Components of Interest

- Metals
  - RPV materials
  - High fluence regions of baffle plate and baffle bolts
  - Highest fluence core barrel SS welds
  - Highest temperature cast austenitic stainless steel (CASS), particularly CF8M
    - Pressurizer surge line likely highest temperature
  - Moderate fluence (1-2 dpa) internals components made of CASS
  - Dissimilar metal welds or RPV penetrations that have been peened or have known flaws
  - Primary system locations with limiting fatigue life
- Concrete
  - Inner portion (highest fluence) of biological shield wall and RPV support system
  - Post-tensioning system and structures
  - Structural sections experiencing signs of Alkali-Silica-Reaction (ASR)
- Electrical – interested in any available components in the following areas:
  - Low and medium (LV & MV) voltage power cables
  - Cables protected with fire retardant coating
  - 1E MOVs and AOVs from harsh and mild environments
  - Medium voltage (such as 4160 V) 1E breakers
  - 1E Molded case breakers (480 V, 250 VDC, 125 VDC)
  - 1E Relays from mild environment GE – HFA, Agastat timing relays, any from Westinghouse, Potter Brumfield, Struthers Dunn, Schweitzer, Brown Boveri, etc.
  - Reactor Trip Breakers
  - Electrical penetrations (Westinghouse/Conax) Obrian
  - Electrical enclosures (fire research): Distribution: switchgear, MCCs, LCs | Control Room Horseshoe, SSCP, ASP, etc .

Generic Information for any Potential Component

1. Service conditions:
   a. time in service (e.g., EFPY or duty cycles for electrical components),
   b. temperature,
   c. fluence (if irradiated),
   d. relative humidity (if applicable)
   e. plant location (harsh or mild environment for electrical components)
   f. operating experience or known degradation?
2. Material information:
   a. Metallic:
      i. grade/alloy, heat, CMTR or composition info available?
      ii. Welding process, weld documentation available?
   b. Concrete:
      i. type of aggregate,
      ii. type of cement,
      iii. water cement ratio
      iv. moisture content

        v. concrete composition
    c. Electrical:
        i. Functional Description
        ii. Purchase Specification, Vendor manuals, drawings etc.,

Component / Need-Specific Questions

1. RPV
    a. High fluence & high shift vessel with well-established unirradiated properties; **Purpose**: a through thickness section to validate fluence & attenuation models
        i. No additional questions / information
    b. Samples from virtually any vessel; **Purpose**: to provide data supporting evolution from the use of correlative (Charpy-based) to direct measurement (FT-based) approaches
        i. No additional questions / information
2. Non-RPV Metals
    a. High fluence reactor internals; **Purpose**: to provide data on void swelling in-service
        i. Temperature and fluence 3-D distribution available?
    b. Higher fluence SS welds (>2 dpa); **Purpose**: to study FT, IASCC, and microstructure
        i. No additional questions / information
    c. Thermally aged unirradiated CASS; **Purpose**: to study FT and microstructure and compare to accelerated aging data
        i. No additional questions / information
    d. Moderate fluence (1-2 dpa) CASS; **Purpose**: to study FT and microstructure and confirm data near limit requiring further evaluation
        i. No additional questions / information
    e. Metallic components that have been peened; **Purpose**: Determine whether SCC mitigation methods are effective at preventing SCC and maintaining mitigation over service time
        i. What area was peened? If there's a weld, was it ground before peening?
        ii. Was there a stress measurement of the surface performed before and after peening prior to service?
        iii. (JNRA-specific) Will there be a stress measurement performed on the peened surface after service? What testing will be done?
    f. Metallic components with known flaws; **Purpose**: to determine whether SCC mitigation methods and NDE detection and sizing are effective
        i. Are there any components with known degradation or flaws, particularly DMWs / pressure boundary?
    g. Metallic components with limiting fatigue life; **Purpose**: to determine whether fatigue flaws are present in high usage locations
        i. What are the highest usage locations for fatigue?
3. Concrete
    a. Structures exposed to high radiation; **Purpose**: to study degradation of concrete due to irradiation, attenuation of radiation through concrete
        i. Engineering Drawings
        ii. Structural calculation for RPV support and bio-shield structure design

iii. Presence of liner and its anchorage
iv. How are the RPV supports embedded and anchored to the concrete structure?
v. Is there an additional structural steel support system for RPV?
vi. Are there ex-vessel neutron detectors and can their data be used to inform fluence on the biological shield wall?
vii. Is there a neutron shield tank?

b. Post-tensioned structures; **Purpose**: to study degradation of post-tensioning (PT) system
    i. Material specification for tendons and anchorages
    ii. Operating experience and inspection reports including corrective actions

c. Structural sections experiencing signs of Alkali-Silica-Reaction (ASR); **Purpose**: to study degradation of concrete from Alkali-Silica-Reaction (ASR)
    i. What signs, where, when detected, and related available documents

4. Electrical
    a. Low and medium (LV & MV) voltage power cables; **Purpose**: to assess behavior of insulation with aging in radiation/high temp environments and methods of condition assessment and to identify vulnerabilities not detected by routine maintenance
        i. What are the actual service loads (e.g., CRD pump power, Containment fan power, etc.)?
    b. Cables protected with fire retardant coating; **Purpose**: to assess aging effects on coatings in terms of their ongoing ability to perform their fire protection function and effects of coatings on cable ampacities during extended operation
        i. No additional questions / information
    c. 1E MOVs and AOVs from harsh and mild environments; **Purpose**: to assess behavior of MOV components with aging in radiation/high temp environments and methods of condition assessment
        i. What are the actual service loads (e.g., CRD pump power, Containment fan power, etc.)?
    d. MV (such as 4160) 1E breakers, 1E Molded case breakers (480V, 250V DC, 125 VDC), and 1E Relays from mild environment GE – HFA, Agastat timing relays, any from Westinghouse, Potter Brumfield, Stuthers Dunn etc.; **Purpose**: To assess operation beyond manufacturers recommended design life based on maintenance rule based maintenance methods and to identify vulnerabilities not detected by routine maintenance
        i. What are the actual service loads (e.g., CRD pump power, Containment fan power, etc.)?
    e. Reactor trip breaker; **Purpose**: To assess operation beyond manufacturers recommended design life based on maintenance rule based maintenance methods and to identify vulnerabilities not detected by routine maintenance
        i. What are the actual service loads (e.g., CRD pump power, Containment fan power, etc.)?
    f. Electrical penetrations; **Purpose**: To assess operation beyond manufacturers recommended design life based on maintenance rule based maintenance methods and to identify vulnerabilities not detected by routine maintenance
        i. No additional questions / information

g. Electrical enclosures (fire research): Distribution: switchgear, MCCs, LCs | Control: Horseshoe, SSCP, ASP, etc.; **<u>Purpose</u>**: Fire testing, both bench scale and full scale, of electrical enclosures and their internal components to enhance realism in fire PRA by supporting a better understanding of fire ignition and growth within electrical enclosures
    i. No additional questions / information

From:	Sircar, Madhumita
To:	Albert Bates; Vincent J Barone; Robert Yale; "Gerard P. Van Noordennen"; Michael Russell; Giles, Stuart A; Fraser, Robert G.; Steven Mannon; Seber, Dogan; Pires, Jose; Tom Rosseel (rosseeltm@ornl.gov); Le Pape, Yann; Wall, James; Johnson, Samuel; Villalobos, Salvador; Snyder, Amy; Risner, Joel M.; Alpan, F. Arzu; Colin D. Judge
Cc:	Anderson, Stephanie; Steve F. Enright; Robert M. Quinn; Robert Corbett; Arthur L. Hammond; Tajuelo Rodriguez, Elena; Tregoning, Robert
Subject:	Harvesting Irradiated Concrete from Unit 2 and 3 of Bioshield
Date:	Thursday, April 01, 2021 10:58:37 AM
Attachments:	Scope of Work-Draft_SONGS Harvesting_01April2021.docx

Please find attached the scope of work document with some edits. Please feel free to add/edit and share before the next meeting. Our next meeting is on April 7th, 3-4:30pm EST.

Thanks,

Mita Sircar

Tel: 301-415-1804

Scope of Work for SCE

Task 1: Gather documents, calculations, data, and drawings for harvesting and research

a) Concrete composition, mix design, type of aggregates (quarry), cement type, and concrete properties (including, if available: compressive strength, Young's modulus, petrographic data of the aggregates)

b) Data, if any, on the exposure conditions (temperature, relative humidity, gamma and neutron) in the reactor cavity, primary reactor shield wall, inside the containment building and adjacent buildings. This information will help the coring location plan to separate varied exposure effects.

