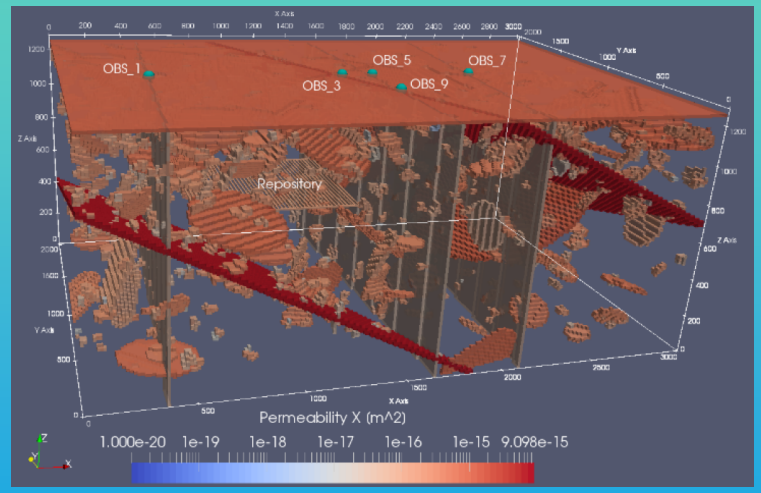
SAND2022-6276C

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Spent Fuel and Waste Science and Technology (SFWST)

Clean. Reliable. Nuclear.



Introduction to Mitigation and Repair of Spent Nuclear Fuel Canisters

SFWST May Meeting

May 12, 2022

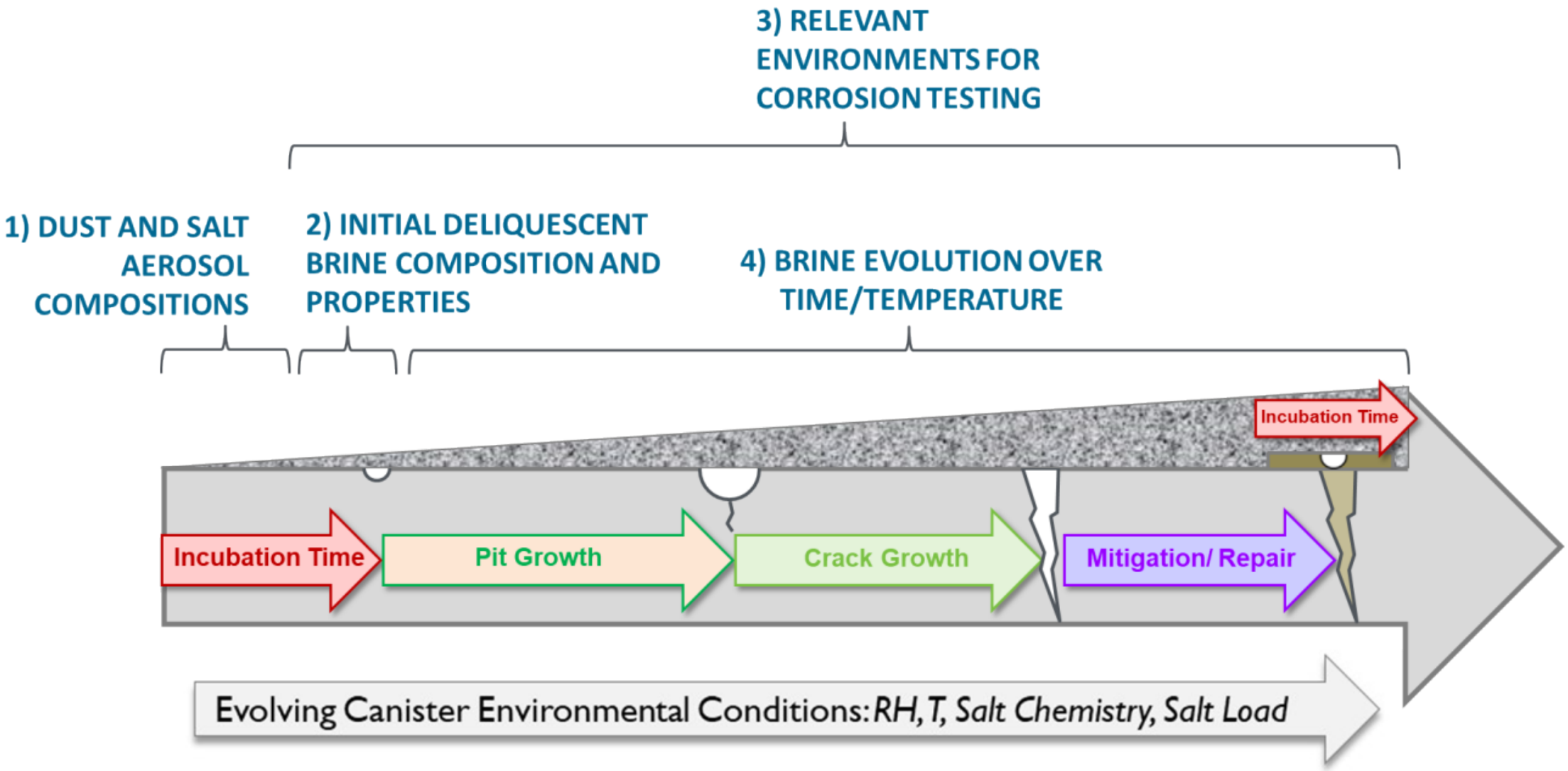
Andrew Knight[1], Brendan Nation[1], Erin Karasz[1], Ken Ross[2]

