of Structures with Regard to Corrosion of Embedded Steel SP 65-13." *International Conference on Performance of Concrete in Marine Environment.* Detroit: American Concrete Institute. 223-236.

2.6 Normative References

ACI 207.3R (2018) *Report on Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions*

ACI 364.1R (2019) *Guide for Assessment of Concrete Structures before Rehabilitation*

ACI 365.1R (2017) *Report on Service Life Prediction*

ASTM C33/C33M (2018) *Standard Specification for Concrete Aggregates*

ASTM C39/C39M (2020) *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*

ASTM C42/C42M (2018a) *Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*

ASTM C295/C295M (2019) *Standard Guide for Petrographic Examination of Aggregates for Concrete*

ASTM C387/C387M (2017) *Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar*

ASTM C457/C457M (2016) *Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*

ASTM C469/C469M (2014) *Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression*

ASTM C642 (2013) *Density, Absorption, and Voids in Hardened Concrete*

ASTM C823/C823M (2012, R2017) *Standard Practice for Examination and Sampling of Hardened Concrete in Constructions*

ASTM C856/C856M (2020) *Standard Practice for Petrographic Examination of Hardened Concrete*

ASTM C1218/C1218M (2017) *Standard Test Method for Water-Soluble Chloride in Mortar and Concrete*

ASTM C1723 (2016) *Standard Guide for Examination of Hardened Concrete Using Scanning Electron Microscopy*

ASTM D4327 (2017) *Standard Test Method for Anions in Water by Suppressed Ion Chromatography*

USACE ER 1110-2-2002 (1995) *Evaluation and Repair of Concrete Structures*

3 GENERAL REQUIREMENTS

Comply with Task Order Specifications, all federal, state, and local regulations. As used in the Task Order Specifications, the term construction refers to any construction-type support activity which is required to execute this Statement of Work.

Coordinate planned work activities with the Government Technical Team (GTT). Report exceptions and deviations from this Statement of Work to the Contracting Officer. Only the Contracting Officer has the authority to authorize work or de-scope work elements of this Task Order.

3.1 Work Hours

Unless otherwise indicated, onsite concrete assessment work will be located on a Govt compound, military installation, or station. Work hours are normally eight-hour days between 0700 and 1700 Monday through Friday. Obtain advance approval from the Contracting Officer for contractor personnel to remain on site beyond normal working hours. Notify the Contracting Officer at least 48-hours in advance to obtain approval for access to the jobsite or work outside of normal working hours or on Saturday, Sunday, and Federal Holidays.

Unless otherwise notified, SME Consultant meetings with Govt and RA will take place during normal business hours, Hawaii Standard Time. Meetings with the public are expected to take place between the hours of 1200 HST – 2100 HST.

3.2 No Waiver by the Government

The failure of the Govt in any one or more instances to insist upon strict performance to any of the terms of this contract or to exercise any option herein conferred shall not be construed as a waiver or relinquishment to any extent of the right to assert or rely upon such terms or options on any future occasion.

3.3 Information Security

Security requirements apply to all contractors, subcontractors, and suppliers associated with this contract. In addition to special or extraordinary security requirements, comply with the following:

a. Do not publicly disclose information concerning any aspect of the condition reports or services relating to this contract, without prior written approval of the Contracting Officer.

b. Do not disclose or cause to be disseminated information concerning the operations of the activity, operations of the activity's security, or information regarding the continuity of operations.

c. Do not disclose any information to any person not entitled to receive it. Failure to safeguard any classified information that may come to the Contractor or any person under his control, may subject the Contractor, his agents or employees to criminal liability under 18 U.S.C., Sections 793 and 798.

d. Direct to the Contracting Officer or Installation Security Officer for resolution all inquiries, comments or complaints arising from any matter observed, experienced, or learned as a result of or in connection with the performance of this contract, the resolution of which may require the dissemination of official information.

e. Coordinate photography with Installation requirements.

f. This effort will result in an aggregation of information which is sensitive and is protected from disclosure. A non-disclosure agreement will be required. Certain documents must be labeled privileged from disclosure.

Deviations from or violations of any of the provisions of this section, will, in addition to all other criminal and civil remedies provided by law, subject the Contractor to immediate termination for default and withdrawal of the Govt acceptance and approval of employment of the individuals involved.

3.4 Proprietary Rights

All field notes, drawings, photographs, specimens, reports, findings, data, and documents collected and produced as part of this contract become property of the Govt. These data shall not be used, in whole or part, published or unpublished, as a part of any technical or non-technical presentation, or otherwise released by the Contractor without written approval of the Contracting Officer.

3.5 Installation Access and Red Hill Badging

Within five days after award, for workers requiring Red Hill access, submit request(s) for access and badges in accordance with Task Order Specifications, DBIDS for JBPHH, and FLCPH Badging Flowcharts. Fulfill required background investigation information requests within one week of initiation. For workers already in possession of DBIDS access, a CAC, or a Red Hill badge, coordinate access requirements with the COR.

3.6 Safety and Occupational Health Requirements

Comply with USACE EM 385-1-1 and Section 01 35 26. Ensure a qualified Site Safety and Health Officer is onsite during work at Red Hill.

Submit matters of interpretation of standards to the COR for resolution before starting work. Where the requirements of this SOW, Task Order Specifications, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply. Govt safety oversight will be led by designated representatives.

3.6.1 Accident Notification and Reports

For recordable injuries and illnesses, and property damage accidents resulting in at least $2,000 in damages, contractor shall:

a. Provide initial notification via telephone or email as soon as possible from the time of mishap.

b. Provide initial contractor Incident Reporting System (CIRS) report within 4-hours of mishap.

c. Conduct an accident investigation to establish the root cause(s) of the mishap.

d. Provide final CIRS report within five calendar days of mishap.

e. COR will provide forms or electronic system access for CIRS report.

Notify the Contracting Officer as soon as practical, but not later than four hours, after any accident meeting the definition of Recordable Injuries or Illnesses or High Visibility Accidents, property damage equal to or greater than $2,000, or any weight handling equipment accident. Include contractor name; contract title; type of contract; name of activity, installation or location where accident occurred; date and time of accident; names of personnel injured; extent of property damage, if any; extent of injury, if known, and brief description of accident (e.g., type of equipment being used, PPE used). Preserve the conditions and evidence on accident site until the Govt investigation team arrives and Govt investigation is conducted.

4 CONTRACT MEETINGS AND REPORTING

4.1 Kickoff Meeting / Teleconference

Upon Task Order award, within three weeks host a telephonic Kickoff Meeting with the GTT to establish the responsibilities of parties, to discuss the schedule, and to ensure mutual understanding of the scope. Prepare the meeting agenda. After opening remarks by the COR, lead the discussion of specific project requirements. Generate and submit meeting minutes for COR review and approval. This meeting shall occur prior to contractor personnel starting work.

4.2 Concrete Core Preparatory Phase Meeting

Schedule and hold onsite a preparatory meeting prior to starting Task 1 work. Agenda is to discuss safety, and all technical aspects of Task 1 work.

4.3 Progress Meeting/Telcon

At various times, coordinate and host progress meetings with the GTT. The intent will be to discuss progress, quality, coordination, and mutual understanding. Meetings dates will be determined later. Assume they are telephonic. The COR will notify contractor when meetings are required. Prepare and submit brief minutes of the meetings per Table S.

5 PROPOSAL

5.1 Cost

Provide a detailed cost proposal for Tasks identified in Table 5.1 required to execute work in this SOW.

Table 5.1 Cost Proposal

Task 1 Concrete Sample Acquisition, Repair, Shipping; Mechanical KTR Mobilization	$
Task 2, Laboratory Testing, Examination, and Reports	$
Task 3 SME Consulting Work	$
Administrative Submittals	$

5.2 Technical

Provide proposal with succinct detail that demonstrates understanding and compliance with the principal means and methods. Identify the SME Consultant, mechanical support subcontractor, and test laboratory.

6 OPTION ITEMS

In the event quantities of work are required in excess of what is in this SOW, Govt would like to establish unit prices for several Option Items. Should the work become necessary, unit prices will provide the basis for rapid execution of a change. Provide a fully burdened cost for optional work, using the referenced SOW paragraph as the basis for each Option Item, pursuant to the tables below. Option Item prices remain valid for the duration of the period of performance.

Only the Contracting Officer has the authority to authorize Option Item work. Do not proceed with any Option Item work unless the option has been exercised and the work is authorized by the Contracting Officer.

6.1 Option 1 - External Report Review and Analysis

Basis for the option work is paragraph External SME Report Analysis.

Table 6.1 Optional External Report Review

Type	Unit of Measure	Price
Technical Document	Each	$
Corrosion or Repair Practices Report	Each	$

6.2 Option 2 - Third Party Review Response

Basis for the option work is paragraph Third Party Review Response.

Table 6.2 Optional Third Party Review Responses

Work Item	Type, Unit of Measure	Price
Analysis	Minor, Each	$
Analysis	Substantial, Each	$
Review and Response to Comments	Minor, Each	$
Review and Response to Comments	Substantial, Each	$
Report Supplement	Minor, Each	$
Report Supplement	Substantial, Each	$

6.3 Option 3 - Electronic Meeting Participation

Basis for the option work is paragraph Appearance and Participation at Public and Regulatory Agency Meetings.

Table 6.3 Optional Electronic Meeting Participation

Type of Involvement	Unit of Measure	Price
Participation, Govt Only	Each Meeting	$
Participation, Govt + RA	Each Meeting	$
Participation, Govt + RA + Public	Each Meeting	$

6.4 Option 4 - SME Consultant Mobilizations

Basis for the optional work is paragraph Mobilizations.

Table 6.4 Optional Mobilization

Type of Participation	Unit of Measure	Price
Onsite Meeting	Each	$

6.5 Option 5 - Laboratory Testing

Basis for the optional work is paragraph Laboratory Testing and Examination.

Table 6.5 Optional Laboratory Work

Type	Unit of Measure	Price
Engineer	Hour	$
Chemist	Hour	$
Petrographer	Hour	$
SEM/EDS	Hour	$
Technician	Hour	$

7 GOVERNMENT FURNISHED INFORMATION

1. DBIDS for JBPHH
2. SECNAV 5512-1
3. FLCPH Badging Flow Charts
4. JB2 0-180
5. Task Order Specifications
6. Submittal Register
7. Concrete Core Information Form

8 PLACE OF PERFORMANCE

RHBFSF, Joint Base Pearl Harbor Hickam, Honolulu, Hawaii.

9 PERIOD OF PERFORMANCE

The anticipated period of performance is estimated to be 16 months from date of award.

10 PRIMARY POINTS OF CONTACT

Contracting Officer

Mr. Sal Vargas
NAVFAC EXWC Code ACQ72
1100 23rd Avenue, Building 1100, Port Hueneme, CA 93043-4347
(805) 982- 2565
salvador.r.vargas1@navy.mil

Government Technical Team

Project Manager

Ms. Terri Regin
NAVFAC EXWC Code CI112
720 Kennon Street, S.E. Suite 333
Washington Navy Yard, DC 20374
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Project Engineer
Mr. Patrick Hauk
NAVFAC EXWC Code CI112
1000 23rd Avenue
Port Hueneme, CA 9304DSN: 288-5196
(805) 982- 1187
patrick.hauk@navy.mil

Design Manager, COR
Mr. Frank Kern
NAVFAC EXWC Code CI112
1000 23rd Avenue
Port Hueneme, CA 93043
(805) 982- 2149
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11 GLOSSARY

ACI	American Concrete Institute	EXWC	Engineering and Expeditionary Warfare Center
API	American Petroleum Institute	FLCPH	Fleet Logistics Center Pearl Harbor
ASCE	American Society of Civil Engineers	GTT	Government Technical Team
ASTM	American Society for Testing and Materials	Govt	Government
CAC	Common Access Card	GFI	Government Furnished Information
CD	Compact Disc	JBPHH	Joint Base Pearl Harbor Hickam
COR	Contracting Officer's Representative	KTR	Contractor
DBIDS	Defense Biometric Identification System	NAVFAC	Naval Facilities Engineering Command
DoD	Department of Defense	SEM	Scanning Electron Microscope
DLA	Defense Logistics Agency	SOW	Statement of Work
EDS	Energy-Dispersive X-ray Spectroscopy	USACE	US Army Corps of Engineers

END STATEMENT OF WORK

Table S Submittal List, Schedule, and Distribution

Submittal Description	Submittal Schedule			Distribution
	Initial	Govt. Review	Final	
Incident Reports	24 hrs after	-	-	EC
Project Schedule	3 WACA	1 week	-	EC
SME Consultant Resume	3 WACA	1 Week	-	EC
Safety Plan	3 WACA	2 weeks	1 WAGR	EC
Meeting Minutes	2 BD after	-	-	EC
Laboratory Report	1 WACO	1 Week	1 WAGR	EC
Concrete Assessment Report	1 WACO	2 Week	2 WAGR	EC
External Report Review	1 WACO	1 Week	-	EC
Third Party Review Responses	1 WACO	1 Week	-	EC
As Found in Task Order Specifications (Submittal Register)	-	-	-	EC

Legend / Notes:

WACA – Weeks after Contract Award

WACO – Weeks after Completion of Applicable Work

WAGR – Weeks after Govt Review

BD – Business Days

EC – Electronic Copy, subject to format / e-mail size requirements specified in the SOW

HC – Hard Copies, quantity four (4). Each hard copy shall include a CD/DVD insert including electronic copies of the report. contractor shall provide another eight (8) electronic copies of the report on CD/DVD

[1] – Weekly reports shall be e-mailed by 1000 local time of the first following business day

ATTACHMENT H
CTL Group Qualifications

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Boyd Clark, Ph.D.

VICE PRESIDENT OF MATERIALS

As the Vice President of Materials at CTLGroup, Dr. Clark excels in materials science, new product design, and the research and analysis of building materials. He is additionally proficient in the application and use of transmission electron microscopy (TEM), scanning electron microscopy (SEM), optical microscopy, X-ray diffraction (XRD), and X-ray fluorescence (XRF). With over 25 years experiences as a principal investigator for concrete structures, bridges, and parking deck failures, Dr. Clark is a leader in litigation and support for CTLGroup. Prior to joining CTLGroup, Dr. Clark worked at a major testing and consulting firm where, among other roles, he served as Director of Construction Materials Services. There, he was involved in research and problem solving analyses for materials including ceramics, metals, minerals, and building products.

Academic Credentials

Ph.D. Intercollege Materials Program
Pennsylvania State University, 2001

M.S. in Materials Science and Engineering
University of California-Berkeley, 1988

B.S. in Materials Science and Engineering
University of California-Berkeley, 1983

Contact Information

5400 Old Orchard Road
Skokie, Illinois 60077

(847) 972-3348

BClark@CTLGroup.com

Representative Project Experience

Materials Analysis + Structural Investigation

- Determined the cause of deterioration in concrete members including railroad ties, bridges and piers, parking garages, residential foundations + swimming pool plasters.
- Evaluated concrete in a building damaged as a result of the collapse of the World Trade Center Towers. The evaluation included failure analysis, appraisal of thermal effects on cementitious and metal building systems and the extent to which diesel fuel ingress compromised structural integrity.
- Evaluated and designed cementitious systems for the incorporation of simulated mixed waste (radioactive and non-radioactive) from the Hanford Reservation.
- Has overseen multiple projects for the Nuclear Industry; projects have been governed by both DOE and NRC regulations. Projects include qualifying constituents for concrete production, evaluating structural integrity and durability of concrete containing radioactive waste, and operations to evaluate concrete and mortar specimens with low levels of radioactivity, including examinations using multiple analytical techniques and physical testing.
- Evaluated concrete samples using multiple analytical techniques to determine cause of deterioration; concrete members evaluated include concrete railroad ties, bridges and piers, parking garages, stucco applications, residential foundations, and swimming pool plasters.
- Proficient in the application and use of transmission electron microscopy (TEM), scanning electron microscopy (SEM), optical microscopy, and X-ray diffraction (XRD).

Laboratory Oversight

- Overseen various laboratory functions for the testing of cement, fly ash, slag, concrete, and other components related to construction materials. Testing includes wet chemical, mechanical (structural) behavior, physical parameters, microscopy, and analytical chemistry techniques, including organic and inorganic analytical techniques.
- Skilled in application of laboratory systems and quality control programs for numerous test methods in environmental and construction industry.
- Managed routine laboratory operations for environmental assessments using both organic and inorganic test procedures.
- Research and problem-solving analyses for a wide variety of materials, including semiconductors, metals, minerals, and building products utilizing multiple analytical techniques.

Nuclear Industry

- Oversaw multiple projects for the Nuclear Industry, governed by both DOE and NRC regulations. Projects included qualifying constituents for concrete production,

evaluating structural integrity and durability of concrete containing radioactive waste, and research of cementitious waste forms for long term disposal.
- Developed laboratory operations to evaluate concrete and mortar specimens with low levels of radioactivity, including examinations using multiple analytical techniques and physical testing.
- Evaluation and design of cementitious systems for incorporation of simulated mixed waste (radioactive and non-radioactive) from the Hanford Reservation. Projects involved the evaluation of physical and chemical parameters for long-term containment and/or solidification of liquid or solid waste components.

Environmental Toxins Analyses

- Managed laboratory performing environmental testing using standard analytical and wet chemistry techniques for building products, contaminated soils and water specimens.
- Evaluation of a building damaged as a result of the collapse of the World Trade Center Towers. Evaluation included appraisal of the extent of diesel fuel ingress and the extent of dust contamination on electronic components.
- Managed department evaluating dust samples for multiple industrial clients. Both bulk and air-borne dust samples were evaluated on a routine testing basis. Testing included organic and inorganic component evaluations.
- Managed projects using automated SEM and optical microscopy techniques to enhance particulate evaluation. These testing results were, in turn, used many times for source apportionment purposes. Also assisted in the development of automated techniques for project-specific purposes.
- Designed sampling programs and reporting systems for monitoring nuisance dust, respirable and bulk crystalline silica in the mining industry.