- The latest reactor pressure vessel (RPV) fluence calculations for SONGS Units 2 and 3 performed for surveillance capsule analyses indicate that SONGS Unit 2 would have higher neutron fluence compared to Unit 3 at 32 effective full-power years (EFPY) on the RPV. Therefore, SONGS Unit 2 is chosen as the plant to estimate the neutron fluence on the concrete primary reactor shield wall. It is estimated that SONGS Unit 2 was at ~23 EFPY at plant shutdown. Assuming that the assumptions used for fluence projections beyond end-of-cycle (EOC) 10 (13.3 EFPY) from the last surveillance capsule analysis of SONGS Unit 2 remains valid and the methods used in Sections 3.2 and 3.3 of Esselman, T. and P. Bruck, 2018, *Expected Condition of Concrete Exposed to Radiation at Age 80 Years of Reactor Operation*, ORNL/TM-2018/769, Oak Ridge National Laboratory are applicable, a maximum neutron fluence (E > 0.1 MeV) on the concrete primary reactor shield wall at ~23 EFPY is estimated to be 1.7E+19 n/cm^2.

c) Drawings of the Reactor and Concrete Primary Reactor Shield Wall, Reactor Supports, important penetrations through primary reactor shield wall.

d) Reactor operational history and operational data.

~~d)~~e) Purchasing and fabrication information pertaining to the reactor supports. The following information has significant value: original purchasing documents and associated specifications, including CMTR (Certified Material Test Report) for each heat of material used to manufacture columns, relevant fabrication specifications/documentation, documentation of welding, if applicable (including weld travelers), information of relevant repairs performed (e.g., locations, applicable standards and materials), and any associated quality assurance documents.

~~e)~~f) How many surveillance coupons were there? The data of the surveillance coupons that were tested earlier.

- Based on publicly available documents, six surveillance capsules have been installed at SONGS Unit 2 as well as SONGS Unit 3 prior to plant operation. Two surveillance capsules at each of these units have been removed prior to plant shutdown. Therefore, SONGS Units 2 and 3 should have had four surveillance capsules each at reactor shutdown.

~~f)~~g) Reactor fuel rearrangement, frequency of reactor fuel outages, type of fuel, power uprates

~~g)~~h) Reactor geometrical dimensions, cycle-by-cycle core design data (pin power distributions, temperatures, core thermal power (MWt), effective full-power years of operation), and monthly thermal generation (MWt-h) is requested. Any issues of obtaining this data are to be discussed.

~~h)~~i) In-vessel surveillance dosimetry data for fluence validation

- In order to evaluate the importance of harvesting the surveillance capsules, the following information is requested:
  - Has there been any major changes in the reactor core design since EOC 10 for SONGS Unit 2 (e.g., as part of a fluence reduction program)?
  - Have there been any modifications to the reactor pressure vessel internals since EOC 10?
  - Can the cycle-by-cycle assembly beginning-of-cycle and EOC burnups be provided for an assessment (Cycles 1 through 16)?

SONGS Unit 2 surveillance capsule report of Capsule 263-degree is in NRC ADAMS. Updated pages of the SONGS Unit 2 surveillance capsule report of Capsule 97-degree is also in NRC ADAMS. Can the Capsule 97-degree report be provided? Can dosimetry measurement data not available in these reports be provided?

~~i)~~j) Radiation transport calculations/simulations

NRC, ORNL, and EPRI to prepare the list of documents.

Scope of Work for SDS

Task 1: Documents and drawings for harvesting

a) In-vessel surveillance coupons/capsules/dosimeters
   - Subject to joint effort with metal group and interagency collaboration.
   - Collect information about dimension of the capsule, availability of the container with SDS, temporary onsite storage, shipping to BWXT or similar facility

   Timeline: Fuel Transfer Canal flooding in May 2021, harvesting 3Q/4Q 2021, SDS can store for short period

b) Radiation and activation data for concrete and steel columns

Task 2: Unirradiated concrete with composition similar to the primary reactor shield wall
Harvesting 3 plain concrete cores (no rebar) from the primary shield. Dimension: diameter 2 inches, length 6 inches. (Location: The exact location of harvesting to be discussed with SCE)

- Providing documentation on the location of the cores and coring process.
- Surveying the specimens according to NRC license. Reporting the isotopes and activities. This information will be reviewed by ORNL's Radiation Control Staff prior to accepting the specimens.
- Packaging the specimens
- Shipping the bubble-wrapped specimens to Oak Ridge National Laboratory (Oak Ridge, TN)
- Completion date: As soon as possible after January 2021.

Urgent to determine suitability of the material for research (Decision point). Verify that the aggregate, minerals and concrete are susceptible to radiation damage.

Task 3: Site visit, meeting and walkdown to the relevant area of harvesting
Technical meeting to gain insights from plant owner and the decommissioning organization.

To review drawings, on site meeting with staff from decommissioning group and plant owner, and walk down (take notes, pictures) to finalize the harvesting locations and NDE plan.

One and half days meeting

Visitors: NRC (2-3), ORNL (3), EPRI (2-3)
Decommissioning Group: # staff person and hours
Plant owner: # staff persons and hours

Site visit depends on COVID travel restrictions and unirradiated specimen characterization.
Get unirradiated core, perform EPRI NDE, prepare slices, run MXRF for silica content.
Two site visits – one pre-harvesting and one at the time of harvesting.
How much advance notice to SDS is needed for site meeting. Visitors may include foreign national ORNL employee.

~~**Task 4: Harvesting liner and stud if exist, packaging and shipping to ORNL**~~

~~Use liner plate as retrospective dosimetry. Study the interface of steel and concrete~~

~~Characterize concrete immediately adjacent to liner. Record degree of cracking, fragmentation, aggregate swelling for assessment of radiation effects, if possible.~~

~~Interested in niobium because 93Nb(n,n')93mNb has a long product half-life of 16.13 years. May be measured by portable XRF. Is it capable to measure 50ppm? It is possible to measure this with the right gun. Testing a coupon may be an alternative.~~
Note: Liner doesn't exist

Task 5: NDE, Cavity visual examination, and other testing in-situ
Provide access, temporary platform or scaffolding, ladder, lighting to perform NDE, visual examination and other testing.
EPRI/Sal please add more specificity

Access for Visual examination
- Evaluate liner issues
- Lighting

Access for NDE in areas near harvesting locations
- Three or four elevations
- Scaffolding and access to various elevation inside the primary reactor shield wall

This task may require about one week.

Visual Examination on-site and Endoscopy
NDE: EPRI to add details
Other in-situ testings include in-situ stresses, residual strength, instrument inside the bore hole and measure the changes. Cross-bore hole tomography

Task 6: Harvesting details – Location, length, numbers, diameter
Getting core from outside (Later)

Locations:
a) Beltline – 2in*, 3in, and 4in dia at beltline, 3 cores for each dia (9 cores total)
b) High temperature and high irradiation region near hot leg at ID of primary reactor shield wall – 3in and 4in dia 3 cores each (6 cores total)
c) High temperature, near hot leg – OD of primary reactor shield wall – 3in or 4in dia, 3 cores for each dia (6 cores total)
d) Unirradiated (bottom of the of primary reactor shield wall) – 3in or 4in dia, 3 cores for each dia (6 cores total)

Length: 2-3 ft (coring from inside face of the primary reactor shield wall)
* 2 in dia is comparable with the CVR/NRAJ experiments.

May require scaffoldings and other temporary access requirement (same as Task 5)

Task 7: Packaging, storing, shipping
Packaging for irradiated cores:
- 3 cores, 2in dia, 2-3 feet long
- 9 cores, 3-4in dia, 2-3 feet long
- 9 cores, 3-4in dia, 2-3 feet long

Packaging for unirradiated cores:
- 6 cores, 3-4in dia, 2-3 feet long

- Temporary storing by the contractor and then shipping to Oak Ridge, TN

Should there be a subcontractor by SDS or by this joint research team? (Later)

Task 8

RPV support steel columns - Fluence level, material composition, and fabrication

Columns will be removed after removing the RPV. Harvesting and NDE of the steel supports will be available in 2023 and 2024.

Notes:

- Blue texts are for additional information not for contract.
- Separate meeting is to be scheduled for contract development including the contract folks tentatively in Q1 of 2021, POC: Albert and Steve.
- It is confirmed that 2in, 3in, and 4in cores can be extracted. Steve to confirm how deep the coring can go for 4in dia.
- Possibility for harvesting concrete block tentatively 2ftx2ft or 1ftx1ft. Steve and Stu said cutting block would be difficult.

Consideration and Prioritization of Ex-Plant Materials Harvesting for Materials Degradation Research

Introduction

Recent plans to shut down several nuclear power plants (NPPs) provide opportunities for harvesting components that were exposed to actual light water reactor (LWR) environments. Technical issues associated with extended plant operation, such as reactor pressure vessel (RPV) embrittlement, irradiation-assisted degradation (IAD) of reactor internals and primary components, concrete structures and containment degradation, and electrical cable aging, may be used to focus harvesting efforts on high-priority issues. Harvesting can provide highly representative aged materials for research and, in some cases, may be the only practical source of representative aged materials to address certain specific issues. The data and information grained from harvested material can inform aging management approaches to ensure they are appropriate and adequate to ensure safe operation. Harvesting can be expensive and time-consuming, which makes it essential to focus on those technical needs with the highest importance and cooperate with multiple organizations whenever possible to optimally leverage resources.