[1]Sandia National Laboratories

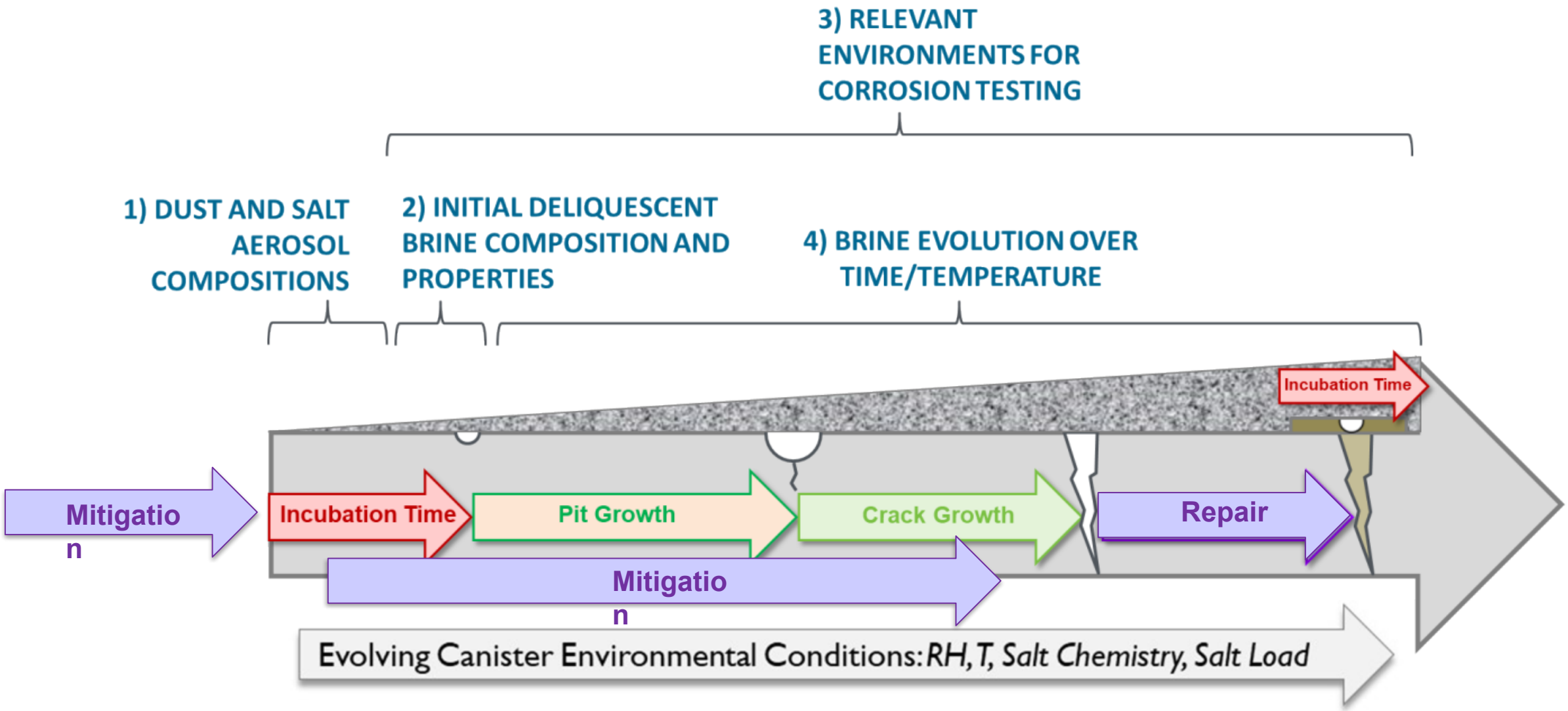
[2]Pacific Northwest National Laboratories