Concrete Construction

- Evaluated concrete samples using multiple analytical techniques to determine cause of deterioration. Concrete components evaluated include concrete railroad ties, bridges and piers, parking garages, stucco applications, residential foundations, and swimming pool plasters.
- Evaluation of a building damaged as a result of the collapse of the World Trade Center Towers. Evaluation included appraisal of thermal effects on cementitious and metal building systems; assessments were used to evaluate the extent of compromised concrete structural integrity.
- Managed department evaluating cementitious materials for failures and concrete mix design determinations. Testing generally employed SEM and optical microscopy techniques for projects
- Evaluated stucco construction defects in residential applications, including mix design problems, component failures, and durability issues.

Coating Failures

- Evaluated numerous construction defects involving failures of coatings. Coating failures have included paint delamination, cementitious material finish coats, and elastomeric coatings on exterior building surfaces. Substrate materials, with coatings, have included aluminum frames, concrete, stucco, and plastics. Evaluation of construction defects included origin of coating failure, defects present in coatings (voids and foreign materials), determination of coating thicknesses, assessment of organic and inorganic constituents, and identification of specific products used for the coatings.
- Project involving the evaluation of premature deterioration of oil refinery fireproofing. Cementitious fireproofing applied to steel girders for use in an oil refinery expansion was delaminating and cracking due to outdoor exposure. Numerous analytical techniques were employed to evaluate the cause of observed yellowing of the product and correlated microstructural changes to the fireproofing. Determined that

causation was directly related to the inadequate manufacturing practices employed for the pre-bagged products used in casting the fireproofing on the beams.
- Assessed numerous failure projects of the coatings on architectural aluminum frames for high-rise buildings in marine environments. In these projects fluoropolymer compounds were required for the long term durability. Assessments included evaluation of component manufacturing and failure mechanisms.

Corrosion

- Involved with projects evaluating the corrosion of various metal components using optical microscopy, SEM, and other analytical techniques. Multiple routine investigations passed through the laboratory to characterize corrosive ionic species and to assess extent of corrosion.
- Large projects involved corrosion of household articles from chlorine gas (train derailment) and corrosion of metal components in single family residences in Southern California, Arizona, Hawaii and Florida.
- Led development of new product designed to prevent corrosion of metal in concrete using chemical inhibitors. Comparisons included using existing (marketed) liquid corrosion inhibitors.

Publications

Feng, X. and Clark, B. 2014. "Portland-Limestone Blended Cement: Effects of Limestone Characteristics". Portland Cement Association R+D SN3241.

Feng, X., and Clark, B. 2012. "Correlations between the Laboratory Test Methods for Potential Alkali-Silica Reactivity of Aggregates." 14th International Conference on Alkali Aggregate Reaction, Austin, Texas. May.

Cooke, G. A., L. L. Lockrem, B. A. Clark, and R. Westberg. 2008. Cast Stone Technology for Treatment and Disposal of Iodine Rich Caustic Waste Demonstration - Final Report. CH2M Hill, RPP-RPT-26725, Hanford Group, Richland, Washington.

Henocq, P., E. Samson, J. Marchand, and B. Clark. 2007. "Determination of the Chloride Content Threshold to Initial Steel Corrosion." 5th International Essen Workshop – TRANSCON 07 – Transport in Concrete: Nano- to Macrostructure, Essen, Germany. June 11-13.

Atteridge, D., M. Avila, V. Baca, S. Stevens, R. Westberg, K. M. Bishop, G. A. Cooke, L. L. Lockrem, B. Clark, R. J. Lee, and M. Silsbee. 2005. "Development of a Cast Stone Formulation for Hanford Tank Wastes." Full Paper, Presented at the RemTech 2005 Symposium, CH2M Hill, RPP-RPT-27297-FP, Banff, Alberta. October 19-21.

Avila, M., G. A. Cooke, L. L. Lockrem, G. L. Koci, M. D. Guthrie, K. J. Lueck, B. Clark, R. J. Lee, and M. Silsbee. 2005. "Development of Waste Forms for the Hanford Brines Basin 42 Waste Water + WTP Secondary Wastes + Bulk Vitrification Secondary Waste." Full Paper, Presented at the RemTech 2005 Symposium, CH2M Hill, RPP-RPT-27298-FP, Banff, Alberta. October 19-21.

Clark, B. A., S. Badger, N. Thaulow, S. Sahu, G. Hobbs, R. J. Lee, J. Marchand, and U. Jakobsen, 2004. "Petrography Analysis of a Building Foundation Impacted by 9/11." Presented at and abstract published in the Hal Taylor Cement and Concrete Conference Book, Les Diablerts, Switzerland. June 20-23.

Brown, P. W., B. A. Clark, and R. D. Hooton. 2004. "Microstructural Changes in Concretes with Sulfate Exposure." Cement and Concrete Composites, 2, No. 8: 993-999. November.

Brown, P. W., B. A. Clark, and R. D. Hooton. 2003. "The Co-Existence of Thaumasite and

Ettringite in Concrete Exposed to Magnesium Sulfate at Room Temperature and the Influence of Blast-Furnace Slag Substitution on Sulfate Resistance." Cement and Concrete Composites, 25, No. 8:939-945. December.

Clark, B. A., and P. W. Brown. 2002. "Phases Formed During Hydration of Tetracalcium Aluminoferrite in 1.0 M Magnesium Sulfate Solutions." Cement and Concrete Research, 24: 331-338. June/August.

Badger, S. R., B. A. Clark, S. Sahu, N. Thaulow, and R. J. Lee. 2001. "Determination of the Water to Cement Ratio of Hardened Concrete Utilizing Backscattered Electron Imaging." Presented at the Transportation Research Board Conference, Washington, D.C. January.

Badger, S. R., B. A. Clark, S. Sahu, N. Thaulow, and R. J. Lee. 2001. "Backscattered Electron Imaging to Determine Water-to-Cement Ratio of Hardened Concrete." Transportation Research Record. Concrete, Materials and Construction, 1775:17-20.

Brown, P. W., and B. A. Clark. 2001. "An Overview of the Roles of Ca(OH)2 in Cementing Systems." Calcium Hydroxide in Concrete, American Ceramic Society, 73-75.

Clark, B. A., and P. W. Brown. 2000. "The Formation of Calcium Sulfoaluminate Hydrate Compounds from C3A, Gypsum, and NaOH Solutions - Part II." Cement and Concrete Research, 30:233-240.

Clark, B. A., and P. W. Brown. 2000. "The Formation of Monosulphate From Tetracalcium Aluminoferrite and Magnesium Sulphate." Advances in Cement Research, 12, No. 2: 71-78.

Clark, B. A., and P. W. Brown. 2000. "The Formation of Ettringite from Tricalcium Aluminate and Magnesium Sulphate." Advances in Cement Research, 12, No. 4: 137-142. October.

Clark, B. A., and P. W. Brown. 1999. "The Formation of Calcium Sulfoaluminate Hydrate Compounds from C3A, Gypsum, and NaOH Solutions - Part I." Cement and Concrete Research, 29:1943-1948.

Clark, B. A., and P. W. Brown. 1999. "Formation of Ettringite From Monosubstituted Calcium Aluminosulfate Hydrate and Gypsum." Journal of the American Ceramic Society, 82, No. 10:2900-2905.

Clark, B. A., and P. W. Brown. 1999. "Phases Formed From Hydration of Tetracalcium Aluminoferrite and Magnesium Sulfate." Advances in Cement Research, 11, No. 3:133-137.

Sahu, S., B. A. Clark, and R. J. Lee. 1998. "Delayed Ettringite Formation and the Mode of Concrete Failure." Materials Science of Concrete - The Sidney Diamond Symposium, 379-394.

Ten Huisen, K S., B. A. Clark, M. Klimkiewicz, and P. W. Brown. 1997. "A Microstructural Investigation of Calcium-Deficient and Stoichiometric Hydroxyapatite Synthesized from CaHPO4*2H2O and Ca4(PO4)2O." Cells and Materials, 6 (1-3): 251-267.

Thaulow, N., U. H. Jakobsen, and B. A. Clark. 1996. "Composition of Alkali Silica Gel and Ettringite in Concrete Railroad Ties: SEM, EDX and X-Ray Diffraction Analyses." Cement and Concrete Research, 26, No. 2:309-318.

Skalny, J. P., B. A. Clark, and R .J. Lee. 1993. "Alkali-Silica Revised." Presented at the 15th International Conference on Cement Microscopy, Dallas, Texas.

Jie, Y., D. A. Warner, B. A. Clark, N. Thaulow, and J. P. Skalny. 1993. "Temperature Relics in Steam Cured Concrete." Presented at the 15th International Conference on Cement Microscopy, Dallas, Texas.

Skalny, J. P., B. A. Clark, and R. J. Lee. 1992. "Alkali-Silica Reaction Revisited." Proceedings of the 14th International Conference on Cement Microscopy, 309-324.

Clark, B. A., E. A. Draper, R. J. Lee, J. P. Skalny, M. Ben-Bassat, and A. Bentur. 1992. "Electron-Optical Evaluation of Concrete Cured at Elevated Temperatures." Proceedings of the American Concrete Institute Symposium on How to Produce Durable Concrete in Hot Climates, San Juan, Puerto Rico.

Clark, B. A., A. J. Schwoeble, R. J. Lee, and J. P. Skalny. 1992. "Detection of ASR in Opened Fractures of Damaged Concrete." Cement and Concrete Research, 22:1170-1178. November.

Liu, J. B., B. A. Clark, and R. M. Fisher. 1990. "Applications of Scanning Tunneling Microscopy in the Materials Characterization Laboratory." Proceedings of the XIIth International Congress for Electron Microscopy.

Hoyt, J. J., B. A. Clark, and D. de Fontaine. 1989. "A Synchrotron Radiation Study of Phase Separation in Al-Zn Alloys - I. Kinetics." Acta Metallurgica, 37, No. 6: 1597-1609.

Clark, B A. 1988. "Unmixing Kinetics in Al-Zn Alloys." Thesis, University of California, Berkeley, California.

Clark, B. A., D. de Fontaine, and J. J. Hoyt. 1987. "Unmixing Kinetics in Al-Zn Alloys." Presented at the Flume-Rothery Memorial Symposium (in conjunction with the 1987 AIME Meeting), Denver, Colorado.

Hoyt, J. J., M. Sluiter, B. A. Clark, M. Kraitchman, and D. de Fontaine. 1987. "Anomalous X-Ray Scattering Study of Early-Stage Precipitation in Al-Zn-Ag." Acta Metallurgica, 35, No. 9:2315-2322.

Hoyt, J. J., O. Lyon, J. P. Simon, B. A. Clark, B. Davis, and D. de Fontaine. 1986. "The Determination of Partial Structure Functions in Al-Zn-Ag Alloys." Solid State Communications, 57, No. 3:155-158.

Lyon, O., J. J. Hoyt, R. Pro, B. Davis, B. A. Clark, D. de Fontaine, and J. P. Simon. 1985. "Anomalous Small-Angle X-Ray Scattering on Al-Zn and Al-Zn-Ag Alloys." Journal Applied Crystallography, 18:480-486.

Presentations

Clark, B. 2012. "Forensic Materials Analysis: What Analytical Approach is Needed?" Construction Materials Seminar, University of Illinois. February 29.

Feng, X., and Clark, B. 2011. "Evaluation of the Physical and Chemical Properties of Fly Ash Products for Use in Portland Cement Concrete." 2011 World of Coal Ash Conference, Denver, Colorado. May.

Clark, Boyd A., Larry L. Lockrem, Gary A. Cooke, Marisol Avila, Richard Westberg, Michael R. Silsbee, and Richard J. Lee. 2006. "Hanford Site Cement-Based Waste Stream Solidification Studies." Presented at the Cementitious Materials for Waste Treatment, Disposal, Remediation and Decommissioning Workshop, CH2M Hill, RPP-31811-VA, Savannah River National Laboratory, Aiken, South Carolina. December 12-14.

Cooke, Gary, Larry L. Lockrem, Marisol Avila, Richard Westberg, Michael R. Silsbee, Boyd Clark, Mike D. Guthrie, Gary L. Koci, and Kristi J. Lueck. 2006. "Cement Solidification of Ammonium Sulfate Rich Basin 42 Waste Water from the Hanford Effluent Treatment Facility." Presented at the Cementitious Materials for Waste Treatment, Disposal, Remediation and Decommissioning Workshop, CH2M Hill, RPP-31803-VA, Savannah River National Laboratory,

Aiken, South Carolina, December 12-14.

Clark, B. A., Teo Rebagay, Richard Westberg, Sandy Stephens, Vicki Baca, David Attridge, Michael Silsbee, Marisol Avila, and R. J. Lee. 2005. "Development of a Cast Stone Formulation for Hanford Tank Wastes." Abstract submitted to Remediation Technologies Symposium, Alberta, Canada. October 19-21.Silsbee, Michael, Marisol Avila, Boyd A. Clark, and R. J. Lee. 2005. "Development of Waste Forms for the Hanford Brines Basin 42 Waste Water, Waste Treatment Plant Secondary Wastes and Bulk Vitrification Secondary Waste." Abstract submitted to Remediation Technologies Symposium, Alberta, Canada. October 19-21.

Clark, B. A. 2003. "The Practice and Duties of Forensic Investigators." Presented at ACI, September 30.

Clark, B. A., P. W. Brown, A. J. Schwoeble, Y. Jie, and R. J. Lee. 1995. "Comparison of Ettringite Morphologies Observed on Fracture Surfaces and in Thin Sections." Presented at The American Ceramic Society 97th Annual Meeting, Cincinnati, Ohio.

Clark, B. A., and R. J. Lee. 1993. "Energy Dispersive X-Ray Analysis of Cement Paste Features Resulting From Heat Treatment." Presented at the American Ceramic Society 95th Annual Meeting and Exposition, Cincinnati, OFI.

Clark, Boyd A. 1993. "A Comparison of SEM and TEM Analyses of Mortars Cured at Various Temperatures." Materials Science Candidacy Paper.

Clark, B. A., A. M. Dailey, Y. Jie, J. P. Skalny, and R. J. Lee. 1993. "TEM and EDS Analysis of Cement Paste in Concrete and Experimental Mortars." Poster Session American Ceramic Society PAC RIM Meeting, Honolulu, Hawaii.

Clark, B. A, J. P. Simon, J. J. Hoyt, R. Pro, O. Lyon, and D. de Fontaine. 1986. "Unmixing Kinetics in Al-Zn Alloys." Presented at The Metallurgical Society Annual Meeting, New Orleans, Louisiana.

Prior Experience

CTLGroup, Skokie, Illinois

Senior Principal Materials Scientist + Materials Laboratory Services Director, 2010 - Present

RJ Lee Group, Inc., Monroeville, Pennsylvania

Manager, Sustainable Infrastructure Business Unit, 2010 - 2010
Director, Construction Materials Services, 2005 - 2010
Senior Materials Scientist, 2000 - 2005
Manager, X-Ray Diffraction Department, 1996 - 2000
Materials Scientist, 1988 - 1996

Boyd Clark, Ph.D.

Professional Honors, Awards, Fellowships, and Affiliations

American Concrete Institute (ACI) Member
- Responsibility in Concrete Construction Committee 132
- Fly Ash in Concrete Committee 232
- Natural Pozzolans Committee 240
- Durability of Concrete Committee 201
- Sustainability Committee 130
- Corrosion of Metals in Concrete Committee 222

American Society for Testing and Materials (ASTM) Member
- ASTM Cement Committee C01 and ASTM Concrete and Aggregate Committee C09.
- Subcommittee member
  - Supplementary Cementitious Materials C09.24
  - Aggregate Reactions in Concrete C09.50
  - Petrography C09.65
- Subcommittee chair
  - C01.99 Research Topics and Evaluation of Standards

Laura Powers

PRINCIPAL PETROGRAPHER + MATERIALS SCIENTIST

Ms. Powers has extensive experience in evaluating geological and building materials using polarized-light microscopy and other petrographic methods, scanning electron microscopy with x-ray spectroscopy, electron microprobe analysis, x-ray fluorescence, x-ray diffraction, physical testing, and chemical testing methods. Her expertise includes assessing the composition and condition of historical building materials for restoration and conservation purposes, identification of defects and deficiencies in precast and cast-in-place concrete, analysis of non-portland cement-based building materials, assessing damage caused by fire and explosion, and evaluating performance of materials in aggressive environments.

Throughout her career, Ms. Powers has worked with a wide variety of building materials including: concrete, mortar, stucco, gypsum plaster, dimension stone, adobe, fired clay products, natural and synthetic fibers, metals, and coatings. She has also participated in research in sequestration of biohazardous and low-level radioactive materials in cementitious systems, radionuclide migration in concrete, laser ablation cleaning of stone, expansion mechanism of delayed ettringite formation (DEF), and autogenous shrinkage of high-performance concrete (HPC).

Ms. Powers has coordinated and performed numerous field and laboratory forensic investigations of materials behavior and performance issues, and provided expert testimony at trial, arbitration, and mediation. She is a frequent speaker at professional conferences and has presented topics on cement-based materials, aggregates, and petrography for courses at the Portland Cement Association and for courses and seminars at multiple universities.

Academic Credentials

M.S. in Geology
University of Saskatchewan - Saskatoon, Canada, 1985

B.S. in Geology
University of Massachusetts - Amherst, 1977

Contact Information

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Representative Project Experience

Petrographic + SEM/EDS Analysis

- Performed field investigation and laboratory studies including petrographic and SEM/EDS studies to assess the condition of a section of early 1900s-era concrete aqueduct that was partially buried in sulfate soils.
- As part of a team of petrographers, conducted rapid turn-around petrographic examinations of more than 200 concrete cores taken to assess fire damage to the interior of a highway tunnel caused by a fuel tanker fire.
- Conducted petrographic examinations and coordinated chemical analyses of historic mortars, concrete, and stone from 1800s-era lighthouses and fortifications. Results were used to assess in-place condition and formed the basis for repairs.
- Experienced in the application of petrographic methods, including polarized-light and electron microscopy, and integration of chemical and physical tests in investigations of building materials performance. Materials studied include: concrete, mortar and masonry assemblies, dimension stone, stucco, gypsum-based materials, and individual material components.