The purpose of this report is to explain the use of a series of tables developed by the Office of Nuclear Regulatory Research to inform a systematic approach to harvesting planning and decision-making. Given the significant benefits and costs of undertaking harvesting, careful consideration of where and how to expend limited NRC resources is prudent and appropriate to ensure value to NRC's regulatory programs and consistent with the NRC's Principles of Good Regulation. This work supports Task 2 of NRR-2017-006, "Research Assistance on Potential Significant Technical Issues During the Subsequent Period of Extended Operation."

Harvesting Prioritization Tables

Before undertaking a harvesting program it is necessary and prudent to identify what technical issues or questions would be answered by the harvested materials. Therefore, the harvesting prioritization tables help to define and prioritize the NRC's interests for harvesting in the four primary SLR issue areas: RPV embrittlement, IAD of reactor internals and primary system components, concrete structures, and electrical cables and components. For each area, relevant and knowledgeable staff in RES identified components of interest for harvesting, as well as what testing would be performed and what technical knowledge would be gained that is currently lacking. These three columns ("Interest Description," "Planned Testing," and "Technical Knowledge Gained") are defined as the "Basic Information" section of the harvesting prioritization table.

The next section of the tables defines technical criteria to assist in prioritizing the harvesting interests defined in the "Basic Information" section. There are four technical criteria that should be considered, each of which has a rating score. The rating scores from each of these technical criteria are averaged to define a technical score. These criteria along with scoring guidance are described in Table 1 below. The general scoring system used for each technical criteria is high (H), medium-high (MH), medium (M), medium-low (ML), and low (L). In addition to the four technical criteria, an additional consideration of cost and complexity is ranked, which is based on the level of irradiation of the component to be harvested. The technical score and the cost consideration should be used together in order to prioritize harvesting needs and to make an informed decision on which interests to pursue first.

The harvesting prioritization tables are designed to provide the relevant information in one place to make informed harvesting decisions based on the technical value and costs associated with harvesting a particular component within one of the primary SLR issue areas. These decisions will be more fully-informed by plant-specific details of the components, cost and timeline at a particular plant.

Table 1 Criteria for Harvesting Prioritization

Criteria Title	Description	Scoring Guidance
Criticalness of Technical Issue Addressed	Harvesting to address issues of higher safety significance and less data available should be prioritized over issues with lower safety significance and more data available.	H = High safety significance and/or very limited available data MH = Medium-high safety significance and/or limited data available M = Moderate safety significance and/or some data available ML = low to moderate safety significance and/or medium to large amount of data available L = Low safety significance and/or large amount of data available
Importance of Harvested Materials over Laboratory Aging	Key considerations are the ease of laboratory replication of aging mechanism and unique field aspects of the aging mechanism. Degradation mechanisms that are harder to replicate with simulated aging conditions would be of higher priority for harvesting. For example, simultaneous thermal and irradiation conditions are difficult to replicate outside of the plant environment. Alternatively, accelerated aging may not be feasible for a mechanism sensitive to dose rate. These two degradation mechanisms may be best evaluated using harvested materials. For unique field aspects, legacy materials (e.g., fabrication methods, composition) that are no longer available, but may play an important role in a potential degradation mechanism, would have a higher priority than harvesting materials that can be obtained from other sources with representative properties.	H = Nearly impossible to replicate service environment / critically important to use harvested materials MH = Challenging to replicate service environment / important to use harvested materials M = Possible with some limitations to replicate service environment / moderately important to use harvested materials ML = Not challenging to replicate service environment / less important to use harvested materials L = Very easy to replicate service environment / not important to use harvested materials
Applicability to US Operating Fleet	There is greater value in developing knowledge to address an issue that may be applicable to a larger number of plants compared to one that may only affect a relatively small number of plants.	H = All plants MH = All PWRs M = All BWRs or most PWRs ML = ~10-15 plants L = <5 plants
Regulatory Considerations Related to Inspections and AMPs	The less confidence that NRC staff has in the effectiveness of the relevant AMP, the higher priority for harvesting. A key consideration for AMPs are the availability of inspection methods. If mature inspection methods exist and are easy to apply to monitor degradation, harvesting may be less valuable. If inspection methods do not exist, harvesting may be more valuable to increase confidence in the assessment of age-related degradation in that particular component.	H = Lower confidence in AMPs or very limited inspection methods available MH = Low-to-moderate confidence in AMPs or limited inspection methods available M = Moderate confidence in AMPs or some inspection methods available ML = Medium-high confidence in AMPs or good inspection methods available L = High confidence in AMPs or effective, well-accepted inspection methods exist
Harvesting cost and complexity	Activities with higher costs and complexity are less attractive than similar activities with lower costs and that are simpler to execute. For example, harvesting unirradiated concrete or electrical cables is less expensive and less complex than harvesting from the RPV internals or the RPV.	H = Highly irradiated (>5 dpa) MH = Lightly irradiated / contaminated M = Minimal contamination or high effort unirradiated ML = Unirradiated, moderate effort expected L = Unirradiated, low effort expected

Harvesting Opportunities Tables

Once harvesting priorities are identified and ranked, the other side of the harvesting equation is to determine what opportunities are available and worth pursuing. Therefore, a second set of tables have been developed to identify the available and potential upcoming harvesting opportunities. While many plants are shutting down and decommissioning in the U.S., even more plants are shutting in various other countries, including Japan, Sweden, Korea, and Switzerland. Therefore, both domestic and international harvesting opportunities are captured in these tables.

The tables all gather similar information on harvesting opportunities to provide an understanding of what opportunities are available at different plants around the world. The first few columns identify basic information about the plant, including its country, name, design, size (in MWe), core inlet/outlet temperature, and number of years in operation. The next few columns focus more on harvesting considerations, including the planned or actual plant shutdown date, what the harvesting or decommissioning plan / timeline is and what organizations are involved in or interested in harvesting.

The remaining columns provide a more detailed set of information to identify whether the potential components available from a specific plant are worth pursuing. The goal is to capture enough information in terms of materials and their aging conditions to differentiate among plants for what plants would be preferred to perform harvesting for particular components. In general, the type of information that should be gathered from any particular plant is similar, although there will certainly be some variability based on unique plant-specific history and readily available information.

First, there is a column to identify what components have been previously discussed for harvesting from this plant (if any). The remaining columns identify specific components for which information is desired and were developed in coordination and discussion with EPRI staff:

- Reactor Pressure Vessel (RPV) Beltline,
- PWR RPV Head Penetrations / BWR Instrumentation Penetrations,
- Baffle Plate,
- Internals Bolts,
- Core Shroud / Barrel Welds,
- Lower Support Column (if made of CASS),
- Steam Generator (SG) Tubes / Plugs,
- Reactor Coolant System (RCS) Piping,
- RCS Piping Welds,
- RCS Piping Elbows,
- Pressurizer (PZR) Surge Line.

For each component, there are sub-columns for material, environment, and operating experience. Ideally the material sub-column should identify the metal alloy and fabrication method, while the environment category should provide information regarding time in service, fluence, temperature, and water chemistry.

There are two tables within the set of harvesting opportunities tables. The first table focuses on identifying key information from recent/active harvesting efforts. This table includes harvesting programs that are recently complete (within the last 5 years) or currently underway. The second table captures planned and potential harvesting efforts, which includes those that are under active discussion between research organizations and the utility or responsible decommissioning company or plants that have shutdown or plan to shutdown, but do not have particular harvesting efforts planned at this time.

The harvesting opportunities tables are intended to provide information on the landscape of harvesting opportunities around the world, as well as cooperation partners for each. These tables should help NRC make informed harvesting decisions to ensure that important data can be gained from harvested materials based on the optimal opportunities for NRC participation, without unnecessary duplication of efforts.

Previously Harvested Materials Tables

In addition to identifying harvesting opportunities, NRC staff was also aware of previously harvested materials that are currently available at various contractor lab facilities. These materials were regarded as low-hanging fruit for harvesting if they may help address any harvesting interests without requiring a new harvesting effort. Identifying the test specimens and materials from previous harvesting efforts is also a good practice for knowledge management and potentially valuable in the future if there may be further use for these materials.

The tables ultimately captured previously harvested materials from three NRC contractor facilities, Argonne National Laboratory (ANL), Battelle-Columbus, and Pacific Northwest National Lab (PNNL). ANL's materials are primarily small irradiated specimens, while Battelle-Columbus has large primary system piping and elbow sections and PNNL has a large inventory ranging from smaller test specimens to very large pipe sections that have been used primarily for NDE research over the years.

The columns in the table identify basic information to assess the value of the materials for research purposes. The goal was to provide enough information to understand what is available, but not too much information to be overwhelming. The first few columns identify which lab has the specimen or component, whether it is irradiated (and the fluence if so), and the number of identical or similar samples. The next few columns provide information on the geometry and dimensions as well as the material (alloy or grade) and weld (if applicable). The final few columns identify if the specimens has flaws (primarily for NDE research) as well as what publications report the data from past research on these materials.

Informed Harvesting Decisions

The purpose of the various tables discussed in this report is to enable efficient and informed decision-making for what and where to harvest components from decommissioning plants. Each of these documents should be updated periodically at least once a year based on the latest knowledge and information to ensure the identification and prioritization of harvesting interests and the understanding of the opportunities for harvesting are current and up-to-date. These updates to NRC's harvesting priorities and opportunities will then be reflected in the information gathering for specific harvesting opportunities.