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Mitigation and Repair

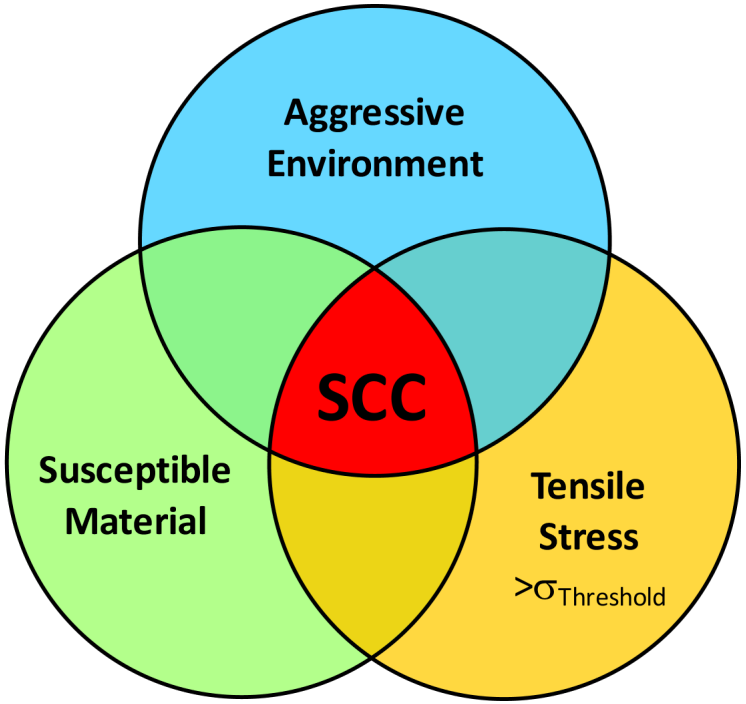


Mitigation and Repair

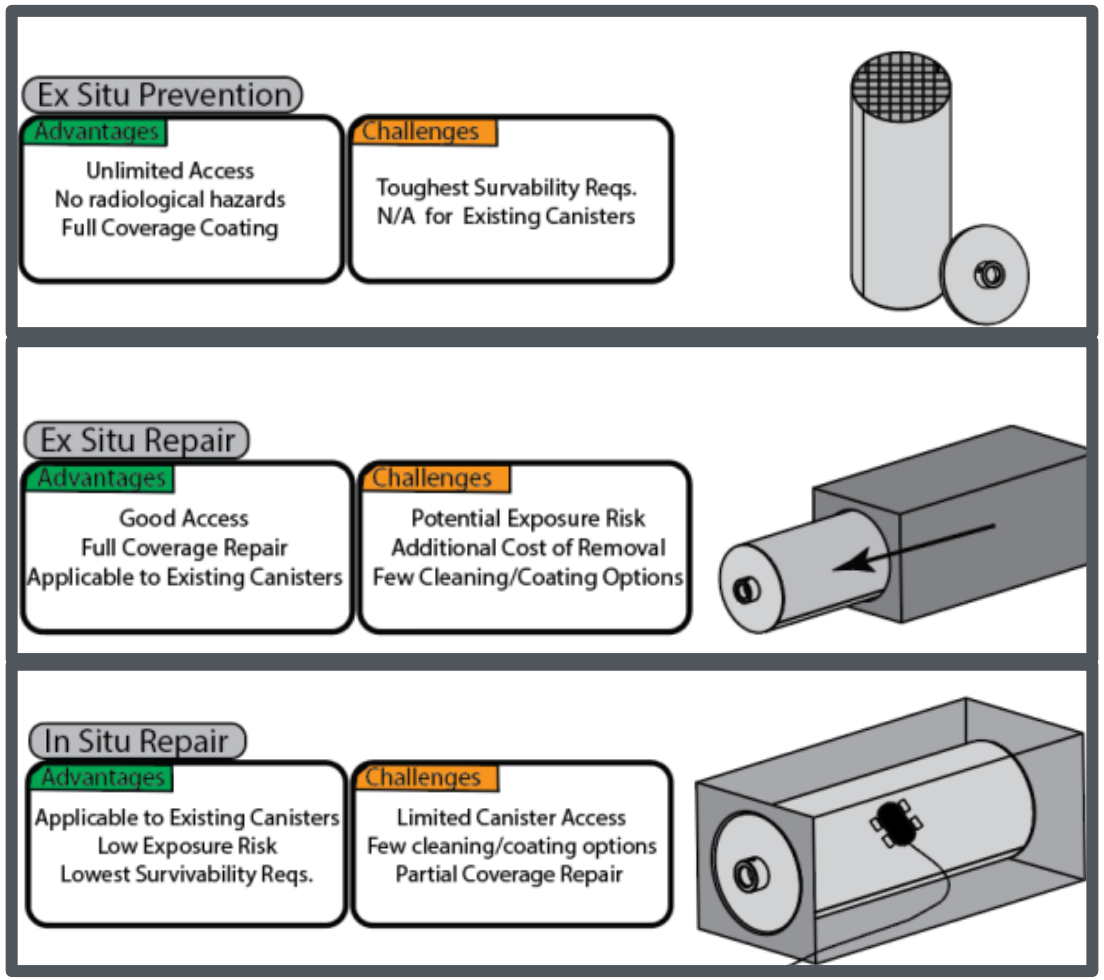


Why Do We Need to Consider Mitigation and Repair?

1. Cannot rule out potential for SCC to occur
   - Canisters are made of 300 series stainless steel, which are susceptible material
   - Measured stresses demonstrate sufficiently high tensile stresses exist
   - Aggressive environment is possible given composition, amount, and achievable surface RH.
     - Likelihood increases with increasing time and decreasing temperature
2. Crack detection and identification methods are not well developed
   - It is challenging to find a crack on canister
     - **Prevention** and **mitigation** of SCC may become important to ensure canister integrity
3. Disposal pathways may take a while
   - The time period for dry storage is currently indefinite
     - Increasing the likelihood of SCC, and demonstrating the need for mitigation and repair strategies
   - *Mitigation and repair strategies must consider disposal implications*