Litigation Support

- Evaluated individual constituent materials in pre-bagged concrete product and performed detailed microscopical analyses to correlate the product with concrete fragments found with a murder victim.
- Analyzed debonded stucco and bonding compound from multi-story residential tower. The analyses were used to support repair claims.
- Analyzed individual construction materials and conducted detailed microanalysis of clogs in drains in newly renovated military barracks to determine the origin of clogs and likely responsible party.

Laura Powers

Forensic Investigation

- Conducted on-site petrographic studies of concrete cores in a nuclear power plant to investigate the cause of cracking and source of secondary deposits.
- Performed microscopical analyses of deposits collected from damaged paint finishes on automobiles downwind of industrial facilities to determine the source of fugitive particulate matter.
- Analyzed concrete fragments from a jet engine damaged in transit to a maintenance facility and performed comparative analyses of concrete from the underside of multiple damaged bridges to determine possible match.
- Researched the effects of high-temperature fires on concrete performance and performed petrographic analysis of fire damage in concrete, masonry, stucco, and gypsum plaster.
- Performed forensic microscopy to identify sources of airborne and waterborne particulates from floods, explosions, fires, and stack emissions.

Materials Science

- Developed a course in concrete and aggregate petrography for the Portland Cement Association and served as principal instructor. Frequent speaker at professional society meetings, university seminars, workshops, and forums.
- Conducted geochemical, petrologic, and field investigations of gold, uranium, chromium, nickel, cobalt, copper, lead, zinc ore deposits in Canada, Australia, and the United States. Constructed paragenetic models for ore deposition.
- Conducted research on sequestration of biohazardous and low-level radioactive materials in cementitious systems (waste forms).
- Assessed service environment degradation mechanisms such as acid-attack, cyclic freezing and thawing, aggressive chemical exposure, and thermal cycling.

Masonry + Historical Structures

- Investigated composition and condition of historic building materials in multiple locations for the National Park Service to assist restoration and conservation efforts.
- Conducted an evaluation of original and later exterior repair mortars and interior plaster at a historic church in Atlanta, Georgia for a restoration and repair campaig.
- Evaluated the composition and condition of multiple generations of mortar for the rehabilitation and re-purposing of the 1880s structure into artist's lofts.
- Evaluated the original 1920s stone masonry mortar to formulate a durable compatible mortar for restoration and rehabilitation of the structure at Paradise Inn Annex in Mt. Rainier, Washington.
- Evaluated the composition and condition of mortar from the 1880s textile mill to formulate a compatible mortar for rehabilitation of the structure and conversion into loft apartments.
- Conducted site observations of the condition of the 1870s stone masonry at the American Museaum of Natural History in New York, New York. Evaluated original and later repair mortars, as well as trial mixtures for compatible replacement mortars to be used in a repair campaign.
- Conducted laboratory, quarry, and field investigation of stone to assess historical performance as part of an evaluation for its potential use in new construction at Whitman College, Princeton University.
- Evaluated select characteristics of multiple proprietary repair mortars marketed for restoration purposes to assess potential compatibility issues with existing masonry mortars at Battelle Memorial Institute.
- Assessed the effectiveness of different laser cleaning trials on soiled marble at the New York Public Library in New York, using polarized-light microscopy and scanning electron microscopy with x-ray spectroscopy.
- Conducted field and laboratory evaluation of stone and mortar deterioration and color variation to assist architects in mitigating distress and restoring appearance of the masonry at the Indian Community School in Franklin, WI.

Laura Powers

Structural Assessment

- Investigated defects and deficiencies in precast concrete and cast-in-place concrete.
- Principal investigator on the project team for a Middle Eastern dam grout evaluation where she was responsible for performing petrographic and SEM/EDX analysis of grout, coordinating organic and inorganic chemical tests, and preparing a comprehensive report on grout composition and condition. The analyses concluded the weak grout had been over-watered and the composition did not conform to project specifications.
- Principal petrographer for the petrographic examination of concrete cores from tank supports, where she investigated the cause of cracking and spalling of concrete support columns for water tanks. Analyzed the characteristics of concrete cores from distressed and non-distressed locations to determine the pattern and depth of damage. The cracking and spalling were attributed to cyclic freezing and thawing of critically saturated, non-air-entrained concrete.
- As principal petrographer, performed field investigation of the condition of the interior and exterior of a 100-year-old concrete aqueduct, determined core locations for laboratory analysis, conducted petrographic examinations of more than sixty cores, and coordinated chemical analyses and mechanical testing to assess the condition of the aqueduct. The investigation showed that critical portions of the structure exhibited severe loss of section caused by a combination of cyclic freeze/thaw damage and the thaumasite form of sulfate attack (TSA) related to sulfate soils.
- Performed on-site petrographic examinations of cores taken from the containment structure at a nuclear power facility to assess the cause of cracking and associated water leakage. Analysis determined that cracking occurred at a cold joint, formed during the initial construction, that had opened due to expansion of wood debris from formwork and corrosion products of metallic debris.

Publications

Building Materials Information Sheet 11: Early Cements. Built Environment Journal, Powers, Laura J., Royal Institution of Chartered Surveyors, London, 62, April/May 2020.

Petrographic Examination and SEM/EDX Analysis of Ultra-High Performance Concrete, Powers, Laura J. and Ferraro, Jaclyn, Proceedings, 17th Euroseminar on Microscopy Applied to Building Materials, Toronto, Ontario, CANADA, 2019, Extended Abstracts.

How Clean? A Methodology to Assess Progress of CCR Removal in Real Time, Powers, Laura and Jennings, Victoria, World of Coal Ash 2019, St. Louis, Missouri, Electric Power Research Institute First Place Poster Award

Thaumasite Sulfate Attack: Case Studies and Implications, Hou, Xiaoqiang, Powers, Laura, Lawler, John, Tureyen, Koray, Proceedings of the 37th International Conference on Cement Microscopy, ICMA, Seattle, Washington, 2015.

Radionuclide Migration through Sediment and Concrete: 16 Years of Investigations, Golovich, E. C., Mattigod, S. V., Snyder, M. M. V., Powers, L. J., Whyatt, G. A., and Wellman, D. M., Pacific Northwest National Laboratory report to U. S. Department of Energy, National Technical Information Service, November 2014.

Effect of Internal Curing on Freeze-Thaw Durability of Dry-Cast Concrete Segmental Retaining Wall Units and Solid Interlocking Concrete Paving Units, Walloch, Craig, Speck, Jeff, and Powers, Laura, ASTM STP 1577, 2014, 29 p.

Petrographic Analysis of Historic Mortars, Powers, Laura J., Papas, Susanne M., Masonry Edge/Story Pole. V. 6 n. 2, 2011.

Microscopical Studies of Mortar Made with Lunar Aggregate, Powers, L. J, Proceedings of the Thirty-Third International Conference on Cement Microscopy, ICMA, San Francisco, California, 2011.

The Importance of Petrographic Examination in Compositional Analysis of Mortar, Powers, L. J. and Papas, S. M., Proceedings of the Thirty-Second International Conference on Cement Microscopy, ICMA, New Orleans, Louisiana, 2010.

Cementitious Wasteforms for Immobilization of Low-Activity Radioactive Wastes, Wellman, D. M., Bovaird, C. C., Mattigod, S. V., Parker, K. E. Clayton, L. N., Powers, L. and Wood, M. I. in Concrete Materials: Properties, Performance and Applications, editor: J. T. Sentowski, Nova Science Publishers, Inc., 2009, Chapter 5.

Effect of Iron and Carbonation on the Diffusion of Iodine and Rhenium in Waste Encasement Concrete and Soil Fill Material under Hydraulically Unsaturated Conditions, Wellman, D. M., Parker, K. E., Powers, L., Whyatt, G. A., Clayton, L. N., Mattigod, S. V., and Wood, M. I., Applied Geochemistry, Vol. 23, Issue 8, August 2008, pp. 2256 - 2271.

Comparison of Field Testing with Laboratory Testing of the Durability of Dimension Stone, Bortz, S. A., Powers, L., and Wonneberger, B., ASTM STP 1499, Dec. 2007, pp 138-153.

The Potential Use of Laser Ablation for Selective Cleaning of Indiana Limestone, K.C. Normandin, L. Powers, D. Slaton, and M.J. Scheffler, Springer proceedings in physics, 2007, Vol. 116, Lasers in the Conservation of Artworks - LACONA VI Proceedings, Vienna, Austria, Sept. 21-25, 2005, pp 65-73.

Quantification of ASR in Concrete: An Introduction to the Damage-Rating Index Method, Powers, L. J. and Shrimer, F. T., SCP Symposium and Proceedings of the Twenty-Ninth International Conference on Cement Microscopy, ICMA, Quebec City, Quebec, Canada, 2007.

Microchemical Tests for Concrete Petrography, Powers, L. J., SCP Symposium and Proceedings of the Twenty-Ninth International Conference on Cement Microscopy, ICMA, Quebec City, Quebec, Canada, 2007.

A Discussion of the Benefits and Problems of ASTM C 1324 for Analyzing Hardened Masonry Mortars, Powers, L., Coleman, A., and Papas, S., Journal of ASTM International, Mar. 2007, Vol. 4, No. 2.

Relationship Between Indentation Hardness and Water-to-Cement Ratio of Hardened Mortar and Concrete, Cong, D. X., Reed, M. H., Powers, L. J., Shotwell, B. L. and Brown, B. D., Journal of ASTM International, Feb. 2006, Vol. 3, No. 2.

The Power of Petrography, Powers, L. J., Structure Magazine, Jan. 2006, Vol. 3, No. 2, pp 25-28.

A New Look at an Old Cement, Powers, L. J. and Walsh, J., Proceedings of the Twenty-Seventh International Conference on Cement Microscopy, ICMA, Victoria, British Columbia, Canada, 2005.

Clinker Comparisons Wet vs. Dry, Miller, F. M., Powers, L., Zdunowska, J. and Zemaitis, J., World Cement, Vol. 35: No. 4, April 2004, pp 127-135.

Ettringite Deposits in Voids, Detwiler, R. J., Taylor, P. C. and Powers, L. J., Transportation Research Record, Concrete 2004, No. 1893, pp 75-80.

How Much Curing Is Enough? Erlin, B., Nasvik, J. and Powers, L., Concrete Construction, Dec. 2003, pp 45-47.

Petrographic Examination Used to Analyze a Distressed Sewer Line Coating, Gebler, S. H., Powers, L., Willems, T. and Detwiler, R., Journal of Protective Coatings and Linings, Vol. 19,

No. 5, May 2002, pp 49-52.

Petrography as a Concrete Repair Tool, Powers, L. J., Concrete Repair Bulletin, Jan./Feb. 2002, pp 22-25.

Preparing Specimens for Microscopy, Detwiler, R. J., Powers, L. J., Hjorth Jakobsen, U., Ahmed. W. U., Schrivener, K. L., and Kjellson, K.O., Concrete International, Vol. 23, No. 11, 2001, pp. 50-58.

Assessment of Concrete in Sulfate Soils, Detwiler, R. J., Taylor, P. C., Powers, L. J., Corley, W. G., Delles, J.B., and Johnson, B. R., Journal of Performance of Constructed Facilities, August 2000, pp. 89-96.

Investigation of Deteriorated Concrete in Pavements, Miller, F. M., Detwiler, R. J., and Powers, L. J., Research and Development Serial No. 2197, Portland Cement Association, Skokie, IL, 2000.

Developments in Alkali-Silica Gel Detection, Powers, L. J., Concrete Technology Today, Vol. 20, No 1, April 1999, pp. 5-7.

Effect of Sulfates in Concrete on Their Resistance to Freezing and Thawing, Detwiler, J. R., and Powers-Couche, L. J., Ettringite The Sometimes Host of Destruction, ACI SP 177, Bernard Erlin Editor, 1999, pp. 219-247.

Investigation of an Historic Portland Cement Stucco, Powers, L. J., Proceedings, Seventh Euroseminar on Microscopy Applied to Building Materials, Delft, The Netherlands, 1999.

Investigation of Discoloration of Concrete Slabs, Miller, F., M., Powers, L. J., and Taylor, P. C., Research and Development Bulletin RD 2228, Portland Cement Association, Skokie, Illinois, 1998.

Lunar and Martian Resource Utilization - Cement and Concrete, Lin, T. D., Bhattacharja, S., Powers-Couche, L., Skaar, S. B., Horiguchi, T., Saeki, N., Munaf, D., Peng, Y. N., and Casanova, I., Abstracts, Workshop on Using in situ Resources for Construction of Planetary Outposts, April 30-May 1, 1998, Albuquerque, New Mexico. p 35.

Effect of Ettringite on Frost Resistance, Detwiler, R. J., and Powers-Couche, L. J., Concrete Technology Today, Vol. 18, No. 3, December 1997, pp. 1-4.

Behavior of Fresh Mortar in a Vacuum and Microstructure of Mortar Hardened in a Vacuum, Powers-Couche, L. J., and Lin, T. D., in Proceedings of the Fifth International Conference on Space, Vol. 1, 1996, pp 608-613.

Effect of Shotcrete Quality on Cracking of Swimming Pools, Gebler, S. H., Litvin, A., and Powers-Couche, L. J., Proceedings of the Concrete for Infrastructure and Utilities, E&FN Spon, London, England, 1996, pp. 275-285.

Microstructures of Fire-Damaged Concrete, Lin, W. M., Lin, T. D., and Powers-Couche, L. J., American Concrete Institute, Materials Journal, Vol.93, No. 3, 1996, pp. 199-205.

A Tale of Two Kiln Burners, Powers-Couche, L. J., and Miller, F. M., Proceedings of the Eighteenth International Conference on Cement Microscopy, ICMA, Duncanville, Texas, 1996, pp. 74-84.

Observations of Concrete Exposed to Very High Temperature, Powers-Couche, L. J., Proceedings of the Sixteenth International Conference on Cement Microscopy, ICMA, Duncanville, Texas, 1994, pp. 369-376.

Fire-Damaged Concrete - Up Close, Powers-Couche, L. J., Concrete Repair Digest, December 1992/January 1993.

Petrographic Analysis of Concrete and Related Building Materials, Powers-Couche, L. J., Geological Society of America, North-Central Section Meeting, 29-30 March 1993, Rolla, MO, Abstracts with Programs, Vol/Issue 25:3; 27.

Microscopical Examination of a Slag Cement Concrete, Powers-Couche, L. J., Proceedings of the Fourteenth International Conference on Cement Microscopy, ICMA, Duncanville, Texas, 1992, pp. 256-258.

Petrography Provides Results; Gives Insight into Concrete Distress, Powers-Couche, L. J., Concrete Trader, June, 1991, pp. 1 and 3.

Litigation Experience

Provided expert testimony at depositions, trials and arbitrations in Alabama, Arkansas, California, Florida, Illinois, Massachusetts, Michigan, Mississippi, Missouri, Nevada, North Dakota, Texas, Virginia, and Washington.

Contact Reports

Prepared more than 6,000 contract reports related to investigations of building materials.

Professional Affiliations and Activities

American Concrete Institute (ACI) - National, Wisconsin and Illinois Chapters

Society of Concrete Petrographers - President 2010-2012

American Society for Testing and Materials (ASTM)
- Technical Committee C09 Concrete and Concrete Aggregates
  - Task Group Chair C09.65 Water-Cementitious Materials Ratio
- Technical Committee C12 Mortars and Grouts for Unit Masonry
  - Committee C12 Membership Secretary 2017 - 2019
  - Committee C12 Recording Secretary 2020 -
  - Committee C12 Editorial Committee Chair
- Technical Committee C15 Manufactured Masonry Units

Association for Preservation Technology Western Great Lakes Chapter

Geological Society of America

Mineralogical Society of America

State Microscopical Society of Illinois

Laura Powers

Prior Experience

CTLGroup (Construction Technology Laboratories), Skokie, Illinois
Principal Petrographer and Materials Scientist, 2017 - Present

Wiss, Janney, Elstner Associates, Inc., Northbrook, Illinois
Associate Principal, 2008 – 2017
Consultant, 2003 - 2008

Construction Technology Laboratories, Skokie, Illinois
Principal Microscopist, 2000-2003
Senior Microscopist, 1997-2000
Senior Petrographer, 1995-1997
Petrographer, 1992-1995
Associate Petrographer, 1990-1992

Manville Sales Corporation, Waukegan, Illinois
QA/QC Manager, Refractory Ceramics, 1990
Quality Control Senior Technician, XRF and microscopy analyst, 1989

Macquarie University, Sydney, Australia
School of Earth Sciences Research Assistant and Instructor, 1986-1987

Jose Pacheco, Ph.D., P.Eng.

PRINCIPAL + GROUP DIRECTOR

Dr. Pacheco is a Senior Consultant in the Concrete & Cementitious-Materials Group. His consulting practice is focused on providing technical services for contractors, asset owners, and engineering firms. His involvement is typically a blend of fundamental understanding of cement and concrete technology; concrete materials performance, concrete durability and degradation; and construction practices. He normally leads the technical and management aspects of project acquisition, execution, and deliverables. He has been the strategic lead on projects where the long-term performance of concrete structures, concrete degradation mechanisms, and structural and materials forensics are involved. His work encompasses projects where prediction, assessment, and maintenance strategies for new and existing concrete infrastructure play a crucial role.

Dr. Pacheco has provided technical consulting services related to the development of high performance and conventional concrete mixtures for construction, troubleshooting, and assessment of concrete durability issues, and service life of concrete structures. He is an expert in metallic corrosion, corrosion of steel reinforcement in concrete, and concrete degradation mechanisms. His other areas of technical work include characterization of cementitious materials, moisture and ionic transport properties of concrete, and field assessment of concrete structures and repairs. Dr. Pacheco specializes in providing solutions for asset owners and contractors on several issues, selection and evaluation of construction materials, durability performance of existing concrete and steel structures, and the selection of repair and mitigation techniques for extending service life.