For example, if a harvesting project is implemented to address a certain harvesting priority, that priority may be lowered or removed from the list of harvesting priorities, which would then change the columns in the harvesting opportunities table for the potential components for harvesting. On the other hand, if operating experience or other research indicated a new degradation mechanism of concern, then an additional harvesting priority may be identified and prioritized based on the available information, which would then add potential component(s) for harvesting.

On a practical level, most, if not all, harvesting efforts will be done in cooperation with other research organizations, such as the Department of Energy (DOE), the Electric Power Research Institute (EPRI), and international parties. Having clearly identified NRC priorities and information requests for harvesting will enable efficient and effective interaction with research partners to advance NRC interests within a cooperative research program and ensure the outcome will address NRC's questions. It is also important to recognize that cooperative programs may significantly improve the value for NRC to perform harvesting and the ultimate decision to participate in a particular harvesting program should be made based on the costs and benefits of that specific project (accounting for leveraging with other parties).

Summary and Conclusion

The purpose of this report is to explain the use of a series of tables developed by the Office of Nuclear Regulatory Research to inform a systematic approach to harvesting planning and decision-making. Given the significant benefits and costs of undertaking harvesting, careful consideration of where and how to expend limited NRC resources is prudent and appropriate to ensure value to NRC's regulatory programs. The purpose of the various tables discussed in this report is to enable efficient and informed decision-making for what and where to harvest components from decommissioning plants. Effective maintenance and use of these tools should enable NRC to be prepared to effectively benefit from the array of harvesting opportunities currently being considered and additional opportunities that may develop.

From:	Sircar, Madhumita
To:	"Albert Bates"; "Jerry L Stephenson"; Mannon, Steven; Rory.Kennedy@inl.gov; Peng.Xu@inl.gov; Kelly A. Cunningham; Tom Rosseel (rosseeltm@ornl.gov); Le Pape, Yann; Alpan, F. Arzu; Wall, James; "Johnson, Samuel"; "Villalobos, Salvador"; Pires, Jose; Tregoning, Robert; Hiser, Matthew
Subject:	Information from SCE and SDS
Date:	Monday, June 14, 2021 3:51:15 PM
Attachments:	Scope of Work-Draft SONGS Harvesting 12May2021.docx

I would appreciate if you can let me know your availability for our next meeting.
Suggested dates and time:

6/21st 2-3pm (ET)

6/22nd 2-3pm (ET)

6/24th 2-3pm (ET)

The urgent items from the attached document are:
SCE items (d) through (j)
SDS Task 1

Please forward as needed.

Thanks,
Mita Sircar
Tel: 301-415-1804

Scope of Work for SCE

(Updated per meeting on 04/07/2021)

Task 1: Gather documents, calculations, data, and drawings for harvesting and research

a) Concrete composition, mix design, type of aggregates (quarry), cement type, and concrete properties (including, if available: compressive strength, Young's modulus, petrographic data of the aggregates) – The post construction concrete specifications provided by SCE are most likely based on the original specifications. SCE will continue to search their database. Question: Do we need to continue with this Task 1?

b) Data, if any, on the exposure conditions (temperature, relative humidity, gamma and neutron) in the reactor cavity, primary reactor shield wall, inside the containment building and adjacent buildings. This information will help the coring location plan to separate varied exposure effects. SCE will provide later.
The latest reactor pressure vessel (RPV) fluence calculations for SONGS Units 2 and 3 performed for surveillance capsule analyses indicate that SONGS Unit 2 would have higher neutron fluence compared to Unit 3 at 32 effective full-power years (EFPY) on the RPV. Therefore, SONGS Unit 2 is chosen as the plant to estimate the neutron fluence on the concrete primary reactor shield wall. It is estimated that SONGS Unit 2 was at ~23 EFPY at plant shutdown. Assuming that the assumptions used for fluence projections beyond end-of-cycle (EOC) 10 (13.3 EFPY) from the last surveillance capsule analysis of SONGS Unit 2 remains valid and the methods used in Sections 3.2 and 3.3 of Esselman, T. and P. Bruck, 2018, Expected Condition of Concrete Exposed to Radiation at Age 80 Years of Reactor Operation, ORNL/TM-2018/769, Oak Ridge National Laboratory are applicable, a maximum neutron fluence (E > 0.1 MeV) on the concrete primary reactor shield wall at ~23 EFPY is estimated to be 1.7E+19 n/cm2.

c) Drawings of the Reactor and Concrete Primary Reactor Shield Wall, Reactor Supports, important penetrations through primary reactor shield wall.
SCE sent drawings, NRC-ORNL-EPRI to review and specify what additional drawings are needed (if any). SCE (Vincent's emails) provided more drawing on 05-11-2021, uploaded to the Box.

d) Reactor operational history and operational data.

e) Purchasing and fabrication information pertaining to the reactor supports. The following information has significant value: original purchasing documents and associated specifications, including CMTR (Certified Material Test Report) for each heat of material used to manufacture columns, relevant fabrication specifications/documentation, documentation of welding, if applicable (including weld travelers), information of relevant repairs performed (e.g., locations, applicable standards and materials), and any associated quality assurance documents. [Added per Rob Tregoning]
SCE will look for the information on the reactor support columns.

f) How many surveillance coupons were there? The data of the surveillance coupons that were tested earlier.
Answer: Based on publicly available documents, six surveillance capsules have been installed at SONGS Unit 2 as well as SONGS Unit 3 prior to plant operation. Two surveillance capsules at each of these units have been removed prior to plant shutdown.

Therefore, SONGS Units 2 and 3 should have had four surveillance capsules each at reactor shutdown.

g) Reactor fuel rearrangement, frequency of reactor fuel outages, type of fuel, power uprates (1.4% power uprate approval (Arzu) – it may be associated with LP rotor replacement and steam generator replacement. SCE will look into it)
h) Reactor geometrical dimensions, cycle-by-cycle core design data (pin power distributions, temperatures, core thermal power (MWt), effective full-power years of operation), and monthly thermal generation (MWt-h) is requested. Any issues of obtaining this data are to be discussed.
i) In-vessel surveillance dosimetry data for fluence validation
    - In order to evaluate the importance of harvesting the surveillance capsules, the following information is requested:
        - Has there been any major changes in the reactor core design since EOC 10 for SONGS Unit 2 (e.g., as part of a fluence reduction program)?
        - Have there been any modifications to the reactor pressure vessel internals since EOC 10?
        - Can the cycle-by-cycle assembly beginning-of-cycle and EOC burnups be provided for an assessment (Cycles 1 through 16)?

SONGS Unit 2 surveillance capsule report of Capsule 263-degree is in NRC ADAMS. Updated pages of the SONGS Unit 2 surveillance capsule report of Capsule 97-degree is also in NRC ADAMS. Can the Capsule 97-degree report be provided? Can dosimetry measurement data not available in these reports be provided?

j) Radiation transport calculations/simulations

SCE will provide a brief plan and tentative suitable timeframe for working on the above listed items including estimated cost.

Scope of Work for SDS

SDS will provide a brief plan, tentative suitable timeframe for working on the following tasks including estimated cost.

Task 1: Documents and drawings for harvesting

a) In-vessel surveillance coupons/capsules/dosimeters
   - Subject to joint effort with metal group and interagency collaboration.
   - Collect information about dimension of the capsule, availability of the container with SDS, temporary onsite storage, shipping to BWXT or similar facility

   Steve will provide details and the estimated cost for harvesting the capsules and temporary on-site storage.

Response from Steve:

Confirmation by June or beginning of July would work.

SDS are getting an estimate from the subcontractor that will be extracting the samples who had performed retrieval for SCE previously and will let you know when that is received which should be shortly. The size is approx. 14' but we can cut that to smaller sizes. SDS is also trying to see if there are ICI containers that were used previously somewhere onsite.

SDS will be able to store for a time onsite.

~~Timeline: Fuel Transfer Canal flooding in May 2021, harvesting 3Q/4Q 2021, SDS can store for short period~~

b) Radiation and activation data for concrete and steel columns – input from SDS activity characterization team

Task 2: Unirradiated concrete with composition similar to the primary reactor shield wall
Harvesting 3 plain concrete cores (no rebar) from the primary shield. Dimension: diameter 2 inches, length 6 inches. (Location: The exact location of harvesting to be discussed with SCE)

- Providing documentation on the location of the cores and coring process.
- Surveying the specimens according to NRC license. Reporting the isotopes and activities. This information will be reviewed by ORNL's Radiation Control Staff prior to accepting the specimens.
- Packaging the specimens
- Shipping the bubble-wrapped specimens to Oak Ridge National Laboratory (Oak Ridge, TN)
- Completion date: As soon as possible after January 2021.

Urgent to determine suitability of the material for research (Decision point). Verify that the aggregate, minerals and concrete are susceptible to radiation damage.

Task 3: Site visit, meeting and walkdown to the relevant area of harvesting
Technical meeting to gain insights from plant owner and the decommissioning organization.