Dr. Pacheco serves as the Director of the Concrete & Cement-Based Materials in CTLGroup. He oversees the technical, strategic, and management aspects of the group, including collaboration with other business units in the company. His tasks include the preparation of budgets, overseeing costs and finances, and development of technical staff.

Before joining CTLGroup, he worked as a Junior Scientist at TNO (Netherlands Organization for Applied Research). His worked consisted on providing technical assistance for internal clients on projects focused in cement and concrete production, concrete mixture design and performance evaluation, destructive and non-destructive testing, petrographic and microanalysis (EDS) studies, and electrochemical techniques. Dr. Pacheco has authored and co-authored numerous technical publications in indexed journals and has contributed as an expert reviewer for multiple journals focused on concrete materials and performance, and has provided technical presentations throughout the world.

Academic Credentials

Ph.D. in Civil Engineering
Delft University of Technology,
The Netherlands, 2015

M.S. in Civil Engineering
Delft University of Technology,
The Netherlands, 2015

B.S.E. in Civil Engineering
Universidad Autónoma de Nuevo
León, Mexico, 2008

Licensure/Certification

Professional Engineer (Canada)
BC

Civil Engineer
Mexico

NCEES

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Representative Project Experience

Concrete Durability and Corrosion Protection Plans

- Served as lead consultant on the prediction of atmospheric corrosion predictions for steel pipe elements exposed to the environment in up-state New York for a large tunnel. The elements were barged from the Southwest US through the Atlantic and then trucked up to their final destination. Predictions considered the metallurgy, chloride, and sulfate exposure during transit and storing. Recommendations for long-term storage practices and monitoring programs were provided.
- Served as the lead consultant on the durability of cast-in-place concrete decks for rotary milking platforms. The analysis consisted on a detailed evaluation of the exposure conditions (organic manure and cleaning agents), provided recommendations for material selection, and troubleshooting during construction. The project also included advanced structural analysis to evaluate areas for potential cracking during and after construction.

- Served as lead consultant on the cast-in-place concrete specification development for a multi-purpose building in Astana, Kazakhstan using European Codes and Standards. The elements subject to the specification included parking garages, ramps, and other elements to be exposed to deicer salts.
- Served as the lead consultant on the prediction of atmospheric corrosion predictions for a elevating flooring system in Texas. The system was composed of several metallic components exposed to high concentrations of sulfate in the soil. Predictions were utilized for determining if the system complied with the specified service life for a monumental structure.
- Led analysis on existing documentation of the current condition of a bridge in Virginia and provided recommendations for service life extension. Several elements of the structure suffered from multiple several deterioration mechanisms like delayed ettringite formation (DEF), alkali silica reactivity (ASR), and chloride contamination. Recommendations for monitoring of performance during service were provided.

Service Life Predictions for New and Existing Structures

- Conducted service life predictions for bridge deck elements for the Illinois Tollway considering the transport properties of several concrete mixtures evaluated in the laboratory. The analysis consisted on a comparison of fundamental and finite-element modeling to estimate the design service life for bridge deck elements exposed to the environmental and deicer salt exposure in Illinois.
- Served as the lead consultant on the evaluation of remaining service life of reinforced concrete elements for a shield building exposed to marine breeze overseas. The structure suffered from high concentrations of chlorides that could initiate reinforcement corrosion. Predictions were conducted using commercial, probabilistic, and finite-element modeling tools.
- Served as the lead consultant on the evaluation of remaining service life of reinforced concrete elements for an industrial facility in the Middle East. The structure suffered from high concentrations of chlorides, failures in the cathodic protection system, and potentially on-going corrosion. Predictions were aimed to estimate the time of failure for the cathodic protection systems, provide estimations of the remaining service life, and recommendations for repair and monitoring practices.

Concrete Technology and Concrete Construction

- Led the consulting services related to the fluid penetration resistance of architectural precast panels for construction in Florida. Services included a review of concrete mixture proportions, test data, and other industry standards and specification practices related to concrete permeability.
- Led the consulting and testing services related to the assessment of early-age cracking in various bridge decks in the East Coast. The analysis consisted on review of concrete mixture proportions, ready-mix concrete batch tickets, project specifications and special provisions, cracking surveys, and other available documentations. The deliverable included the likely causes for the observed distress and provided recommendations for laboratory testing methods for confirmation purposes.
- Served as the lead consultant and project manager for the qualification of concrete mixtures for construction for multiple projects in the transportation industry. These projects ranged from bridges, tunnels, parking garages, and marine structures.
- Conducted and assisted Contractors on the development of self-consolidating concrete (SCC) for mass concrete placements for a project in the Energy market. Services rendered included on-call assistance during trial batching, and monitoring of fresh and hardened concrete performance throughout construction.
- Developed the concrete mixture proportions for numerous conventional and high-performance concretes for concrete construction projects. Assisted the contractor or ready-mixed concrete producer on several aspects during development, qualification, and troubleshooting during construction.
- Served as the Principal Investigator for a Department of Transportation on a project

focused on evaluating the performance of internally cured concrete with various curing agents and provided assistance related to the implementation of specifications for construction.

Offshore and Marine Structures

- Served as the lead consultant on the qualification and service life modeling of a retention wall in a USACE the South West. Development of a self-consolidating concrete (SCC) mixture to be used for the fabrication of precast elements. Service life modeling was conducted using finite-element modeling tools.
- Assisted on the investigation of early-age cracking observed in a waterfront structure in VA. The analysis consisted on an evaluation of the concrete mixture proportions, ready-mixed concrete batch tickets, project specifications, and environmental conditions during placement.
- Served as the project manager for the evaluation of the resistance to chloride penetration of a repair concrete mixture for a naval station in HI. The laboratory evaluation consisted on determining the chloride penetrability resistance of various concrete mixtures in accordance with industry accepted test methods.
- Assisted with the development of high-performance and high-performance mass concrete mixtures for a large infrastructure project in Houston, TX. Services were related to the selection and proportioning of concrete materials for achieving fresh and hardened concrete properties including slump retention, low adiabatic temperature rise, early-age and 28-day compressive strength, and chloride ion penetration resistance.

Concrete Repair

- Served as the reinforcement corrosion consultant on the evaluation of a shield building. The evaluation consisted on document review of exploratory borings, evaluation of the condition of the steel reinforcement upon removal of the concrete cover, gravimetric losses, and evaluation of sections for removal and repair.
- Served as the reinforcement corrosion consultant on the durability of reinforced concrete piles for the foundation of a mega-tall building in South East Asia. The analysis consisted of a review of the chemistry of the ground water and the evaluation of the concrete performance of the piles for construction.
- Coordinated the investigation on the evaluation of elastic moduli of cores extracted from high-strength concrete shear walls for a high-rise structure in NY. The work product consisted on a review of the project specifications, review of concrete mixture qualification testing performed by others, and recommendations for repair.

Publications

Pacheco, J. (2019). Incorporating Cracks in Chloride Ingress Modeling and Service Life Predictions. ACI Materials Journal, 116(5).

Isgor, B., Angst, U., Geiker, M., Halmen, C., Hansson, C., Pacheco, J., Tepke, D., Trejo, D. and Vaddey, P. (2019) “Recommended practice for reporting experimental data produced from studies on corrosion of steel in cementitious systems”, RILEM Technical Letters, 4, pp. 22-32. doi: 10.21809/rilemtechlett.2019.90.

Tang, L., Frederiksen, J. M., Angst, U. M., Polder, R., Alonso, M. C., Elsener, B., Hooton, D. & Pacheco, J. (2018). Experiences from RILEM TC 235-CTC in recommending a test method for chloride threshold values in concrete. RILEM Technical Letters, 3, 25-31.

Pacheco, J., Arboleda, C. (2018). Diseño de Mezclas de Concreto de Alto Rendimiento con Vida Util de mas de 100 años. ASOCRETO Septimebre/Octubre No. 150, pp 22-27.

Pacheco, J., & Polder, R. B. (2016). Incorporating cracking of concrete on chloride ingress and service life modeling of concrete structures. Proceedings of Corrosion 2016; Collaborate, Educate, Innovate, Mitigate., Delft, The Netherlands.

Pacheco, J., & Polder, R. B. (2016). Critical chloride concentrations in reinforced concrete specimens with ordinary Portland and blast furnace slag cement. Heron, 61(2), 99-119.

Polder, R. B., Angst, U. M., Pacheco, J., & Peelen, W. H. (2016, September). Propagation of pitting corrosion of steel in concrete: conceptual models for local cross section loss. In Concrete Solutions: Proceedings of Concrete Solutions, 6th International Conference on Concrete Repair, Thessaloniki, Greece, 20-23 June 2016 (p. 417). CRC Press.

Šavija, B., Luković, M., Hosseini, S. A. S., Pacheco, J., & Schlangen, E. (2015). Corrosion induced cover cracking studied by X-ray computed tomography, nanoindentation, and energy dispersive X-ray spectrometry (EDS). Materials and Structures, 48(7), 2043-2062.

Pacheco, J., & Çopuroğlu, O. (2015). Quantitative energy-dispersive X-ray microanalysis of chlorine in cement paste. Journal of Materials in Civil Engineering, 28(1), 04015065.

Mendonça Filho, F. F., Pacheco, J., & Çopuroglu, O. (2015). Semi-and full quantitative EDS microanalysis of chlorine in reinforced mortars subjected to chloride ingress and carbonation. EMABM 2015: Proceedings of the 15th Euroseminar on Microscopy Applied to Building Materials, Delft, The Netherlands, 17-19 June 2015.

Pacheco, J., Šavija, B., Schlangen, E., & Polder, R. B. (2014). Assessment of cracks in reinforced concrete by means of electrical resistance and image analysis. Construction and Building Materials, 65, 417-426.

Pacheco, J., Šavija, B., Schlangen, E., Polder, R.B. (2014). Corrosion of steel in cracked concrete: A microscale study. In: Grantham, M., Basheer, P.M., Magee, B., Soustos, M., Concrete Solutions, Belfast, 2014.

Pacheco, J., Šavija, B., Schlangen, E., Polder, R.B. (2014). Performance assessment of cracks in reinforced concrete. Proceeding of the RILEM International Workshop on Performance-Based Specification and Control of Concrete Durability, 11 -13 June, Zagreb, Croatia, 2014.

Šavija, B., Schlangen, E., Pacheco, J., Millar, S., Eichler, T., & Wilsch, G. (2014). Chloride ingress in cracked concrete: a laser induced breakdown spectroscopy (LIBS) study. Journal of Advanced Concrete Technology, 12(10), 425-442.

Šavija, B., Pacheco, J., & Schlangen, E. (2013). Lattice modeling of chloride diffusion in sound and cracked concrete. Cement and Concrete Composites, 42, 30-40.

Šavija, B., Luković, M., Pacheco, J., & Schlangen, E. (2013). Cracking of the concrete cover due to reinforcement corrosion: a two-dimensional lattice model study. Construction and Building Materials, 44, 626-638.

Šavija, B., Pacheco, J., & Schlangen, H. E. J. G. (2013). Lattice based simulation of chloride ingress in uncracked and cracked concrete: Model validation. In FraMCos-8: Proceedings of the 8th International Conference on Fracture Mechanics of Concrete and Concrete Structures, Toledo, Spain, 10-14 March 2013. International Center for Numerical Methods in Engineering.

Šavija, B., Pacheco, J., Lucović, M., & Schlangen, E. (2013). Modelling of Concrete Cover Cracking due to Reinforcement Corrosion. Construction and Building Materials, 44, 626-638.

Šavija, B., Pacheco, J., & Schlangen, H. E. J. G. (2013). Lattice based simulation of chloride ingress in uncracked and cracked concrete: Model validation. In FraMCos-8: Proceedings

of the 8th International Conference on Fracture Mechanics of Concrete and Concrete Structures, Toledo, Spain, 10-14 March 2013. International Center for Numerical Methods in Engineering.

Pacheco, J., Savija, B., Schlangen, E., & Polder, R. (2012). Relationship between cracking and electrical resistance in reinforced and unreinforced concrete. In 2nd Intl. Conf. on Microstructural-related Durability of Cementitious Composites, Amsterdam, Netherlands.

Pacheco, J., Çopuroğlu, O., Šavija, B., Schlangen, E., & Polder, R. B. (2012, January). Assessment of critical chloride content in reinforced concrete by Energy Dispersive Spectrometry (EDS) revisited. In Concrete Repair, Rehabilitation and Retrofitting III: 3rd International Conference on Concrete Repair, Rehabilitation and Retrofitting, ICCRRR-3, 3-5 September 2012, Cape Town, South Africa (p. 185). CRC Press.

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Pacheco, J., & Polder, R. B. (2010). Preliminary study of electrochemical lithium migration into cementitious mortar. In 2nd International Symposium on Service Life Design for Infrastructures (pp. 1093-1100). RILEM Publications SARL.

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Fajardo, G., Valdez, P., & Pacheco, J. (2009). Corrosion of steel rebar embedded in natural pozzolan based mortars exposed to chlorides. Construction and Building Materials, 23(2), 768-774.

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Pacheco, J., Fajardo, G., Valdez, P., & Badillo, A. (2007). El rol de las puzolanas naturales en el

Jose Pacheco, Ph.D.

Conferences and Seminars

4th International Conference on Service Life Design for Infrastructures (SLD4), 27-30 August 2018, Delft, The Netherlands, RILEM Publications S.A.R.L.

Concrete Solutions: Proceedings of Concrete Solutions, 6th International Conference on Concrete Repair, Thessaloniki, Greece, 20-23 June 2016.

Concrete Solutions: Proceedings of Concrete Solutions, 5th International Conference on Concrete Repair, Belfast, UK, 1-4 September 2014. CRC Press.

RILEM International Workshop on Performance-Based Specification and Control of Concrete Durability., 11 -13 June, Zagreb, Croatia, 2014.

Concrete Repair, Rehabilitation and Retrofitting III: 3rd International Conference on Concrete Repair, Rehabilitation and Retrofitting, ICCRRR-3, 3-5 September 2012, Cape Town, South Africa (p. 185). CRC Press.

Concrete Solutions: Proceedings of Concrete Solutions, 4th International Conference on Concrete Repair, Dresden, Germany, 26-28 September 2011. CRC Press.

2nd International Symposium on Service Life Design for Infrastructure, 2010, Delft, The Netherlands.

Concrete Bridge Conference, Federal Highway Administration, National Concrete Bridge Council, Missouri Department of Transportation, 2008

Invited Lectures

Pacheco, J., Five Things You Need to Know About Service Life. Big 5 Qatar, Doha, Qatar 2018.

Pacheco, J., ACI Technical Session, “Connecting Materials Science and Durability Prediction”, Detroit, MI, 2017.

Pacheco, J., Durabilidad de Concretos de Alto Desempeño. Conferencias Magistrales UANL, 2017.

Prior Experience

CTLGroup, Skokie, Illinois

Senior Consultant & Group Director, Concrete & Cement-Based Materials, 2018
Associate, Materials & Mechanics, 2015 - 2018

TNO, Delft, The Netherlands

Junior Scientist, Structural Reliability, 2014 - 2015
Intern, Built Environment & Geosciences, 2009 - 2010

INTERNATIONAL ACCREDITATION SERVICE®

CERTIFICATE OF ACCREDITATION

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SKOKIE, ILLINOIS 60077

Testing Laboratory TL-200

has met the requirements of AC89, *IAS Accreditation Criteria for Testing Laboratories,* and has demonstrated compliance with ISO/IEC Standard 17025:2017, *General requirements for the competence of testing and calibration laboratories.* This organization is accredited to provide the services specified in the scope of accreditation on the following page(s).

This certificate is valid up to APRIL 1, 2023.

This accreditation certificate supersedes any IAS accreditation bearing an earlier effective date. The certificate becomes invalid upon suspension, cancellation or revocation of accreditation. See www.iasonline.org for current accreditation information, or contact IAS at 562-364-8201.