To review drawings, on site meeting with staff from decommissioning group and plant owner, and walk down (take notes, pictures) to finalize the harvesting locations and NDE plan.

One and half days meeting

Visitors: NRC (2-3), ORNL (3), EPRI (2-3), INL/NSUF (1-2)

Decommissioning Group: # staff person and hours

Plant owner: # staff persons and hours

Site visit depends on COVID travel restrictions and unirradiated specimen characterization.
Get unirradiated core, perform EPRI NDE, prepare slices, run MXRF for silica content.
Two site visits – one pre-harvesting and one at the time of harvesting.
How much advance notice to SDS is needed for site meeting. Visitors may include foreign national ORNL employee.
SCE & SDS to inform suitable window of time. Lead time is not an issue.

~~**Task 4: Harvesting liner and stud if exist, packaging and shipping to ORNL**~~

~~Use liner plate as retrospective dosimetry. Study the interface of steel and concrete~~

~~Characterize concrete immediately adjacent to liner. Record degree of cracking, fragmentation, aggregate swelling for assessment of radiation effects, if possible.~~
~~Interested in niobium because 93Nb(n,n')93mNb has a long product half-life of 16.13 years.~~
~~May be measured by portable XRF. Is it capable to measure 50ppm? It is possible to measure this with the right gun. Testing a coupon may be an alternative.~~
Note: Liner doesn't exist

Task 5: NDE, Cavity visual examination, and other testing in-situ (Later)
Provide access, temporary platform or scaffolding, ladder, lighting to perform NDE, visual examination and other testing.
EPRI/Sal please add more specificity

Access for Visual examination

Evaluate liner issues

Lighting

Access for NDE in areas near harvesting locations

Three or four elevations

Scaffolding and access to various elevation inside the primary reactor shield wall

This task may require about one week.

Visual Examination on-site and Endoscopy
NDE: EPRI to add details
Other in-situ testings include in-situ stresses, residual strength, instrument inside the bore hole and measure the changes. Cross-bore hole tomography
EPRI will perform NDE testing on structures where cores will be taken from the bio shield. To achieve these objectives EPRI staff will require the necessary access and training to adhere to the requirements established by the site owner or responsible.

Safety
EPRI staff will adhere to the necessary rules to maintain the highest level of safety and standards at the site. A pre-job brief and a post job brief will be employed during the activities.

Peer check and three-way communication will be used to ensure a streamlined data collection and a safe work environment.

Site access and training

For site access EPRI staff will review and follow the standard protocols established on site. Regarding training, it is anticipated that EPRI staff will visit the site to collect data from areas within the bio shield. It is anticipated that EPRI staff will require accessing scaffold or manlift to perform testing at different elevations of the bio shield wall.

An estimate of the time commitment necessary to fulfill the requirements of site access and training is necessary to properly budget time for EPRI staff involved in the activities.

Inspection on site

From the locations where cores will be taken, EPRI will grid out 10 ft x 10 ft areas on the surface of the structures to deploy various NDE technologies. The technologies will include GPR, Ultrasonic Shear-wave Tomography, and Ultrasonic Pulse velocity. The NDE testing performed will identify where on the grid cores can be taken without hitting reinforcing bars. The systems expected to be used are portable and battery operated so no power or water is necessary for the deployment.

For marking the surface chalk or other approved form of marking will be used. Photographs and sketches will be used to document the findings and take notes on site.

Because the instruments will be in contact with concrete that was subjected to irradiation operating experience from the site regarding contamination of tools and equipment and guidance on how to protect the tools from contamination would be valuable. The plan would be to protect the equipment and tools with temporary barriers (i.e plastic or other materials) that can be disposed on site and that will reduce the risk of the equipment becoming contaminated.

Task 6: Harvesting details – Location, length, numbers, diameter
Getting core from outside (Later)

Locations:

a) Beltline – 2in*, 3in, and 4in dia at beltline, 3 cores for each dia (9 cores total)
b) High temperature and high irradiation region near hot leg at ID of primary reactor shield wall – 3in and 4in dia 3 cores each (6 cores total)
c) High temperature, near hot leg – OD of primary reactor shield wall – 3in or 4in dia, 3 cores for each dia (6 cores total)
d) Unirradiated (bottom of the of primary reactor shield wall) – 3in or 4in dia, 3 cores for each dia (6 cores total)

Length: 2-3 ft (coring from inside face of the primary reactor shield wall)
* 2 in dia is comparable with the CVR/NRAJ experiments.

May require scaffoldings and other temporary access requirement (same as Task 5)

Task 7: Packaging, storing, shipping (Later)
Shipping can be done by SDS, for irradiated concrete use lead lined drum 55gal
Packaging for irradiated cores:

- 3 cores, 2in dia, 2-3 feet long
- 9 cores, 3-4in dia, 2-3 feet long
- 9 cores, 3-4in dia, 2-3 feet long

Packaging for unirradiated cores:

- 6 cores, 3-4in dia, 2-3 feet long
- Temporary storing by the contractor and then shipping to Oak Ridge, TN

Task 8

RPV support steel columns - Fluence level, material composition, and fabrication

Columns will be removed after removing the RPV. Harvesting and NDE of the steel supports will be available in 2023 and 2024. [per Rob Tregoning]

For cost calculation SDS need details such as numbers, size of the specimens.

Notes:

- Blue texts are for additional information not for contract.
- Separate meeting is to be scheduled for contract development including the contract folks tentatively in Q1 of 2021, POC: Albert and Steve.
- It is confirmed that 2in, 3in, and 4in cores can be extracted. Steve to confirm how deep the coring can go for 4in dia.
- Possibility for harvesting concrete block tentatively 2ftx2ft or 1ftx1ft. Steve and Stu said cutting block would be difficult.

From: Tregoning, Robert
To: AL-SHAWAF Taha (ORANO)
Cc: Purtscher, Pat; Hiser, Matthew
Subject: CR3 Archival Materials
Date: Thursday, April 16, 2020 2:29:00 PM

Dear Taha:

In the prioritization lists I sent you last week, we didn't explicitly identify archival materials as another area of interest. As you're aware, most plants have archival materials that were left over from construction. Weld qualification samples, extra surveillance capsule materials, and/or SG tubes, are some common examples. CR3 should have had an inventory of such archived materials that were required to be saved as part of their license or were saved for plant-specific reasons. NRC is also potentially interested in obtaining such materials.

Do you know if CR3 still has some or all of their archival materials along with any related pedigree information (e.g., CMTs, purchase specs.)? If so, we would certainly be interested in obtaining these materials as part of the scope for any CR3 harvesting activities. However, we know that both the materials and pedigree information is often among the first things that are disposed of after shutdown. If so, we would appreciate any help that you could provide to ensure that such materials/information are not disposed.

We're happy to discuss this further with you if you'd like to either learn more about our interests or to discuss particular materials that may be available.

Kind regards,

Rob

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From:	Sircar, Madhumita
To:	Albert Bates; "Gerard P. Van Noordennen"; Seber, Dogan; Pires, Jose; Tom Rosseel (rosseeltm@ornl.gov); Le Pape, Yann; Wall, James; Johnson, Samuel; Snyder, Amy; Vincent J Barone; Alpan, F. Arzu; Robert M. Quinn; Robert Corbett; Colin D. Judge
Cc:	Hiser, Matthew; Tregoning, Robert; Risner, Joel M.; Anderson, Stephanie; Tajuelo Rodriguez, Elena; Fraser, Robert G.; Giles, Stuart A; Thomas A. Kaiser; Kelly A. Cunningham
Subject:	RE: Confirmed Time - Harvesting Irradiated Concrete Cores from Unit 2 and 3 of Bioshield
Date:	Wednesday, December 16, 2020 5:57:46 PM
Attachments:	Research and Hervesting Planning Updated 12-16-2020.xlsx

Thanks to all who participated in today's meeting.

Please find attached the updated spreadsheet from today's meeting. Our discussion was focused on the lower table with blue background starting from Row number 33.
The blue text was added today.

This spreadsheet was developed to initiate our discussion on the planning for the research and harvesting. Next we will develop a more concise document with scope of work related to harvesting and gathering plant information/documentation.

Happy Holidays and Happy New Year!

Thanks,
Mita Sircar
Tel: 301-415-1804

-----Original Appointment-----
From: Sircar, Madhumita
Sent: Thursday, November 12, 2020 8:06 AM
To: Sircar, Madhumita; Albert Bates; 'Gerard P. Van Noordennen'; Seber, Dogan; Pires, Jose; Tom Rosseel; Le Pape, Yann; Wall, James; Johnson, Samuel; Snyder, Amy; Vincent J Barone; Alpan, F. Arzu; Robert M. Quinn; Robert Corbett; Colin D. Judge
Cc: Hiser, Matthew; Tregoning, Robert; Risner, Joel M.; Anderson, Stephanie; Tajuelo Rodriguez, Elena; Fraser, Robert G.; Giles, Stuart A; Thomas A. Kaiser; Kelly A. Cunningham
Subject: Confirmed Time - Harvesting Irradiated Concrete Cores from Unit 2 and 3 of Bioshield
When: Wednesday, December 16, 2020 3:00 PM-4:30 PM (UTC-05:00) Eastern Time (US & Canada).
Where: Microsoft Teams Meeting
Importance: High

Update: For quick reference, attached summary of the meeting (11-04-2020) and the planning spread sheet. These two files were shared earlier.

Update: Please accept this invitation in case not done yet. Appreciate your attention!
I am going to cancel the 12pm-1:30pm (EDT) on Dec.16th meeting slot and confirming this Alternative Time 3:00-4:30pm (EDT) same day [sent invitation on 11/12]
I have already received confirmation from Gerry, Colin, Arzu, Joel, Elena, Yann, James, Sam, and Jose for Dec. 16th, 3:00-4:30pm(EDT) - Thanks to you all

---

Earlier I sent an invitation for next meeting on Dec.16th, 12-1:30pm (EST). One of the key members has requested for a change of time. Let's try the 2nd option same day, 3:00-4:30pm (EDT).
All: Please respond to this 2nd option at the earliest so that we can lock the time.

Mita

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)

+1 301-576-2978,,(b)(6) # United States, Silver Spring

Phone Conference ID: (b)(6) #

Find a local number | Reset PIN

-- U.S. Nuclear Regulatory Commission --

Learn More | Meeting options

Harvesting Opportunity from SONGS Units 2 & 3

	Plan for Research (Conceptual and Tentative)						
	Test	**Remarks**	**Harvesting**	**NRC**	**ORNL**	**EPRI**	**Others**
1	Characterize unirradiated concrete by extracting concrete specimens from unirradiated part of the structure. The path forward for the research will depend on the susceptibility of the concrete to irradiation damage (Decision Point).	Urgent to determine suitability of the material for research (Decision point). Verify that the aggregate, the minerals and the concrete are susceptible to radiation damage that will add value for research.	Hockey puck size sample (ASAP). ORNL will conduct this study			Regardless of the outcome I think cores should be extracted. If no damage is found the cores should be further irradiated (as stated in row 15). The amount of chronic irradiation already induced on the cores is important and continuing irradiation can save some time in comparison to creating new samples and irradiating them	
2	Request first-pass data, if any, on the exposure conditions (temperature, relative humidity, gamma and neutron) in the reactor cavity, bioshield, inside the containment building and adjacent buildings.	Objective: help the coring location plan to separate vaired exposure effects.					
3	Mechanical Testing (compressive strength, tensile strength, modulus of elasticity, stiffness, fracture properties, etc.) and petrography. Availability of triaxial testing. Size and number of test specimens. Specimen size similar to historical data (from 70's to now)	Graduated test specimen (small to larger sizes) depending upon HotCell capacity. Check available instruments/methods in HotCell	Cores At high radiation (belt line) At low/no irradiation (with other similar environment conditions) Specific azimuthal location and elevation of the cores Length of Cores: full depth from outside the bioshield or 2ft from inside face of the bioshield. (I think full depth is the best option, since we can have high to low radiation impact due to decay within the depth) Consider risk of core breakage Size and number of cores, etc. Determine from a table of testing requirements			The activity analysis performed by SCE/ES should give us an idea whether or not it needs to be done in a hot cell as opposed to e.g. the LAMDA labs	
4	Concrete composition Suggest petrography for effects of admixtures if any, water cement ratio, bleeding characteristics, and degree of hydration. Compare clinker remnants (hydrates) from high irradiation and low/no radiation samples						
5	Aggregate composition, type, texture	Compare with the available data					
6	Microstructure	Check available instruments/methods in HotCell					
7	Porosity, pore size	XCT / USAX					
8	Dimension changes	Without initial baseline, is it not possible to mesure the actual dimensional change. Explore the possibility to instrument around the core hole to monitor stress release after coring					
9	Mass change (Density change?)	What is the baseline material?					
10	Moisture content	Strategy should vary whether a liner is present or not. Liner/no liner is a critical piece of information					
11	Hardness	Nano indentation. ORNL has experience and capabilities to nano-indent irradiated materials.				Surface hardness - rebound hammer and windsor probe this is macro hardness. Petrography typically reports this but the results from petrography are subjective	
12	Damage of aggregate, mortar, cement paste	SEM, XCT					
13	Cracking, Interfacial bonding						
14	Activity of concrete samples with depth	From SCE/ES					
15	Damage profile inside concrete	Need to consider how samples will be sliced without additional damgage					
16	Cores for further irradiation in research reactor	Radiation effects may not be same as those from an operating reactor, but may need to further irradiate to achieve SRP-SLR radiation limits and then test. Caveat: further irradiation test may require additional machining (dia. ~ 40 mm)				Agree with further irradiation	
17	NDE in laboratory NDE may provide information on damage, cracking, Thermal Conductivity	Check capability of ORNL's Hot Cell. Awaiting answers from facility managers.	Block/cores From high and low irradiated areas			Dynamic modulus, UPV (compressional and shear wave), resistivity (may not tell us much but its easy to perform), non linear UT. EPRI can contribute we own some of these systems	
18	Rebar pull out testing and other structural testing Is it possible to get blocks of sufficiently large size to be able to cut into reasonable size beam and column specimens for load tests to failure?	May not be feasible; radiation exposure may not reach the rebar for 30 years of operation (approx. EFPY 25-28). Needs large setup that is hard to achieve for activated materials	Block/Core From high or low irradiated areas				
19	Block of concrete with rebar to study steel-concrete interface (microstructure)	Describe study (SEM is a good option to study a transversal cut with rebar) What is the difference between this item and item 12?	Block/core				
20	Liner and stud Use of the concrete liner plate as retrospective dosimetry. Characterize concrete immediately adjacent to liner. Record degree of cracking, fragmentation, aggregate swelling for assessment of gamma ray effects, if possible	Interested in niobium because 93Nb(n,n')93mNb has a long product half-life of 16.13 years May be measured by portable XRF. Is it capable to measure 50ppm? Testing a coupon may be an alternative. Yes it is possible to measure this with the rigth gun (see resource in link)					
21	Identify the locations for harvesting and NDE	Get drawing from SCE/ES	Tentatively high irradiation areas near the beltline and low irradiation areas below the beltline (near or below EL 6ft)			where NDE can help in the field. When an evaluation is being performed on a concrete structure first you perfom visual, then NDE, and at the end you extract core samples. This is the reason why NDE exists so that we can make a judgement on optimizing sample extraction and evaluate the uniformity of the concrete. Techniques indirect UPV, shear wave velocity, rebound hammer, impulse response, and GPR to evaluate the as built cover vs design. We can do them all.	
22	NDE or other testing in-situ In-situ stresses, residual strength, instrument inside the bore hole and measure the changes. Cross-bore hole tomography	Verify feasibility from SCE/ES. If yes, specify the types of test, contractor, etc. Other than NDE, testing may require about two weeks or more.	N/A Duration of NDE testing			Expansion of the cores due to relaxation of internal compressive stresses may make cores size inside the core drill bit	
23	Visual Examination on-site; Endoscopy	Cavity liner may be an obstruction	N/A				
24	Consortium for benchmarking models against SONGS samples - collect information needed for model validation and verify the need for additional testing	List of parameters from the model developers. Task partly addressed by ICIC/ACES activities	Block/core				
25	Capability of Hot Cell	Check capability of ORNL's Hot Cell. Awaiting answers from facility managers.					
26	Storage	Check possibility with SCE and ORNL					
27	ORNL existing contract will end in March 2021	Can cover some of the front end work. To be discussed with ORNL					