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Raj Nathan
President

18-15965

SCOPE OF ACCREDITATION

IAS Accreditation Number	TL-200
Company Name	CTL Group
Address	5400 Old Orchard Rd. Skokie, IL 60077
Contact Name	Jeff Rusin, Quality Manager
Telephone	(847) 972-3342
Effective Date of Scope	January 30, 2020
Accreditation Standard	ISO/IEC 17025:2017

CMT

ASTM C25	Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
ASTM C31/C31M	Standard practice for making and curing concrete test specimens in the field
ASTM C39/C39M	Standard test method for compressive strength of cylindrical concrete specimens
ASTM C40/C40M	Standard test method for organic impurities in fine aggregates for concrete
ASTM C42/C42M	Standard test method for obtaining and testing drilled cores and sawed beams of concrete
ASTM C67	Standard test methods for sampling and testing brick and structural clay tile
ASTM C78/C78M	Standard test method for flexural strength of concrete (using simple beam with third-point loading)
ASTM C88	Standard test method for soundness of aggregates by use of sodium sulfate or magnesium sulfate
ASTM C91/C91M	Standard specification for masonry cement
ASTM C109/C109M	Standard test method for compressive strength of hydraulic cement mortars (compression only, using 2-in. or [50-mm] cube specimens)
ASTM C114	Standard test method for chemical analysis of hydraulic cement
ASTM C117	Standard test method for materials finer than 75-µm (no. 200) sieve in mineral aggregates by washing

ASTM C123/C123M	Standard test method for lightweight particles in aggregate
ASTM C131/C131M	Standard test method for resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles machine
ASTM C136/C136M	Standard test method for sieve analysis of fine and coarse aggregates
ASTM C140/C140M	Standard test methods for sampling and testing concrete masonry units and related units
ASTM C142/C142M	Standard test method for clay lumps and friable particles in aggregates
ASTM C143/C143M	Standard test method for slump of hydraulic-cement concrete
ASTM C150 / C150M	Standard Specification for Portland Cement
ASTM C151/C151M	Standard test method for autoclave expansion of hydraulic cement
ASTM C157/C157M	Standard test method for length change of hardened hydraulic-cement mortar and concrete
ASTM C172/C172M	Standard practice for sampling freshly mixed concrete
ASTM C173/C173M	Standard test method for air content of freshly mixed concrete by the volumetric method
ASTM C185	Standard test method for air content of hydraulic cement mortar
ASTM C186	Standard test method for heat of hydration of hydraulic cement
ASTM C191	Standard test methods for time of setting of hydraulic cement by vicat needle
ASTM C192/C192M	Standard practice for making and curing concrete test specimens in the laboratory
ASTM C204	Standard test methods for fineness of hydraulic cement by air-permeability apparatus
ASTM C215	Standard test method for fundamental transverse, longitudinal, and torsional resonant frequencies of concrete specimens
ASTM C227	Standard test method for potential alkali reactivity of cement-aggregate combinations (mortar-bar method)

ASTM C266	Standard test method for time of setting of hydraulic-cement paste by gillmore needles
ASTM C270	Standard specification for mortar for unit masonry
ASTM C293/C293M	Standard test method for flexural strength of concrete (using simple beam with center-point loading)
ASTM C348	Standard test method for flexural strength of hydraulic-cement mortars
ASTM C403/C403M	Standard test method for time of setting of concrete mixtures by penetration resistance
ASTM C430	Standard test method for fineness of hydraulic cement by the 45-µm (no. 325) sieve
ASTM C441/C441M	Standard test method for effectiveness of pozzolans or ground blast-furnace slag in preventing excessive expansion of concrete due to the alkali-silica reaction
ASTM C451	Standard test method for early stiffening of hydraulic cement (paste method)
ASTM C452	Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate
ASTM C457/C457M	Standard test method for microscopical determination of parameters of the air-void system in hardened concrete
ASTM C469/C469M	Standard test method for static modulus of elasticity and poisson's ratio of concrete in compression
ASTM C482	Standard test method for bond strength of ceramic tile to Portland cement paste
ASTM C512	Standard test method for creep of concrete in compression
ASTM C617/C617M	Standard practice for capping cylindrical concrete specimens
ASTM C641	Standard test method for iron staining materials in lightweight concrete aggregates
ASTM C702/C702M	Standard practice for reducing samples of aggregate to testing size
ASTM C780	Standard test method for preconstruction and construction evaluation of mortars for plain and reinforced unit masonry
ASTM C856	Standard practice for petrographic examination of hardened concrete
ASTM C1019	Standard test method for sampling and testing grout

ASTM C1038/C1038M	Standard test method for expansion of hydraulic cement mortar bars stored in water
ASTM C1064/C1064M	Standard test method for temperature of freshly mixed hydraulic cement concrete
ASTM C1077	Standard practice for agencies testing concrete and concrete aggregates for use in construction and criteria for testing agency evaluation
ASTM C1116/C1116M	Standard specification for fiber-reinforced concrete
ASTM C1152/C1152M	Standard test method for acid-soluble chloride in mortar and concrete
ASTM C1202	Standard test method for electrical indication of concrete's ability to resist chloride ion penetration
ASTM C1222	Standard practice for evaluation of laboratories testing hydraulic cement
ASTM C1260	Standard test method for potential alkali reactivity of aggregates (mortar-bar method)
ASTM C1314	Standard test method for compressive strength of masonry prisms
ASTM C1324	Standard test method for examination and analysis of hardened masonry mortar
ASTM C1567	Standard test method for determining the potential alkali-silica reactivity of combinations of cementitious materials and aggregate (accelerated mortar-bar method)
ASTM C1581/C1581M	Standard test method for determining age at cracking and induced tensile stress characteristics of mortar and concrete under restrained shrinkage
ASTM C1609/C1609M	Standard test method for flexural performance of fiber-reinforced concrete (using beam with third-point loading)
ASTM C1702	Standard Test Method for Measurement of Heat of Hydration of Hydraulic Cementitious Materials Using Isothermal Conduction Calorimetry
ASTM D4791	Standard test method for flat particles, elongated particles, or flat and elongated particles in coarse aggregate
Physical	
ASTM C29/C29M	Standard test method for bulk density ("unit weight") and voids in aggregate
ASTM C127	Standard test method for relative density (specific gravity) and absorption of coarse aggregate

ASTM C128	Standard test method for relative density (specific gravity) and absorption of fine aggregate
ASTM C138/C138M	Standard test method for density (unit weight), yield, and air content (gravimetric) of concrete
ASTM C177	Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus
ASTM C187	Standard test method for amount of water required for normal consistency of hydraulic cement paste
ASTM C231/C231M	Standard test method for air content of freshly mixed concrete by the pressure method
ASTM C232/C232M	Standard test method for bleeding of concrete
ASTM C496	Standard test method for splitting tensile strength of cylindrical concrete specimens
ASTM C535	Standard test method for resistance to degradation of large-size coarse aggregate by abrasion and impact in the Los Angeles machine
ASTM C566	Standard test method for total evaporable moisture content of aggregate by drying
ASTM C567/C567M	Standard test method for determining density of structural lightweight concrete
ASTM C596	Standard test method for drying shrinkage of mortar containing hydraulic cement
ASTM C642	Standard test method for density, absorption, and voids in hardened concrete
ASTM C666/C666M	Standard test method for resistance of concrete to rapid freezing and thawing
ASTM C672/C672M	Standard test method for scaling resistance of concrete surfaces exposed to deicing chemicals
ASTM C779/C779M	Standard test method for abrasion resistance of horizontal concrete surfaces
ASTM C1012/C1012M	Standard test method for length change of hydraulic-cement mortars exposed to a sulfate solution
ASTM C1105	Standard test method for length change of concrete due to alkali-carbonate rock reaction
ASTM C1218/C1218M	Standard test method for water-soluble chloride in mortar and concrete

ASTM D968	Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM E96/E96M	Standard test methods for water vapor transmission of materials
AREMA	Manual for railway engineering (chapter 30 (ties), sections 4.9.1.1, 4.9.1.2, 4.9.1.3 only))
Structural	
1997 UBC 19-1	Welding reinforcing steel, metal inserts and connections in reinforced concrete construction
ASTM A370	Standard test methods and definitions for mechanical testing of steel products (Excluding Section 18, Rockwell Hardness test)
ASTM A416/A416M	Standard specification for low-relaxation, seven-wire steel strand for prestressed concrete
ASTM A421/A421M	Standard specification for stress-relieved steel wire for prestressed concrete
ASTM A615/A615M	Standard specifications for deformed and plain carbon-steel bars for concrete reinforcement
ASTM A706/A706M	Standard specification for deformed and plain low-alloy steel bars for concrete reinforcement
ASTM A722/A722M	Standard specification for high-strength steel bars for prestressed concrete
ASTM A767/A767M	Standard specification for zinc-coated (galvanized) steel bars for concrete reinforcement
ASTM A775/A775M	Standard specification for epoxy-coated steel reinforcing bars
ASTM A882/A882M	Standard specification for filled epoxy-coated seven-wire prestressing steel strand
ASTM A934/A934M	Standard specification for epoxy-coated prefabricated steel reinforcing bars
ASTM A944	Standard test method for comparing bond strength of steel reinforcing bars to concrete using beam-end specimens
ASTM A1061/A1061M	Standard test methods for testing multi-wire steel prestressing strand
ASTM E72	Standard test methods of conducting strength tests of panels for building construction

ASTM E139	Standard test methods for conducting creep, creep-rupture, and stress-rupture tests of metallic materials
ASTM E328	Standard test methods for stress relaxation tests for materials and structures
ASTM E330/E330M	Standard test method for structural performance of exterior windows, doors, skylights and curtain walls by uniform static air pressure difference
CT 670	Method of test for mechanical and welded reinforcing steel splices
ICC ES AC133	Mechanical splice systems for steel reinforcing bars (test methods referenced in sections 3.0 and 4.0)
ICC ES AC237	Threaded high-strength steel bars for concrete reinforcement (test methods referenced in section 4.0)
ICC ES AC303	Post-tensioning anchorages and couplers of prestressed concrete (test methods referenced in sections 3.0 and 4.0)
Thermal	
AASHTO T 336	Standard method of test for coefficient of thermal expansion of hydraulic cement concrete

AASHTO: The American Association of State Highway and Transportation Officials

AREMA: American Railway Engineering and Maintenance-of-Way Association

CT: CAL-Trans

UBC: Uniform Building Code

MTC
MATERIALS TESTING CENTER

USACE CERTIFICATE OF LABORATORY VALIDATION

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

CTL Group

5400 Old Orchard Road
Skokie, IL, United States
Mr. Richard Schreiman
(847) 972-3342

has demonstrated, by abbreviated audit of its AASHTO accreditation, or by inspection of required records, equipment, procedures, facilities, and/or final reports, its proficiency to perform testing of construction materials, as established by the quality standards of AASHTO R 18 guidance and the requirements of the applicable ASTM standards.

THIS USACE CERTIFICATE OF LABORATORY VALIDATION IS ACCURATE AS OF ITS DATE AND TIME OF GENERATION:
14 JAN 2020 AT 14:08 HOURS

ALL METHODS LISTED ON THIS CERTIFICATE OF VALIDATION WILL EXPIRE ON 01/13/2022

PLEASE CONFIRM THE CURRENT VALIDATION STATUS OF THIS LABORATORY USING THE SEARCH FEATURE ON OUR PUBLIC WEBSITE: https://mtc.erdc.dren.mil

Chad A. Gartrell, PE, Director
USACE Materials Testing Center
Vicksburg, Mississippi, USA

AGGREGATE

Aggregate - C 29 - Opt - Unit Weight and Voids in Aggregate
Aggregate - C 40 - Opt - Organic Impurities
Aggregate - D 75 - Opt - Sampling
Aggregate - C 88 - Opt - Sulfate Soundness
Aggregate - C 117 - Req - Material Finer than 75 µm (No. 200) Sieve
Aggregate - C 123 - Opt - Lightweight Particles
Aggregate - C 127 - Req - Specific Gravity & Absorption in Coarse Aggregate
Aggregate - C 128 - Req - Specific Gravity & Absorption in Fine Aggregate
Aggregate - C 131 - Opt - Los Angeles Abrasion Resistance on Small-Size Coarse Aggregate
Aggregate - C 136 - Req - Sieve Analysis of Aggregates
Aggregate - C 142 - Opt - Clay Lumps
Aggregate - C 227 - Opt - Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar)
Aggregate - C 289 - Opt - Potential Alkali-Silica Reactivity of Aggregates (Chemical Method) (Withdrawn 2016)
Aggregate - C 295 - Opt - Petrographic Examination
Aggregate - E 329 - Opt - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
Aggregate - C 441 - Opt - Effectiveness of Mineral Admixtures or GBFS on Preventing
Aggregate - C 535 - Opt - Los Angeles Abrasion Resistance on Large Size Coarse Aggregate
Aggregate - C 566 - Opt - Total Moisture Content
Aggregate - C 641 - Opt - Staining Materials in Lightweight Aggregates
Aggregate - C 702 - Opt - Reducing Samples to Testing Size
Aggregate - C 1077 - Opt - Concrete and Concrete Aggregate Testing Standards (Quality Standards)
Aggregate - C 1260 - Opt - Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
Aggregate - D 2419 - Opt - Sand Equivalent Value
Aggregate - D 4791 - Opt - Flat and Elongated Particles in Course Aggregate

CEMENT

Cement - C 187 - Opt - Amount of Water Required for Normal Consistency of Hydraulic Cement Paste
Cement - C 191 - Opt - Time of Setting of Hydraulic Cement by Vicat Needle
Cement - C 266 - Opt - Time of Setting of Hydraulic-Cement Paste by Gillmore Needles
Cement - C 1012 - Opt - Length Change of Hydraulic Cement Mortars Exposed to a Sulfate Solution
Cement - C 1038 - Opt - Expansion of Hydraulic Cement Mortar Bars Stored in Water
Cement - C 1222 - Opt - Evaluation of Laboratories Testing Hydraulic Cement

CONCRETE

Concrete - C 31 - Req - Making and Curing Test Specimens in the Field
Concrete - C 39 - Req - Compressive Strength of Cylindrical Specimens

Concrete - C 42 - Opt - Drilled Cores and Sawed Beams
Concrete - C 78 - Opt - Flexural Strength by Third Point Loading
Concrete - C 138 - Req - Unit Weight and Air Content by Gravimetric
Concrete - C 143 - Req - Slump
Concrete - C 157 - Opt - Length Change of Concrete and Mortars
Concrete - C 172 - Req - Sampling
Concrete - C 173 - Req - Air Content by Volumetric ***required if C231 not performed***
Concrete - C 192 - Opt - Making and Curing Test Specimens in Laboratory
Concrete - C 215 - Opt - Fundamental Frequencies of Concrete
Concrete - C 231 - Req - Air Content by Pressure ***required if C173 not performed***
Concrete - C 232 - Opt - Bleeding of Concrete
Concrete - C 233 - Opt - Air-Entraining Admixtures for Concrete
Concrete - C 293 - Opt - Flexural Strength by Center Point Loading
Concrete - E 329 - Opt - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
Concrete - C 403 - Opt - Time of Setting by Penetration Resistance
Concrete - C 418 - Opt - Abrasion Resistance by Sand Blasting
Concrete - C 457 - Opt - Air-Void System by Microscopic Determination
Concrete - C 469 - Opt - Static Modulus of Elasticity and Poisson’s Ratio
Concrete - C 496 - Opt - Splitting Tensile Strength
Concrete - C 511 - Opt - Moist Cabinets, Moist Rooms, Water Storage Tanks
Concrete - C 512 - Opt - Creep of Concrete in Compression
Concrete - C 531 - Opt - Lin Shrinkage - Coeff Thermal Exp - Chemical-Resistant Mortars, Grouts, Etc Concretes
Concrete - C 567 - Opt - Unit Mass of Structural Lightweight Concrete
Concrete - C 597 - Opt - Pulse Velocity Through Concrete
Concrete - C 617 - Opt - Capping Cylindrical Specimens
Concrete - C 642 - Opt - Density, Absorption, and Voids
Concrete - C 666 - Opt - Freezing & Thawing Concrete Specimens
Concrete - C 672 - Opt - Scaling Resistance by Deicing Chemicals
Concrete - C 882 - Opt - Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear
Concrete - C 1064 - Req - Temperature of Concrete
Concrete - C 1074 - Opt - Estimating Concrete Strength by Maturity Method
Concrete - C 1077 - Opt - Concrete and Concrete Aggregate Testing Standards (Quality Standards)
Concrete - C 1084 - Opt - Portland Cement Content of Hardened Concrete
Concrete - C 1152 - Opt - Acid-Soluble Chloride in Concrete
Concrete - C 1202 - Opt - Electrical Indication of Concrete to Resist Chloride Ion
Concrete - C 1218 - Opt - Water-Soluble Chloride in Concrete
Concrete - C 1231 - Opt - Unbonded Caps
Concrete - C 1542 - Opt - Measuring Length of Concrete Cores
Concrete - C 1567 - Opt - Potential Alkali Silica Reactivity Cementitious Materials and Aggregate Accelerated Mortar Bar Method
Concrete - C 1583 - Opt - Tensile Strength - Conc Surfaces - Concrete Repair Overlay - Direct Tension (Pull-off Method)
Concrete - C 1603 - Opt - Method for Measurement of Solids in Water (Concrete Mixing)

MASONRY

Masonry - C 67 - Opt - Sampling and Testing Brick and Structural Clay Tile
Masonry - C 109 - Req - Compressive Strength of Cement Mortars Using Cube Specimens
Masonry - C 140 - Req - Sampling and Testing Concrete Masonry and Related Units
Masonry - C 185 - Req - Air Content of Hydraulic Cement Mortar
Masonry - C 305 - Req - Mechanical Mixing of Cement Pastes & Mortars of Plastic Consistency
Masonry - C 511 - Opt - Mixing Rooms, Moist Cabinets, Cure Tanks
Masonry - C 1093 - Opt - Masonry Testing Standard (Quality Standards)
Masonry - C 1437 - Opt - Flow of Hydraulic Cement Mortar
Masonry - C 1506 - Opt - Water Retention of Hydraulic Cement-Based Mortars and Plasters
Masonry - C 1552 - Opt - Capping Concrete Masonry Units and Related for Compression Testing
Masonry - C 1645 - Opt - Freeze-thaw and De-icing Salt Durability of Solid Concrete Interlocking Paving Units

ATTACHMENT I
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SECTION 02 25 16.00 20

EXISTING CONCRETE ASSESSMENT
06/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 207.3R	(2018) Report on Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions
ACI 365.1R	(2017) Report on Service Life Prediction

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2020) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42/C42M	(2018a) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C295/C295M	(2019) Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C387/C387M	(2017) Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar
ASTM C457/C457M	(2016) Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete
ASTM C469/C469M	(2014) Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C642	(2013) Density, Absorption, and Voids in Hardened Concrete
ASTM C856/C856M	(2020) Standard Practice for Petrographic Examination of Hardened Concrete
ASTM C1218/C1218M	(2017) Standard Test Method for Water-Soluble Chloride in Mortar and Concrete

ASTM C1723	(2016) Standard Guide for Examination of Hardened Concrete Using Scanning Electron Microscopy
ASTM D4327	(2017) Standard Test Method for Anions in Water by Suppressed Ion Chromatography

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO ISO/IEC 17025	(2017) General Requirements for the Competence of Testing and Calibration Laboratories

U.S. ARMY CORPS OF ENGINEERS (USACE)

ER 1110-2-2002	(1995) Evaluation and Repair of Concrete Structures

1.2 PLAN FOR CONCRETE ASSESSMENT

Provide data to yield information about the quality and durability of the concrete, and potential for corrosion in the reinforcement. Accomplish this by means of core drilling to obtain concrete specimens and laboratory testing. Consistent with principles of ER 1110-2-2002 and ACI 365.1R, conduct tests on physical and chemical properties of the reinforced concrete, and perform petrographic analysis.

1.2.1 Coring Work Plan

Prior to starting work, submit a Coring Work Plan for obtaining the specimens. The plan must include the proposed method of coring including a description of equipment and tools and a list of Subcontractors. No work shall be performed until this plan has been approved and no deviation from the approved plan is permitted without prior approval by the Contracting Officer. Address workplace safety in an Accident Prevention Plan prepared and submitted in accordance with Section 01 35 26.