	Plan for Harvesting: Items for Discussion with Southern California Edition (SCE) and Energy Solutions (ES)										
	Items	**Remarks**	**2020-Q4**	**2021-Q1**	**2021-Q2**	**2021-Q3**	**2021-Q4**	**2022-Q1**	**2022-Q2**	**2022-Q3**	**2022-Q4**
1	Unirradiated concrete from CBS	Urgent need of hockey puck size sample from structure with similar concrete and aggregate composition. Review drawings, on site meeting and walk down (take notes, picture, NDE) to finalize the harvesting location. Requirement: Hockey puck size piece of concrete with same aggregate and mix design as of bioshield can be available sometime in Jan. 2021	x								
2	Timeline for all actions with SCE/ES	All columns F-N, are to be filled up in coordination with SCE & ES. Currently shown "X" are tentative. Steve for ES, Albert for SCE to provide the time-line for various activities and development of contracts. RPV segmentation for U#2 in Aug 2023 and U#3 in Apr. 2024	x								
3	Gather documentations for research	NRC, ORNL, and EPRI to prepare the list of documents. Mita to coordinate		x							
4	Cost – Tentative	Gerry to provide an estimate. This is needed at the earliest for contract budget estimate. NRC-ORNL-EPRI need to provide the work statement. Steve for site meeting and access, harvesting, storing and shipping. Al and Vincent to provide for plant information	x								
5	Documents, and drawings for planning the harvesting	Vincent to provide. Received some drawings on 11/05/2020 and shared with the group. Vincent will provide more drawings	x								
6	Technical meeting to gain insights from plant owner and the decomissioning organization	Held meetings: Dec 16th, 2020. Jan 27th 3:00-4:30pm	x	x							
7	Reactor operation history Fuel rearrangement, frequency of RFOs, and change of fuel timeline (if more efficient fuel was used)	Albert to provide	x								
8	In-vessel surveillance dosimetry data for fluence validation	Used for reactor pressure vessel (RPV) fluence validation, but any data for validation of calculated fluences will be useful. Albert will provide operational data and Steve will collect the surveillance coupons/dosimeter once it is available for harvesting and research. How many coupons were there? Also we are interested for the data of the coupons that were tested earlier	x	x							
9	Radiation transport calculations/simulations	To determine the radiation and temperature level on the surface and inside the concrete. [Joel Risner] In addition to any radiation transport calculations that may have been done to assess radiation levels (including heating rates) in the concrete, it would be beneficial for us to have sufficient data to run our own simulations. There are two motivations for this request: 1) It will allow us to use our methods – which we believe are more accurate than typically used methods – to assess radiation levels 2) It will give us the ability to perform parameter studies (if need be) to address potential modeling uncertainties Vincent to provide the operating plant simulations. Steve can provide the reactor vessel related radiation exposure information	x								
10	Concrete composition - original construction information, mix design, aggregate composition	Albert/Vincent to provide	x								
11	Availability of tools and equipment for coring, cutting blocks - high irradiation, high temperature, and no irradiation	Gerry to provide more details. Block size tentatively 2ftx2ft. Steve, Siu - Block would be difficult	x	x							
12	Possibilities of getting 2-3 different diameters of coring Multiple size specimens needed to confirm applicability of our SRP-SLR limits and scaling effects	Gerry will check the coring diameters. Standard size coring will work. Variation of core size such as 2in, 3in, 4in will be suitable to study size effect. It is confirmed that 2in, 3in, and 4in can be extracted. Steve to confirm how deep the coring can go for 4in dia.	x								
13	NDE on-site and on site testing/examination	Identify types of NDEs and other testings onsite - EPRI, ORNL, NRC	x								
14	Availability of tools and equipment for NDE and other testing	NRC, ORNL and EPRI to prepare a list.	x								
15	Contract with SCE/ES (Songs Decommissions Solutions) (two contracts) for harvesting, providing technical information, other services	Two contracts: 1) Obtain technical information, documentations related to plant construction and operation 2) Onsite meeting, site access, support site visit/walkdown (take notes, picture, NDE), harvesting, packaging, storing, shipping A separate meeting is to be scheduled for contract development including the contract folks tentatively in Q1 of 2021, POC: Albert and Steve		x							

16	Harvesting, packing, storing, shipping	Under SDS contract			X	X	X				
17	Indicate location on drawing for harvesting and NDE and on site testing/examination	In two phases: 1) Site visit/walk down before spring of 2021 2) Testing and NDE after removal of RPV and steel columns	X	X							
18	RPV support steel columns - Time line for harvesting coupon from rhe column; Fluence level, Material composition, and fabrication	Columns will be removed after removing the RPV. Harvesting and NDE of the steel supports will be available in 2023 and 2024. (Future possibility)									

From: Sircar, Madhumita
To: Albert Bates; "Gerard P. Van Noordennen"; Seber, Dogan; Pires, Jose; Tom Rosseel (rosseeltm@ornl.gov); Le Pape, Yann; Wall, James; Johnson, Samuel; Snyder, Amy; Vincent J Barone; Alpan, F. Arzu; Tajuelo Rodriguez, Elena
Cc: Hiser, Matthew; Tregoning, Robert; Risner, Joel M.; Anderson, Stephanie; Moyer, Carol; Nie, Jinsuo; Sock, Frederick; Prinaris, Andrew
Subject: RE: Harvesting Irradiated Concrete Cores from Unit 2 and 3 of Bioshield
Date: Monday, November 09, 2020 9:16:13 AM
Attachments: Meeting Summary_11-04-2020.docx
Research and Harvesting Planning_Updated_11-04-2020.xlsx

Please find attached the summary of the meeting on Nov 4th and the updated spread sheet. I greatly appreciate all the participants of this meeting and their valuable input. Please review and let me know if any change is needed.

Thanks to Al and Vinny for providing some drawings which I have shared with NRC-ORNL-EPRI joint team members.

Thanks,
Mita Sircar
Tel: 301-415-1804

-----Original Appointment-----
From: Sircar, Madhumita
Sent: Monday, November 09, 2020 8:28 AM
To: Sircar, Madhumita; Albert Bates; 'Gerard P. Van Noordennen'; Seber, Dogan; Pires, Jose; Tom Rosseel; Le Pape, Yann; Wall, James; Johnson, Samuel; Snyder, Amy; Vincent J Barone; Alpan, F. Arzu; Tajuelo Rodriguez, Elena
Cc: Hiser, Matthew; Tregoning, Robert; Risner, Joel M.; Anderson, Stephanie
Subject: Harvesting Irradiated Concrete Cores from Unit 2 and 3 of Bioshield
When: Wednesday, December 16, 2020 12:00 PM-1:30 PM (UTC-05:00) Eastern Time (US & Canada).
Where: Microsoft Teams Meeting

As decided in the meeting on Nov. 4th , the next meeting is on Dec. 16th.

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)
+1 301-576-2978,(b)(6) # United States, Silver Spring
Phone Conference ID: (b)(6) #

Harvesting Irradiated Concrete from Unit 2 and 3

Virtual Meeting on December 3rd, 2020

Attendees:

Albert Bates, Gerard P. Van Noordennen, Vincent J Barone, Steve Menon, Todd Adler (SCE, SDS)

Pires Jose, Madhumita Sircar, Stephanie Anderson (NRC)

Tom Rosseel, Yann Le Pape, Elena Tajuelo Rodriguez, Arzu Alpan (ORNL)

Samuel Johnson (EPRI)

Not Attended: Amy Snyder, and Dogan Seber (NRC), Joel Risner (ORNL), James Wall (EPRI)

In September 2020, Mita contacted Gerry and Albert to ascertain the opportunity for irradiated concrete harvesting. She received confirmation that Sothern California Edison (SCE) and SONGS Decommissioning Solutions (SDS - AECOM & ES) will support the concrete harvesting efforts. Harvesting irradiated concrete is a common interest of NRC, ORNL, and EPRI; they jointly developed a conceptual research and harvesting plan. The “Research and Harvesting Planning” spreadsheet was attached to the meeting invitation.

In the meeting Gerry shared his experience of harvesting process of Zion in which the details were worked out with ORNL, EPRI, and NRC and point of contact (POC) was ORNL. There were upfront communications to gather information from both sides. Then the RFP was issued, and a purchase order was placed to support the harvesting. This model worked up well, but some of the late start on the list could not be honored because those components were disposed. Concrete was not harvested from Zion.

As a part of SONGS decommissioning, SDS have collected cores from containment building. One of the purposes is to test concrete hardness values at different locations because it makes a difference for the machinery selection. Harvesting support will be provided as cost neutral, meaning it is not intended for profit and now is a good time to plan all that is needed for harvesting.

Albert as representative of the owner and former operator confirmed support for harvesting concrete from SONGS 2 and 3. He will arrange to gather plant related information, documents, calculations (e.g. radiation, power history, core power distribution). The reactor active core was 16-ft tall. The plant went critical in 1983, it has generated significant neutron fluence and gamma dose. Concrete was poured in late 70’s, the aggregate came from Catalina Island. There was on site a batch plant for manufacturing concrete and the record for concrete should be available.

SCE/SDS suggested onsite meeting and site walkdown in January/February 2021. There should be two contracts, one SCE and another with SDS, and the work will be in phases. Some activities can be performed before removal of the RPV and other activities that need access to the reactor cavity should wait until RPV is removed. The decommissioning timeline will be

Find a local number | Reset PIN

-- U.S. Nuclear Regulatory Commission --

Learn More | Meeting options

---

provided to Mita before Dec. 16th, 2020 meeting. The scope of two contracts will generally be for:

1) Obtaining technical information, documentations related to plant construction and operation history. (Anticipated contract with SCE.)

2) Onsite meeting, site access, site visit/walkdown, harvesting, packaging, storing, shipping etc. (Anticipated contract with SDS.)

Information exchange, site visit and other frontend work can continue and proceed before awarding the contracts.

The items from the "Research and Harvesting Planning" spreadsheet were discussed and the input from the meeting are added in "RED".

Next virtual meeting is on December 16th, 2020.