1.2.2 Laboratory Work Plan

Prior to starting work, submit a Laboratory Work Plan. The plan must identify the laboratory and tests to be performed. No work shall be performed until this plan has been approved and no deviation from the approved plan will be permitted without prior approval by the Contracting Officer.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submit the following:

SD-01 Preconstruction Submittals

Petrographer Resume; G

Laboratory Work Plan; G

Coring Work Plan; G

Laboratory Resume; G

SD-07 Certificates

Written Record Of Receipt

SD-09 Manufacturer's Field Reports

Specimen Documentation

1.4 QUALITY ASSURANCE

Comply with all Federal, State and local laws, regulations and ordinances relating to the performance of this work. Procure all required permits, certifications and licenses required by Federal, State, and local law for the execution of this work.

1.4.1 Laboratory Accreditation

Use a laboratory experienced in concrete petrography in accordance with ASTM C856/C856M. All test methods must be accredited by ISO ISO/IEC 17025. Submit Laboratory Resume which lists accreditations and laboratory manager experience.

1.4.2 Petrographer Experience and Qualification

Provide the services of a person qualified by education and experience in concrete petrography to operate equipment used in the analysis and to record and interpret the results obtained in accordance with ASTM C856/C856M. Minimum petrographer experience is five years conducting petrographic analysis and microscopical characterization of hardened concrete.

Minimum petrographer qualification is a bachelor of science degree in Civil Engineering, Materials Science, Geology, Geological Engineering, and an advanced degree in a related field with substantial coursework in geology, mineralogy, petrography, optical mineralogy, or geochemistry. Submit Petrographer Resume which lists experience and qualification.

PART 2 PRODUCTS

2.1 Portland Cement Concrete

In accordance with ASTM C387/C387M, normal strength (3500 psi 28-day compressive) and weight, pre-extended with coarse aggregate.

2.2 Fine Aggregate

In accordance with ASTM C33/C33M, fine aggregate (sand).

PART 3 EXECUTION

3.1 DOCUMENTING SPECIMENS

Before each core is sawn, use a permanent marker to draw two arrows on the face of the concrete. Orient both arrows straight up, one on each side (left and right) of the core. After removal, use a permanent marker and annotate each core with its number, location, and date removed.

Use the Concrete Core Information Form to record specimen removal information and photographs to memorialize as-removed condition. Provide Specimen Documentation including Concrete Core Information Forms and full resolution electronic photographs in jpg format on compact disc media.

3.2 PROTECTIVE MEASURES

Take measures to avoid impact to work of Govt and others in and around the Red Hill complex. Prevent the spread of dust, odors, or contaminants. Use a water management system to secure, prevent spread, and remove cooling water. Install temporary plastic screen around the core site to prevent migration of dust from the cross-tunnel.

3.3 CORE DRILLING

Remove and secure core samples of reinforced concrete in accordance with ASTM C42/C42M. Location, quantity, and size of cores are as indicated.

3.3.1 Procedure

a. Use a wet, rig-mounted, electric system with a premium-grade segmented diamond bit.

b. Do not use a percussive or impact-type tool.

c. Exercise care to maintain recovered core intact and protected from damage.

d. Annotate each core as required in paragraph DOCUMENTING SPECIMENS.

e. Secure the base of the rig to prevent movement during operations.

f. Manage the cooling water to prevent its spread or contamination.

g. Maintain cutting speed near the middle of the manufacturer recommended range. Do not apply excessive force to the bit or overspeed the tool.

h. Populate data fields on the Concrete Core Information Form at the time each core is removed. Photograph (minimum resolution 2048 x 1536) each core in its as-removed condition, depicting the arrows and six sides.

3.4 STORAGE, HANDLING, AND DELIVERY

Maintain custody and protect from damage the core specimens from the time they are removed until they are delivered to the shipping company. Handle the cores as little as possible. Do not allow the cores to be examined or contaminated. Only handle unwrapped cores with clean, cotton-gloved hands.

3.4.1 Preservation of Specimens

Handle and prepare the cores in accordance with the following.

a. After cores have been removed, wipe off surface drill water with a clean cotton towel, place on clean kraft paper and allow remaining surface moisture (if any) to evaporate. For work outdoors, ensure cores are in the shade. Maintain cores at the ambient temperature before wrapping.

b. Do not allow cores to be exposed to water, dirt, organics, direct sunlight, heat, or contamination.

c. If a core is damaged during removal, maintain the large pieces together in as close proximity to their original position as possible. Limit handling to that required to dry, photograph, and wrap. Tightly wrap the core in an attempt to preserve its undamaged shape during transportation.

d. When surfaces are dry but no later than 1-hour after drilling, wrap each core in 6-mil polyethylene and seal with tape to minimize moisture gain or loss. Once cores are wrapped in the sealed plastic, maintain in that condition at all times. Do not allow wrapped cores to be exposed to water, direct sunlight, heat, or contamination.

e. Encircle each wrapped core several times with tightly-wrapped plastic film made from 60-gauge linear low-density polyethylene (stretch wrap).

f. Place identification on the outside of the plastic wrap noting core number, location, and date removed.

3.4.2 Shipping of Specimens

Use commercial transport with tracking and signature service to deliver the core samples to the test laboratory. Handle, encase, and ship the cores to the test laboratory in accordance with the following.

a. Provide rugged, watertight, injection molded, lockable shipping cases to protect from damage during transportation. Equip cases with EPDM rubber o-ring material, stainless steel hinge pin securing a five-latch cover with hasps, extendable handle, and ball-bearing wheels.

b. Use fitted, resilient, closed-cell polyethylene foam of density suitable to tightly surround each wrapped core within a case and prevent damage.

c. Place distinguishing identification on the outside of each case.

d. Position the wrapped cores into the fitted foam with the identification number visible upon opening the case cover.

e. Prepare bills of lading which contain a specific inventory of cores enclosed in each case. Lock each case to prevent tampering. Use an air transport service to expedite delivery to the test laboratory within three business days.

f. Provide Written Record of Receipt from the laboratory for each case.

3.5 REPAIR OF CONCRETE

Minimize the time between removal of a core and repair of the cavity. Protect the hole from contamination at all times. Use clean, potable water for all instances in this Section. Repair the concrete with a procedure compliant with the following.

a. Roughen surface of the substrate. Attempt to attain a minimum surface roughness profile of 1/8 inch.

b. Clean substrate surfaces to remove dust, dirt, contamination, loose material, or deleterious substances.

c. Moisten surfaces with water in accordance with repair material manufacturer instructions. Ensure no standing water remains.

d. Mix the concrete to produce a maximum 3-inch slump. Do not add additional water.

e. Prepare a scrub coat of bonding mortar comprised of one part Portland cement to one part sand (by volume) with sufficient water to produce a creamy consistency. Scrub the bonding mortar into the cavity substrate with a medium stiffness, natural-bristle brush. Cover all surfaces of the cavity and fill all pores and voids with the scrub coat.

f. While scrub coat is still wet, place repair concrete by forcing into the extremities of the cavity with a blunt-ended tool.

g. Manually consolidate the concrete by rodding with a blunt-ended tool. Use methods which will tightly pack the cavity with concrete material and eliminate voids.

h. Use a wood form with release agent to securely constrain the repair material.

i. After concrete has achieved satisfactory cure but no less than 48 hours, remove the wood form.

3.6 LABORATORY TESTING

Provide laboratory testing and report by an accredited laboratory in accordance with ASTM C856/C856M. The purposes of the testing are to analyze physical and chemical properties, and perform petrographic analysis. Inspect and photo-document the specimens prior to any work. Determine which specimens are suited for strength tests and which are appropriate for other tests.

3.6.1 Physical Properties

a. Test and report compressive strength test in accordance with ASTM C39/C39M.

b. Calculate and report density in accordance with ASTM C642.

c. Measure and report static Young's modulus and Poisson's ratio in accordance with ASTM C469/C469M.

3.6.2 Chemical Properties

a. Test and report percent chloride by mass of cementious material in accordance with ASTM C1218/C1218M and as a function of depth from the surface. Assess for the presence of secondary chlorides and if found, report the estimated depth.

b. Prepare samples test for sulfate levels using ion chromatography in accordance with ASTM D4327 and as a function of depth from the surface.

3.6.3 Records

Provide a laboratory report which contains photographs, examiner notes, and results from the individual tests.

3.7 PETROGRAPHIC EXAMINATION

Prepare samples and perform tests necessary to support a petrographic analysis in accordance with ASTM C856/C856M and ASTM C295/C295M. Use visual and microscopial techniques consistent with ACI 207.3R, polarizing microscope, scanning electron microscopy per ASTM C1723, and other investigative methods to inform the analysis. Use thin section analysis from surface and interior portions of the cores.

a. Assess aggregate type, size, shape, amount, and bond with cement paste.

b. Analyze potential, occurrence, and degree of ASR/ACR.

c. Characterize cracks (if any) and compare with typical causes.

d. Evaluate integrity, placement, and deleterious condition of reinforcement.

e. Assess correlation between the density of the cement paste and the water - cement ratio.

f. Identify evidence of secondary chemical reactions between constituents and exposure environment.

g. Characterize binder type and paste content.

h. Characterize the air-void system in accordance with ASTM C457/C457M. Establish air-void content, void frequency, average chord length, specific surface, and the spacing factor.

i. Determine factors that have caused the concrete to serve satisfactorily in the environment to which it is exposed.

j. Check for the presence of delayed ettringite.

k. Determine pH as a function of depth using phenolphthalein.

l. Assess depth of carbonation with thin section analysis.

3.7.1 Records

Provide Petrographic Analysis which contains findings and descriptions by the petrographer of observations and examinations made, interpretation of the findings, and representative photography.

-- End of Section --

ATTACHMENT J

Proposal - Inspect and Repair Protocols Project for Red Hill Underground Storage Tanks

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Inspect and Repair Protocols Project

for Red Hill Underground Storage Tanks (IRPP RhUST)

Lloyd Hihara

14 February 2020

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Inspect and Repair Protocols Project for Red Hill Underground Storage Tanks (IRPP RhUST)

L.H. Hihara

IRRP RhUST proposes to 1) elucidate the limits of nondestructive evaluation on severely corroded steel panels with adherent corrosion products, 2) determine in situ corrosion rates of the steel shell of the Red Hill underground fuel storage tanks (USTs), and 3) evaluate repair and patch protocols to prevent premature failures.

Low-frequency electromagnetic testing (LFET) is frequently used to examine the remaining wall thickness of the UST steel shell plates. Thick, adherent steel corrosion products (i.e., magnetite) on the back side of the plates could affect the LFET signals and indicate remaining wall thicknesses greater than actual values. To study the extent of which magnetite and other steel corrosion products can affect LFET signals, control test panels will be fabricated by generating an array of pits of varying geometries and sizes. Three dimensional profilometry scans will be conducted on the plates to generate three-dimensional scans of the defects, which can be later compared to LFET scans. The defects in the control panels will then be backfilled with magnetite as well as other types of rust corrosion products (e.g., goethite, lepidocrocite). The coupons with the backfill corrosion products will be later scanned using LFET and compared to the previous LFET scans (prior to back filling the defects) and compared to the 3-dimensional profilometry scans. This will determine the limits of LFET to accurately identify and screen corrosion pits on plates with adherent backside corrosion products. Ideally, additional allowances for the presence of magnetite etc. can be identified and incorporated into minimum wall thickness thresholds. The LFET scanning may be completed in a follow-on phase of this project.

Currently, the real time corrosion rates of the steel shell of the Red Hill USTs are unknown. The actual corrosion rate is needed to determine safe time intervals between scheduled maintenance. A protocol for measuring in situ corrosion rates of the UST walls will be developed and tested in the laboratory which can then be successfully applied to the actual USTs. The actual implementation to measure the corrosion rates in situ at Red Hill will depend on access to out-of-service USTs in which locations of corrosion pits are known (by prior NDE screening), and may have to be conducted on a follow-on phase.

Since steel corrosion products are expansive and can bend metal and fracture concrete, the current repair and patch protocols will be re-examined to minimize premature failures. Patch plate coupons will be fabricated and subjected to accelerated corrosion testing to gain insight on likely failure modes. The repair and patch protocols will be redesigned if necessary to maximize life expectancy. In this phase of the project, repair protocols will be studied, accelerated test coupons will be fabricated, and accelerated corrosion testing will be initiated. Study of the failure modes and modeling may be completed in a follow-on phase.

If the above tasks are successfully completed and implemented in the operation of the USTs, a more accurate assessment of the minimum wall thickness and real time corrosion rates will allow more accurate inspection and repair intervals to be determined. Improvements made to the current patch protocols may help to enhance the life expectancy of the UST wall.

The risk are low as the research will not involve compromise to the USTs. The cost for this phase of the project is $750k (Personnel $385k, Materials and Supplies $18k, Equipment $160k, Travel $2k, Overhead 185k), and proposed to be completed within approximately one year. Progress can be measured on an incremental basis by determining if the milestones on the attached Gantt chart are met.

Inspect and Repair Protocols Project for Red Hill UST

PI: Lloyd Hihara / University of Hawaii at Manoa

Objective

The proposed work is the clean, inspect, and repair category:

1) Understand the limits of non-destructive evaluation (NDE) (e.g., low-frequency electromagnetic technique (LFET)) on severely corroded steel panels with adherent backside corrosion products.
2) Understand the operating corrosion mechanisms of the underground storage tank (UST) steel shell, and obtain in situ corrosion rates. Determine if corrosion rates are stable, decelerating, or accelerating.
3) Evaluate repair and patch protocols to prevent premature failures. Since steel corrosion products are expansive and can bend metal and fracture concrete, the current repair and patch protocols should be examined under accelerated testing conditions to anticipate failure modes.

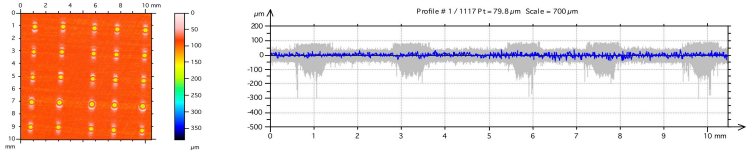


Figure 1: Example 3D and 2D profilometry scans to be compared with NDE scans.

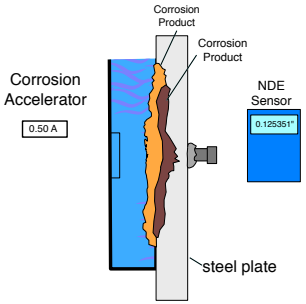
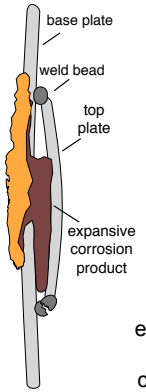


Figure 2: Mounted NDE sensor to determine in situ corrosion rates (proof of concept).

Figure 3: Possible effect of crevice corrosion and expansive corrosion products.

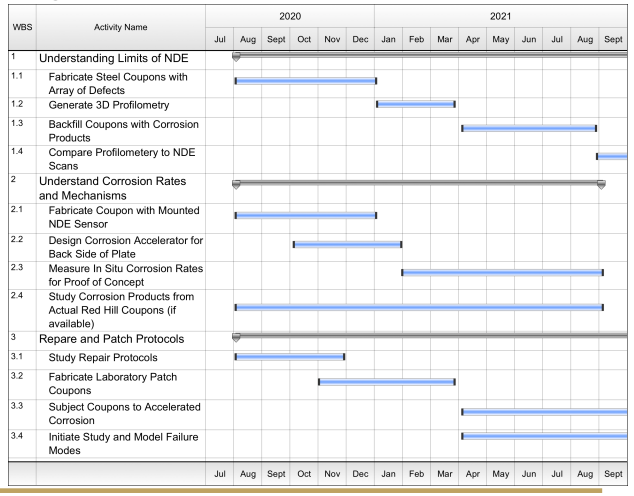


expansive steel corrosion products can fracture concrete and bend metal

Approach

1) Fabricate control steel plate specimens with defects of different sizes and geometries that are backfilled with different types of rust (e.g., magnetite, goethite, lepidocrocite). Compare 3D profilometery scans to NDE scans. The samples will be used in future LFET examinations.
2) Measure backside corrosion rates on laboratory corrosion coupons utilizing ultrasonic sensors for proof of concept. Apply in the future to out-of-service USTs
3) Fabricate welded patch-plate coupons for accelerated corrosion testing, and study failure modes.

Key Milestones



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ATTACHMENT K
Proposal - Concrete Tank Degradation Inspection and Retrofit

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RED HILL BULK FUEL STORAGE FACILITY
NAVFAC/NAVSUP
Concrete Tank Degradation Inspection and Retrofit

Contact: Lin Shen
Dept. Civil and Environmental Engineering
2540 Dole Street, Holmes Hall 383
Honolulu, Hawaii 96822
email: linshen@hawaii.edu

The objectives of this portion (secondary containment-corrosion in concrete) of the project are to 1) identify the locations and extent of cracking/degradation of the concrete and steel structure surrounding the oil tanks, 2) understand the causes and mechanism of the concrete and steel degradation based on chemical and mineralogical analysis, and 3) propose appropriate retrofitting technologies and strategies.

1) Identify locations/extents of concrete degradation

This phase will be conducted based on the findings of from the "Inspection" part of this project, where drones carrying ultrasonic, infrared, and electromagnetic sensors can provide information about the general location and extent of deterioration. Several locations will then be selected and state-of-art inspection techniques such as Half-Cell Potential (for steel corrosion probability), linear polarization method (for corrosion rate), and ground penetrating radar will be performed to get the detailed information about concrete degradation and steel corrosion. Small samples will also be collected for further lab analysis in the next phase .

2) Using chemical and mineralogical analysis of cored sample to evaluate the causes of degradation

Samples will be analyzed in the lab based on petrographic analysis, Scanning Electron Microscopy (SEM)-with Energy-Dispersive X-Ray Spectroscopy (EDS), X-Ray Diffraction, Mercury Intrusion Porosimetry, etc.

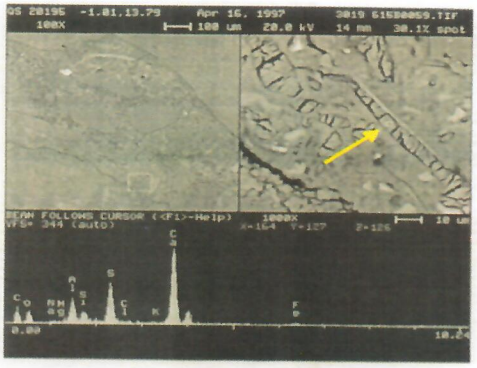


Fig1. Scanning Electron Microscopy (SEM)- with Energy-Dispersive X-Ray Spectroscopy (EDS)

There are many potential reasons for leakage and degradation of concrete and steel degradation. For example, leakage may be caused by cracking of concrete due to reaction between chemicals in the soil/ground water and concrete, or cracking due to corrosion of reinforcement, or cracking due to reactive aggregate of the concrete. The exact causes and severity of concrete and steel degradation will be identified in phase 2.

3) Propose appropriate retrofitting technologies based on the findings from 1) and 2).

Appropriate retrofitting technologies will be proposed by identifying the exact causes and extent of concrete and steel degradation based on the field inspection and laboratory analysis, and by considering the actual constructability of various retrofitting techniques for the Red Hill Fuel Storage system. For example, if voids and cracking are found responsible for leakage and degradation, low-viscosity monomers maybe injected to seal cracks and voids which are unreachable from conventional repair strategies. For repair of corroded steel layer, information about speed, probability, and extent of corrosion will greatly facilitate future retrofitting plan.

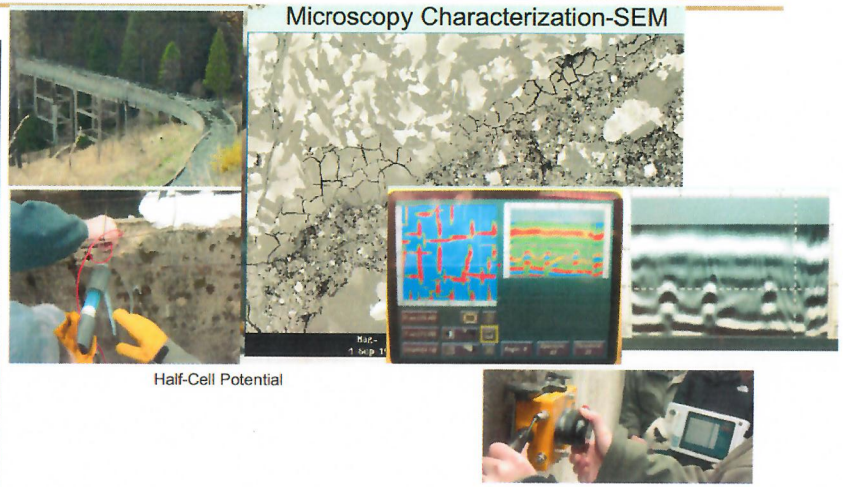
SPONSOR

Red Hill Project – 2 Secondary Containment (corrosion in concrete)

PI: Lin Shen / University of Hawaii at Manoa

Objective

The objectives of this portion (secondary containment-corrosion in concrete) of the project are to 1) identify the locations and extent of cracking/degradation of the concrete structure surrounding the oil tanks, 2) understand the causes and mechanism of the concrete degradation based on chemical and mineralogical analysis, and 3) propose appropriate concrete retrofitting technologies and strategies.



Approach

1) Identify locations/extents of concrete degradation based on the findings of PIs from the "Inspection" part of this project together with state-of-art concrete inspection techniques such as Half-Cell Potential and ground penetrating radar;

2) Using chemical and mineralogical analysis of cored sample to evaluate the causes of degradation;

3) Propose appropriate retrofitting technologies based on the findings from 1) and 2).

Co-Is/Partners: David Ma, Ian Robertson, Roger Babcock, Lloyd Hihara et al.

Key Milestones

- Milestone #1 Identify locations/extents of concrete degradation
  6 month after NTP
- Milestone #2 Analyze samples and evaluate causes of degradation
  12 months after NTP
- Propose appropriate retrofitting technologies and strategies
  18 mon after NTP

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ATTACHMENT L

Proposal - Element, Phase, and Oxidation State Mapping of Red Hill UST Corrosion by Advanced Microscopy Methods

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Red Hill Corrosion Monitoring for Mitigation: Element, Phase, and Oxidation State Mapping

White Paper on the Red Hill Bulk Fuel Storage Facility

PI: Dr. Hope Ishii, hope.ishii@hawaii.edu, HIGP POST 602, 1680 East-West Rd, Honolulu, HI
Organization: Advanced Electron Microscopy Center, University of Hawai'i at Mānoa

Corrosion is a fluid-mediated redox phenomenon that modifies oxidation state, structure, and composition. It often initiates around nanoscale defects, rapidly propagates, and ultimately leads to failure. Fuel tanks located in the Red Hill Bulk Fuel Storage Facility (U.S. Navy) regularly undergo non-destructive examination methods to monitor the effects of corrosion and metal fatigue. Recently, destructive testing was also performed, and the impact of corrosion on tank wall thickness was measured in coupons extracted at the exterior surface in contact with the concrete casing [1]. The analyses validate the current non-destructive methods, but the underlying corrosion problem has yet to be addressed. The local water source(s)/pathway(s), and specific corrosion mechanism(s) that result, are not yet well understood. The current solution is a literal Band-Aid: Where a tank wall has lost thickness due to corrosion, an extra layer of steel is welded in place to retain structural integrity. The Navy's ongoing interest in improving fuel storage has resulted in discussions of upgrades and new fuel tank designs, and we propose to contribute to these future improvements and to ongoing corrosion mitigation efforts with improved understanding of the corrosion mechanisms operating in existing tanks.

We propose three objectives: 1) Determine the micrometer-scale corrosion pathways and roles of indigenous/induced structural defects; 2) Search for foreign corrosive species, check for concentration and/or oxidation state gradients, and seek their source(s) in local materials; and 3) Assess the possibility of distinguishing historic from contemporary corrosion episodes.

We will characterize fuel tank samples using state-of-the-art electron and ion beam instruments, unique in the State of Hawai'i. They are a focused ion beam–scanning electron microscope (FIB-SEM, Fig. 1) with energy dispersive x-ray spectrometer (EDS) and a scanning transmission electron microscope (S/TEM) with electron energy-loss spectrometer (EELS) and EDS (Fig. 2). They provide images and spectral maps for visualizing structure and morphology as well as corrosion product distribution, phases, compositions, and oxidation states in sample regions of centimeters down to the nanoscale. See attached quad chart.

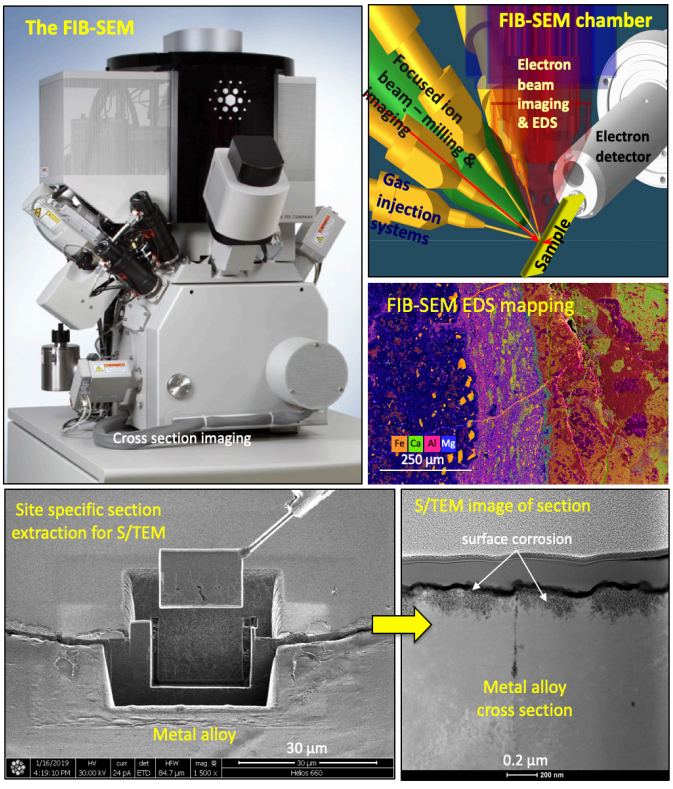
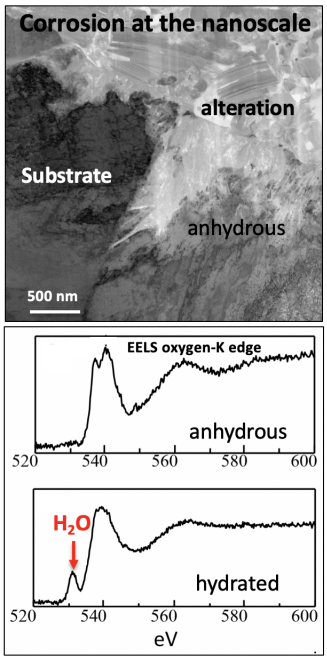


Figure 1: *The FIB-SEM, interior schematic, and examples of element mapping by EDS, site-specific cross-section by FIB for mapping, and coupon extraction for S/TEM imaging.*

Specifically, we will first image and map element composition on large areas of corroded surfaces for overall chemistry and morphology. This low- to high-magnification approach mitigates the risk of focusing on non-representative regions. We will then generate cross-section, image, and map compositions of the corroded interface to investigate the relationship of corrosion to defects that may facilitate corrosion (delamination, fractures, grain boundaries, manufacturing defects, etc.), assess local scale corrosion depth and material loss, determine corrosion product phases, and assess foreign corrosive species that may act as "tracer" elements to fingerprint water pathways and distinguish old from new corrosion. Gradients in "tracer" species, if present, will be mapped, and additional analyses materials surrounding the tank (e.g. concrete casing, gunite, basalt bedrock) may lead us to the source(s) of those species. For a selected subset of samples, we will extract micrometer-sized coupons in cross-section in order to obtain high-resolution imaging, element maps, and oxidation state maps in corrosion products. We will map the oxidation states of iron as well as those of "tracer" elements.

We propose to study coupons from multiple regions in the tank to ensure robust and statistically significant findings. For cost and time estimates, we assume a total of 6-8 coupons. If all coupons are allocated at the project start, we estimate that work can be completed within 6 months. Initial analysis by SEM and EDS typically requires 1-2 hrs/sample (depending on sample dimensions). Based on the initial analyses, a subset of coupons will be subjected to higher spatial resolution analysis and oxidation state analysis: Site-specific, electron-transparent coupons will be extracted using the FIB, a process that typically requires 4-6 hrs. These will be characterized by S/TEM-EDS and -EELS, typically 1-2 hrs/sample. The fee for SEM-FIB is $110 per hour and STEM-EDS and -EELS is $160/hr. Total project cost and duration will depend on total number of samples provided.

Figure 2: *S/TEM imaging and oxygen EELS spectrum demonstrating hydration.*



We expect our proposed investigation to provide significant insights into the underlying cause(s) and mechanisms of corrosion of the Red Hill tanks, key input for design of future tanks, and a potential way to determine if corrosion is historic or contemporary. Our team (Ishii, Bradley and Ohtaki) has extensive experience in characterization of weathering and corrosion phenomena in metals, alloys, ceramics (including concretes), and geological materials.

References: [1] T.N. Ackerson and J. Breetz (IMR test lab) "Destructive Analysis of 10 Steel Coupons Removed from Red Hill Fuel Storage Tank #14" Report No. 201801967 (2018). [2] K.K. Ohtaki, J.P. Bradley, H.A. Ishii "Combined focused ion beam-ultramicrotomy method for TEM specimen preparation of porous fine-grained materials." *Microsc. Microanal.* doi: 10.1017/ S1431927619015186 (2019). [3] G.B. Freeman, B.R. Livesay, J.P. Bradley et al. "Intermetallic embrittlement of thin unsupported tin/copper specimens", *J. Electronic Mat*. 23 (9), 1-7 (1994). [4] T.A. Abrajano, J.K. Bates, J.P. Bradley, "Analytical Electron Microscopy of Leached Nuclear Waste Glasses," *Ceramic Trans.* 9, 211-228 (1990). [5] C. Zevenbergen, J.P. Bradley et al., "Natural weathering of MSW bottom ash in a disposal environment." *Microbeam Analysis* 3, 125-135 (1994). [6] Graham G.A. et al. "Applied focused ion beam techniques for sample preparation of astromaterials for integrated nano-analysis." *Meteor. Planet. Sci.* 43, 561-569 (2008).

Red Hill Corrosion Monitoring for Mitigation:
Element, Phase, and Oxidation State Mapping

PI: Dr. Hope Ishii / Advanced Electron Microscopy Center, U. Hawai'i at Mānoa

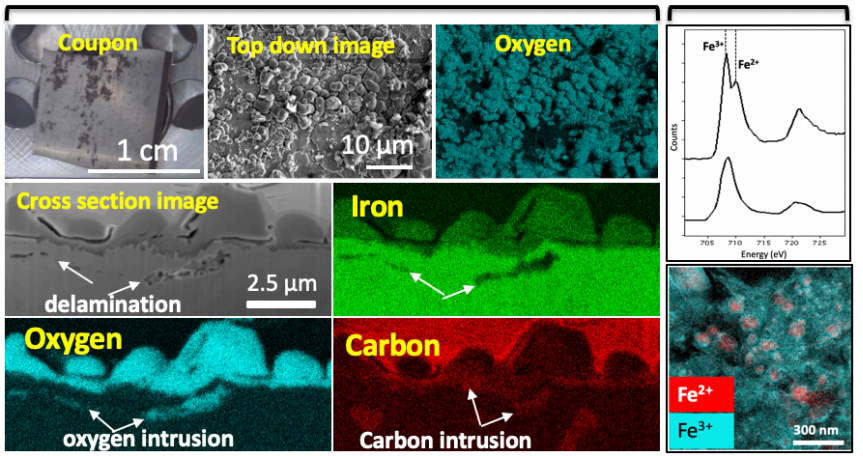
Objectives

1. Determine the micrometer-scale corrosion pathways and roles of indigenous and induced structural defects (surface delamination, intrusion at fractures, grain boundaries, or manufacturing defects, etc.).
2. Search for foreign corrosive species ("tracers"), check for concentration and/or oxidation state gradients, and seek their source(s) among local materials (concrete liner, gunite, local bedrock).
3. Assess the possibility of distinguishing between historic and contemporary corrosion episodes.

Electron imaging & element and oxidation state mapping

Morphology and element distributions

Fe ox. state



Approach

1. Cut steel coupons, polish in cross-section
2. Collect electron micrographs and elemental maps with full X-ray spectrum at each pixel, first on surface, then in cross-sections
3. Extract maps of "tracer" elements, e.g. Na, K, P, Cl, S
4. Analyze local materials, as appropriate
5. Perform S/TEM oxidation state maps
6. Compare chemical maps (elemental and oxidation state) across different locations
7. Compile imaging and map data to assess corrosion pathways, tracer elements, and episodic corrosion

Co-Is/Partners: Dr. Kenta Ohtaki and Dr. John Bradley

Key Milestones

	Estimated completion*
• Project start	t_0
• Sample preparation	t_0 + 2 weeks
• Imaging & Mapping of initial sample set	t_0 + 1.5 months
• Feedback on additional sample locations	t_0 + 1.5 months
• Imaging & Mapping of follow-up samples	t_0 + 3 months
• High resolution imaging, element mapping, and oxidation state mapping	t_0 + 4 months
• Report on "tracer" elements and episodic corrosion	t_0 + 6 months
• Report on corrosion pathways	t_0 + 6 months

* Assumes 6-8 samples

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ATTACHMENT M
Contract Statement of Work – POD for LFET

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CONTRACT STATEMENT OF WORK

Project Title: POD for LFET
Contract No: N62583-15-D-1702
Task Order: TBD
WON: 1626758
Contractor: TBD
ACQR: TBD

SOW HISTORY

Modification	Date	Description
Basic Award		Original Scope

Date: 07 Dec 2018
Submitted By: Frank Kern

Note: Contract was awarded March 2019.

GLOSSARY

AAI.....Aluminum Association, Inc.