Harvesting Opportunity from SONGS Units 2 & 3

	Plan for Research (Conceptual and Tentative)						
	Test	Remarks	Harvesting	NRC	ORNL	EPRI	Others
1	Characterize unirradiated concrete by extracting concrete specimens from unirradiated part of the structure. The path forward for the research will depend on the susceptibility of the concrete to irradiation damage (Decision Point).	Urgent to determine suitability of the material for research (Decision point). Verify that the aggregate, the minerals and the concrete are susceptible to radiation damage that will add value for research.	Hockey puck size sample (ASAP). ORNL will conduct this study			Regardless of the outcome I think cores should be extracted. If no damage is found the cores should be further irradiated (as stated in row 15). The amount of chronic irradiation already induced on the cores is important and continuing irradiation can save some time in comparison to creating new samples and irradiating them	
2	Request first-pass data, if any, on the exposure conditions (temperature, relative humidity, gamma and neutron) in the reactor cavity, bioshield, inside the containment building and adjacent buildings	Objective: help the coring location plan to separate varied exposure effects.					
3	Mechanical Testing (compressive strength, tensile strength, modulus of elasticity, stiffness, fracture properties, etc.) and petrography. Availability of triaxial testing. Size and number of test specimens. Specimen size similar to historical data (from 70's to now)	Graduated test specimen (small to larger sizes) depending upon HotCell capacity. Check available instruments/methods in HotCell	Cores At high radiation (belt line); At low/no irradiation (with other similar environment conditions) Specific azimuthal location and elevation of the cores Length of Cores: full depth from outside the bioshield or 2ft from inside face of the bioshield. (I think full depth is the best option, since we can have high to low radiation impact due to decay within the depth). Consider risk of core breakage Size and number of cores, etc. Determine from a table of testing requirements.			The activity analysis performed by SCE/ES should give us an idea whether or not it needs to be done in a hot cell as opposed to e.g., the LAMDA labs	
4	Concrete composition Suggest petrography for effects of admixtures if any, water cement ratio, bleeding characteristics, and degree of hydration. Compare clinker remnants (hydrates) from high irradiation and low/no radiation samples						
5	Aggregate composition, type, texture	Compare with the available data					
6	Microstructure	Check available instruments/methods in HotCell					
7	Porosity, pore size	XCT / USAX					
8	Dimension changes	Without initial baseline, is it not possible to mesure the actual dimensional change. Explore the possibility to instrument around the core hole to monitor stress release after coring					
9	Mass change (Density change?)	What is the baseline material?					
10	Moisture content	Strategy should vary whether a liner is present or not. Liner/no liner is a critical piece of information.					
11	Hardness	Nano indentation. ORNL has experience and capabilities to nano-indent irradiated materials				Surface hardness - rebound hammer and windsor probe this is macro harndess. Petrography typically reports this but the results from petrography are subjective.	
12	Damage of aggregate, mortar, cement paste	SEM, XCT					
13	Cracking, Interfacial bonding						
14	Activity of concrete samples with depth	From SCE/ES					
15	Damage profile inside concrete	Need to consider how samples will be sliced without additional damgage					
16	Cores for further irradiation in research reactor	Radiation effects may not be same as those from an operating reactor, but may need to further irradiate to achieve SRP-SLR radiation limits and then test. Caveat: further irradiation test may require additional machining (dia. ~ 40 mm)				Agree with further irradiation	
17	NDE in laboratory NDE may provide information on damage, cracking. Thermal Conductivity	Check capability of ORNL's Hot Cell. Awaiting answers from facility managers.	Block/cores From high and low irradiated areas			Dynamic modulus, UPV (compressional and shear wave), resistivity (may not tell us much but its easy to perform), non linear UT. EPRI can contribute we own some of these systems	
18	Rebar pull out testing and other structural testing Is it possible to get blocks of sufficiently large size to be able to cut into reasonable size beam and column specimens for load tests to failure?	May not be feasible, radiation exposure may not reach the rebar for 30 years of operation (approx. EFPY 25-28). Needs large setup that is hard to achieve for activated materials	Block/Core From high or low irradiated areas				
19	Block of concrete with rebar to study steel-concrete interface (microstructure)	Describe study (SEM is a good option to study a transversal cut with rebar) What is the difference between this item and item 12?	Block/core				
20	Liner and stud Use of the concrete liner plate as retrospective dosimetry Characterize concrete immediately adjacent to liner. Record degree of cracking, fragmentation, aggregate swelling for assessment of gamma ray effects, if possible	Interested in niobium because 93Nb(n,n')93mNb has a long product half-life of 16.13 years. May be measured by portable XRF. Is it capable to measure 50ppm? Testing a coupon may be an alternative. Yes it is possible to measure this with the right gun (see resource in link)					
21	Identify the locations for harvesting and NDE	Get drawing from SCE/ES	Tentatively high irradiation areas near the beltline and low irradiation areas below the beltline (near or below EL 6ft)			…where NDE can help in the field. When an evaluation is being performed on a concrete structure first you perform visual, then NDE, and at the end you extract core samples. This is the reason why NDE exists so that we can make a judgement on optimizing sample extraction and evaluate the uniformity of the concrete. Techniques indirect UPV, shear wave velocity, rebound hammer, impulse response, and GPR to evaluate the as built cover vs design. We can do them all.	
22	NDE or other testing in-situ In-situ stresses: residual strength, instrument inside the bore hole and measure the changes. Cross-bore hole tomography	Verify feasibility from SCE/ES. If yes, specify the types of test, contractor, etc. Other than NDE, testing may require about two weeks or more.	N/A Duration of NDE testing			Expansion of the cores due to relaxation of internal compressive stresses may make cores size inside the core drill bit.	
23	Visual Examination on-site: Endoscopy	Cavity liner may be an obstruction	N/A				
24	Consortium for benchmarking models against SONGS samples - collect information needed for model validation and verify the need for additional testing	List of parameters from the model developers. Task partly addressed by ICIC/ACES activities	Block/core				
25	Capability of Hot Cell	Check capability of ORNL's Hot Cell Awaiting answers from facility managers					
26	Storage	Check possibility with SCE and ORNL					
27	ORNL existing contract will end in March 2021	Can cover some of the front end work. To be discussed with ORNL.					

	Plan for Harvesting: Items for Discussion with Southern California Edition (SCE) and Energy Solutions (ES)										
	Items	Remarks	2020-Q4	2021-Q1	2021-Q2	2021-Q3	2021-Q4	2022-Q1	2022-Q2	2022-Q3	2022-Q4
1	Unirradiated concrete from CBS	Urgent need of hockey puck size sample from structure with similar concrete and aggregate composition. Review drawings, on site meeting and walk down (take notes, picture, NDE) to finalize the harvesting location	X								
2	Timeline for all actions with SCE/ES	All columns F-N, are to be filled up in coordination with SCE & ES. Currently shown 'X' are tentative. Gerry to provide	X								
3	Gather documentations for research	NRC, ORNL, and EPRI to prepare the list of documents		X							
4	Cost – Tentative	Gerry to provide an estimate. This is needed at the earliest for contract budget	X								
5	Documents, and drawings for planning the harvesting	Vincent to provide. Received some drawings on 11/05/2020 and shared with the group.	X								
6	Technical meeting to gain insights from plant owner	Next meeting on Dec 16th, 2020	X	X							
7	Reactor operation history Fuel rearrangement, frequency of RFOs, and change of fuel	Albert to provide	X								
8	In-vessel surveillance dosimetry data for fluence validation	Used for reactor pressure vessel (RPV) fluence validation, but any data for validation of calculated fluences will be useful. Albert will provide operational data (flux data) and Gerry will collect the surveillance dosimeter once it is available for harvesting and research.	X	X							
9	Radiation transport calculations/simulations	To determine the radiation and temperature level on the surface and inside the concrete: [Joel Risner] In addition to any radiation transport calculations that may have been done to assess radiation levels (including heating rates) in the concrete, it would be beneficial for us to have sufficient data to run our own simulations. There are two motivations for this request: 1)It will allow us to use our methods – which we believe are more accurate than typically used methods – to assess radiation levels 2)It will give us the ability to perform parameter studies (if need be) to address potential modeling uncertainties Vincent to provide	X								
10	Concrete composition - original construction information, mix design, aggregate composition	Albert/ Vincent to provide	X								
11	Availability of tools and equipment for coring, cutting blocks	Gerry to provide more details. Block size tentatively 2ftx2ft	X	X							
12	Possibilities of getting 2-3 different diameters of coring. Multiple size specimens needed to confirm applicability of our SRP-SLR limits and scaling effects	Gerry will check the coring diameters. Standard size coring will work. Variation of core size such as 2in, 3in, 4in will be suitable to study size effect	X								
13	NDE on-site and on site testing/examination	Identify types of NDEs and other testings onsite - EPRI, ORNL, NRC	X								
14	Availability of tools and equipment for NDE and other testing	NRC, ORNL, and EPRI to prepare a list	X								
15	Contract with SCE/ES (Songs Decommissions Solutions) (two contracts) for harvesting, providing technical information, other services	Two contracts: 1) Obtain technical information: documentations related to plant construction and operation 2) Onsite meeting, site access, support site visit/walkdown (take notes, picture, NDE), harvesting, packaging, storing, shipping.		X							
16	Harvesting, packing, storing, shipping	Under SDS contract			X	X	X				
17	Indicate location on drawing for harvesting and NDE and on site testing/examination	In two phases 1) Site visit/walk down before spring of 2021 2) Testing and NDE after removal of RPV and steel columns	X	X							
18	RPV support steel columns - Time line for harvesting coupon from the column, Fluence level, Material composition, and fabrication	Columns will be removed after removing the RPV. Harvesting and NDE of the steel supports will be available in 2022. (Future possibility)									