ABIH .....American Board of Industrial Hygiene

ACI .....American Concrete Institute

ACM.....Asbestos-Containing Materials

AFFF .....Aqueous Film Forming Foam

AFHE.....Automated Fuel Handling Equipment

AISC.....American Institute of Steel Construction

AISI .....American Iron and Steel Institute

API.....American Petroleum Institute

ASCE.....American Society of Civil Engineers

ASM .....American Society for Metals

ASME.....American Society of Mechanical Engineers

ASNT.....American Society for Nondestructive Testing

AST .....Aboveground Storage Tank

ASTM.....American Society for Testing and Materials

ATG.....Automatic Tank Gauging

AWS .....American Welding Society

CAC.....Common Access Card

CAD.....Computer-Aided Design

CD .....Compact Disc

CONUS.....Continental United States

COR.....Contracting Officer's Representative

CFR .....Code of Federal Regulations

DESC.....Defense Energy Support Center (Now called DLA-Energy)

DFT .....Dry Film Thickness

DLA.....Defense Logistics Agency

DoD .....Department of Defense

DSTAN.....Defense Standards

DVD .....Digital Video Disc

FAR .....Federal Acquisition Regulation

FE .....Field-Erected

FISC .....Fleet and Industrial Supply Center (Now known as FLC)

FLC .....Fleet Logistics Center (Formerly FISC)

GFE .....Gas-Free Engineer

GFE .....Government Furnished Equipment

GTT.....Government Technical Team

ID .....Identification

IS .....In-Service

ISO .....International Organization for Standardization

JEGS .....Japanese Environmental Governing Standards

JIS .....Japanese Industrial Standards

JV .....Joint Venture

KO .....Contracting Officer

LBP .....Lead-Based Paint

MB .....Megabytes

MIL-STD .....Military Standards

MFL .....Magnetic Flux Leakage

MOV .....Motor-Operated Valve

MPC .....Materials Properties Council

NACE.....National Association of Corrosion Engineers

NAVFAC .....Naval Facilities

NAVFAC EXWC Naval Facilities Engineering and Expeditionary Warfare Center

NBBPVI.....National Board of Boiler and Pressure Vessel Inspectors

NDE .....Nondestructive Examination

NFPA .....National Fire Protection Agency

NTR.....Navy Technical Representative

OCONUS .....Outside the Continental United States

OOS.....Out-Of-Service

OSHA.....Occupational Health and Safety Administration

OUS.....Outside the United States

PAUT.....Phased Array Ultrasonic Testing
PEI.....Petroleum Equipment Institute
PIP .....Process Industry Practices
POC .....Point of Contact
POL .....Petroleum, Oil, and Lubricants
POV .....Privately Owned Vehicles
PPE .....Personal Protective Equipment
PQR .....Procedure Qualification Records
QA .....Quality Assurance
QC .....Quality Control
RFI.....Request for Information
RT.....Radiographic Testing
SF.....Shop-Fabricated
SSPC.....Steel Structures Painting Council
SOFA.....Status of Forces Agreement
SOW .....Statement of Work
STI..... Steel Tank Institute
SWUT ..... Shear-Wave Ultrasonic Testing
TO ..... Task Order
TR ..... Technical Representative
UFC..... Unified Facilities Criteria
UFGS ..... Unified Facilities Guide Specification
UL ..... Underwriters Laboratories
U.S. ..... United States
USACE..... US Army Corps of Engineers
UST ..... Underground Storage Tank
UT ..... Ultrasonic Testing
VBT..... Vacuum Box Testing
VT ..... Visual Testing
WPQ..... Welder Performance Qualification
WPS ..... Welding Procedure Specification
WRC ..... Welding Research Council

1 NEED

As a proxy for destructive testing, industry has developed various nondestructive examination (NDE) techniques to acquire fuel storage tank condition data. Industry has validated technologies to be reliable and standardized examination procedures through proprietary method. It is common to base important business decisions on the results of standard NDE procedures. Thus the reliability of NDE technologies is of utmost importance.

At some facilities, NDE technologies have been found to be unsuitable for use due to constraints such as geometry, material thickness, protective coating, and temporal inefficiencies. The Navy has previously deployed low frequency electromagnetic technique (LFET) as a means to overcome some of these constraints and acquire otherwise unobtainable tank condition data. LFET for use on storage tanks has been efficient but has never undergone reliability analysis.

1.1 Objective and Goal

This Statement of Work (SOW) defines requirements to design an analysis to determine the Probability of Detection (POD) for Low Frequency Electromagnetic Technique (LFET), participate in data acquisition, perform statistical analysis on the data, and report results.

2 BACKGROUND

2.1 Integrity Assessment

The integrity of the Navy's fuel storage infrastructure is of paramount importance to ensure mission readiness and avoid environmental consequences. Sustainment, Restoration and Maintenance (SRM) costs are heavy. The Navy is charged with integrity assessments of thousands of aboveground and below-ground fuel storage tanks. Due to an active SRM program, many of the storage tanks have remained in viable service for decades with single-wall construction and no secondary containment.

A crucial element in the integrity determination made regarding the suitability of a storage tank for continued service, is an examination of the tank hydraulic surfaces to acquire condition information. For an underground storage tank, the analog to examination of an aboveground tank bottom is examination of all surfaces of the tank. An examination can take place through coating and assessment is made on both top (product) side and back (soil) side surfaces for metal loss.

2.2 Government Technical Team

For this Task Order, technical and project manager roles have been designated which form the Government Technical Team (GTT).

3 OBJECTIVES

1. Design the capability demonstration, process variables, and conditions under which the LFET examination will be performed
2. Perform numerical simulations to refine essential variables and inform specimen fabrication
3. Produce a roster of representative examination conditions
4. Prepare methodology to conduct a matrix of examinations representative of process variables
5. Determine target discontinuity size, geometry, and spatial characteristics
6. Acquire meaningful data, optimize procedures, perform statistical analysis, and report results

4 REQUIREMENTS

The overall concept is to design and support the performance of a POD assessment for LFET and determine the largest target discontinuity the NDE system can miss. This requires establishment of the relationship between POD, target size, and other variables which define the capabilities of LFET. The

potential for false positives will be determined. Uncertainty in detection due to physical characteristics will be mitigated by using representative test specimens pre-populated with discontinuities of known geometry. Uncertainty in LFET process variables will be mitigated by performing an examination test matrix on all specimens.

The fabrication of test specimens and the performance of LFET as the source of assessment data will be accomplished by others in a second phase. Work to acquire and analyze data as part of execution of requirements in this SOW will take place both before and during the second phase.

Provide means and methods to execute this Statement of Work. Provide appropriate subcontractor support from qualified companies, consultant(s), and specialists to execute this SOW. Provide and distribute submittals in accordance with Table S.

4.1 POD Specialist

Provide a POD specialist who is also a registered mechanical engineer with verifiable expertise in MIL-HDBK-1823 to complete the tasks and achieve the objectives identified in this statement of work

4.2 Task 1 Examination Design

Review LFET operation and variables by meeting with an LFET manufacturer and observing the NDE process. Use this information to inform the target discontinuity data. Assume meeting with LFET contractor takes place in Pittsburgh PA over a two-day period.

Design a capability demonstration which will define process variables and conditions under which LFET examinations and data acquisition will be performed. Simulate test conditions with a statistical model to refine and optimize model.

4.2.1 Elements of the examination design are:

a. Identify LFET process variables which can influence detection

b. Specify representative inspection conditions in a manner adequate to conduct meaningful analysis

c. Produce a roster of representative examination conditions

d. Prepare methodology to conduct a matrix of examinations representative of process variables

e. Define a protocol for matrix revision in the event early data acquisition produces unexpected results.

f. Define target discontinuity size, geometry, and spatial characteristics

4.2.2 Process Variables

Generate a comprehensive list of essential variables which are expected to affect NDE performance. Provide an examination matrix representative of all process variables. Develop an algorithm to assess the sensitivity of variables and diminish the size of the matrix if no significant effect on POD is found. Typical essential variables are:

a. Representative test specimens

b. Examination equipment

c. NDE examiners

d. LFET sensors

e. Equipment calibration consistent with process procedures

f. Examination procedures

g. Environmental conditions

4.2.3 Numerical Simulation

Perform statistical simulation modeling of the examination design to refine essential variables, optimize a corrosion description algorithm, aggregate the influence of physical characteristics of corrosion, and inform specimen fabrication.

These simulations are to be performed periodically during the design of the testing matrix and protocol, to determine, among other things, if the proposed inspections will have sufficient resolution and confidence, given the number, and design, of specimens to be allocated. These statistical simulations will be summarized in a report, and discussed by the GTT. Simulations will also be updated periodically when new information becomes available.

4.3 Task 2 Representative Specimen Design

Provide a basis for test specimens populated with anomalies in geometry, volume, and spatial relationships representative of target discontinuities to include unflawed areas of specimens. Test specimens will be provided by others. Ensure basis addresses multiple specimen sets, training specimens, vertical configuration, geometry and spatial distribution, and requirements of the examination design. Provide in a manner suitable for fabrication by a machine shop.

4.4 Task 3 Data Acquisition

After test specimens have been delivered to the Navy laboratory, support data acquisition activities on test specimens. Expect there to be 3-6 months between finishing the specimen design and the data acquisition phase. Data acquisition will be provided by others. Oversee examinations on test plates in conditions suitable to assess LFET reliability. Ascertain a test range of values for each process variable deemed significant. Examine specimens across the range of values. Preliminarily evaluate process variables to determine those which have no effect on results. Randomize individual matrix elements of an examination to minimize uncontrolled effects. Consolidate examination matrix as needed to eliminate ineffectual variables. Finalize matrix and conduct required examinations. Acquire sufficient data to conduct meaningful analysis.

4.4.1 Matrix Revision

During early data acquisition, assess date to determine whether results are aligned with simulations and expectations. Should significant discrepancies arise, execute the revision to the test matrix to address the discrepancies and refine variables and procedures. Should unresolvable discrepancies be encountered report this finding to the COR.

4.5 Task 4 Data Analysis

Analyze data. Review statistical methods and assess the most relevant form. Produce quantitative descriptions of LFET system performance, POD(a) curves, false positive estimates, and statistics for comparing NDE systems based on the curves and statistics. Produce POD(a) curves with MH1823 POD software. Prepare a summary examination report containing preliminary data. Report results and findings.

4.6 Task 5 Final Report

Prepare a permanent record of data and an examination report. Evaluate LFET examination and report findings and conclusions in the report. Include description of the LFET system, the examination design, examination results, data, and data analysis.

4.7 General

4.7.1 Security Requirements

Security requirements apply to all subcontractors and suppliers associated with this contract. In addition to this SOW, ordinary or extraordinary security requirements, comply with the following:

1. Do not disclose information concerning any aspect of the materials, work, or services related to this contract without prior written approval of the Contracting Officer.
2. Do not disclose any aspect of the proprietary LFET procedures without prior written approval of the Contracting Officer.
3. Do not disclose or cause to be disseminated any information concerning operations of security.
4. Do not disclose any information to a person not entitled to receive it. Failure to safeguard information that may come to the contractor or any person under contractor control, may subject the contractor, agents or employees to criminal liability under 18 U.S.C., Sections 793 and 798.
5. Direct to the Contracting Officer or Installation Security Officer for resolution all inquiries, comments or complaints arising from any matter observed, experienced, or learned as a result of or in connection with the performance of this contract, the resolution of which may require the dissemination of official information.
6. Comply with photography requirements of NBVC Security.
7. Do not disclose or disseminate proprietary technology or information obtained as a result of this SOW.

Deviations from or violations of any of the provisions of this paragraph, will, in addition to all other criminal and civil remedies provided by law, subject the contractor to immediate termination for default and withdrawal of the GOV's acceptance and approval of employment of the individuals involved.

4.7.2 Proprietary Rights

All test notes, photographs, specimens, results, designs, comments, recommendations, specifications, and other documents collected and produced as part of this contract shall be considered property of the GOV. These data shall not be used, in whole or part, published or unpublished, as a part of any technical or non-technical presentation, or otherwise released by the contractor outside the GOV without prior written approval of the Contracting Officer.

4.7.1 Conduct

The contractor employee(s) shall conduct themselves in a proper, impartial, efficient, courteous and businesslike manner. Coordination and cooperation with other contractors is a key element to success, and is required. Contractor employees must remain objective in assessments of whether technical criteria have been met. The Contracting Officer may require the contractor remove from the work any individual the GOV reasonably determines is uncooperative, unqualified, fails to satisfactorily perform work, is careless, objectionable, or contrary to public interest, or acts inconsistent with the best interests of National Security.

4.7.2 No Waiver by the Government

The failure of the GOV in any one or more instances to insist upon strict performance to any of the terms of this contract or to exercise any option herein conferred shall not be construed as a waiver or relinquishment to any extent of the right to assert or rely upon such terms or options on any future occasion.

4.8 Schedule

Within two weeks of award provide a schedule which details performance of all work in this SOW. After Phase 1, expect a gap in time for fabrication and delivery of specimens before laboratory work can commence. COR will provide notification of intent to commence laboratory phase of work. Provide capability to mobilize within thirty calendar days of receipt of notice. Assume the gap between performance of Phase 1 and commencement of laboratory work to be 3-6 months.

4.9 Participation in Meetings and Phone Calls

Attend and participate in telephonic quality control and progress meetings.

4.10 Communication and Coordination

Coordinate planned work activities with the GTT. Report exceptions and deviations from this Statement of Work to the Contracting Officer. Only the Contracting Officer has the authority to authorize work or de-scope work elements of this Task Order.

4.11 Technical References

Work shall comply with Task Order requirements, all federal, state, and local regulations. In addition, requirements include the Task Order Specifications and the most recent editions of the following:

American Petroleum Institute (API)

a) API Standard 653
b) API 570

Department of Defense

a) MIL-HDBK 1823A

5 LABORATORY WORK RESTRICTIONS

5.1.1 Work Hours

Unless otherwise indicated, laboratory-phase work will be located on a GOV compound, military installation, or station. Work hours are normally eight hour days between 0700 and 1600 Monday through Friday. Obtain advance approval from the Contracting Officer for contractor personnel to remain on site beyond normal working hours. Notify the Contracting Officer at least 48-hours in advance to obtain approval for access to the jobsite or work outside of normal working hours or on Saturday, Sunday, and Federal Holidays.

5.2 Installation Access

Within thirty days after award, for workers requiring NBVC access, submit request(s) for access and badges in accordance with DBIDS for NBVC. Coordinate access with the COR.

5.3 General

5.4 Safety and Occupational Health Requirements

Comply with USACE EM 385-1-1. Provide the services of a qualified Site Safety and Health Officer. It is acceptable for the onsite engineer providing work to serve as SSHO.

5.4.1 Accident Notification and Reports

For recordable injuries and illnesses, and property damage accidents resulting in at least $2,000 in damages, contractor shall:

a. Provide initial notification via telephone or email as soon as possible from the time of mishap.

b. Provide initial contractor Incident Reporting System (CIRS) report within 4-hours of mishap.

c. Conduct an accident investigation to establish the root cause(s) of the mishap.

d. Provide final CIRS report within 5 calendar days of mishap.

e. COR will provide forms or electronic system access for CIRS report.

Notify the Contracting Officer as soon as practical, but not later than four hours, after any accident meeting the definition of Recordable Injuries or Illnesses or High Visibility Accidents, property damage equal to or greater than $2,000, or any weight handling equipment accident. Include contractor name; contract title; type of contract; name of activity, installation or location where accident occurred; date and time of accident; names of personnel injured; extent of property damage, if any; extent of injury, if known, and brief description of accident (e.g., type of equipment being used, PPE used). Preserve the conditions and evidence on accident site until the GOV investigation team arrives and GOV investigation is conducted.

6 MEETINGS AND REPORTING

6.1 Kickoff Meeting / Teleconference

Upon Task Order award, within three weeks host a telephonic Kickoff Meeting with the GTT to establish the responsibilities of parties, to discuss the schedule, and to ensure mutual understanding of the scope. Prepare the meeting agenda. After opening remarks by the COR, lead the discussion of specific project requirements. Generate and submit meeting minutes for COR review and approval. Use contractor format as long as all key points are covered. This meeting shall occur prior to contractor personnel starting work.

6.2 LFET Manufacturer Meeting

Review LFET operation and variables by attending a meeting with an LFET manufacturer and observing demonstrations of the NDE process as part of Task 1. Assume the meeting takes place in Pittsburgh PA over a two-day period.

6.3 Progress Meeting/Telcon

At various times, coordinate and host progress meetings with the GTT. The intent will be to discuss progress, quality, coordination, and mutual understanding. Meetings dates will be determined later. Assume they occur quarterly and will be telephonic. Should conditions arise which necessitate an increased frequency, the meetings could take place as often as weekly during mobilization. The COR will notify contractor when meetings are required. Prepare and submit brief minutes of the meetings per Table S.

6.4 Weekly Report

Generate and provide a progress report for each week on-site. The reports shall have attached a description of the work activities witnessed and/or performed. Distribute reports per Table S.

6.5 Out-Brief

Upon completion of all required tasks, conduct an out-brief with the GTT. The purpose of this meeting is to ensure that scope requirements have been successfully completed and to brief on significant findings.

7 PROPOSAL

7.1 Cost

Provide a detailed cost proposal in the format identified in the table below required to execute the work required in this SOW.

Cost Proposal

Administrative Submittals	
Task 1 Examination Design	
Task 2 Representative Specimen Design	
Task 3 Data Acquisition	
Task 4 Data Analysis	
Task 5 Final Report	

7.2 Technical

Provide proposal with succinct detail adequate to evaluate the principal means and methods.

7.3 Assumptions and Deviations

Proposal shall include a list of assumptions and deviations, if any, from the SOW and Task Order Specifications.

Except for cases in which contractor has specifically claimed in an original technical proposal a justifiable deviation or an exception to this SOW, whenever there is a conflict between this SOW and contractor's proposal, this SOW shall govern.

8 GOVERNMENT FURNISHED INFORMATION (GFI)

a) DBIDS

9 PLACE OF PERFORMANCE

Building 1100, Naval Base Ventura County, Port Hueneme, California.

10 PERIOD OF PERFORMANCE

The anticipated period of performance is estimated to be 28 Jan 2019 to 15 May 2020

The PoP is being extended to 30 Dec 2022. Project was placed on-hold due to COVID-19.

11 OPTION ITEMS

12 PRIMARY POINTS OF CONTACT

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END STATEMENT OF WORK

Table S Submittal List, Schedule, and Distribution

Submittal Description	Submittal Schedule			Distribution
	Initial	Govt. Review	Final	
Incident Reports	24 hrs after	-	-	EC
Project Schedule	2 WACA	1 week	-	EC
APP	3 WACA	2 weeks	1 WAGR	EC
Meeting Minutes	2 BD after	-	-	EC
Examination Design	2 WACO	1 week	1 WAGR	EC
Numerical Simulation Report	2 WACO	1 week	1 WAGR	EC
Specimen Design	1 WACO	1 week	1 WAGR	EC
Summary Report	1 WACO	1 week	1 WAGR	EC
Final Report	4 WACO	1 week	1 WAGR	EC
Weekly Lab Reports	[1]	-	-	EC

Legend / Notes:

WACA – Weeks after Contract Award

WACO – Weeks after Completion of Applicable Work

WAGR – Weeks after GOV Review

BD – Business Days

EC – Electronic Copy, subject to format / e-mail size requirements specified in the SOW

HC – Hard Copies, quantity four (4). Each hard copy shall include a CD/DVD insert including electronic copies of the report. contractor shall provide another eight (8) electronic copies of the report on CD/DVD

[1] – Weekly reports shall be e-mailed by 1000 local time of the first following business day

END OF DOCUMENT