When Do We Need to Consider Mitigation and Repair?



During manufacturing of a new canister for mitigation

On an existing canister removed from the overpack to mitigate potential SCC

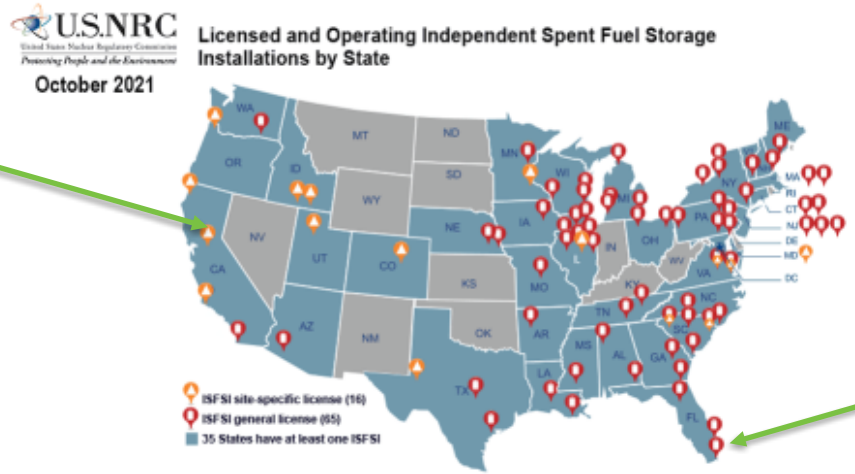
On an existing canister inside its overpack to mitigate potential SCC or repair a known SCC

Application of any mitigation and repair technology could potentially change the regulatory status of the canister

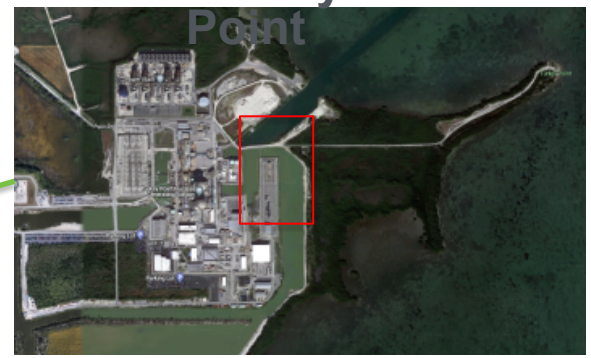
Where Do We Need to Consider Mitigation and Repair?

- Geographic Locations vary significantly
  - Weather and dominant salt composition
  - Highest Cl^- containing salt loading is anticipated at marine or near marine sites. Though Cl^- deposition at inland sites is possible.
    - 7 ISFSI Sites have been sampled, additional ones are scheduled. Salt load is estimated and composition is determined
- What is the threshold for “aggressive environment” for which mitigation should be considered?
  - Need to factor the brine composition (impact of nitrates, brine deliquescence behavior, etc.)

Rancho Seco



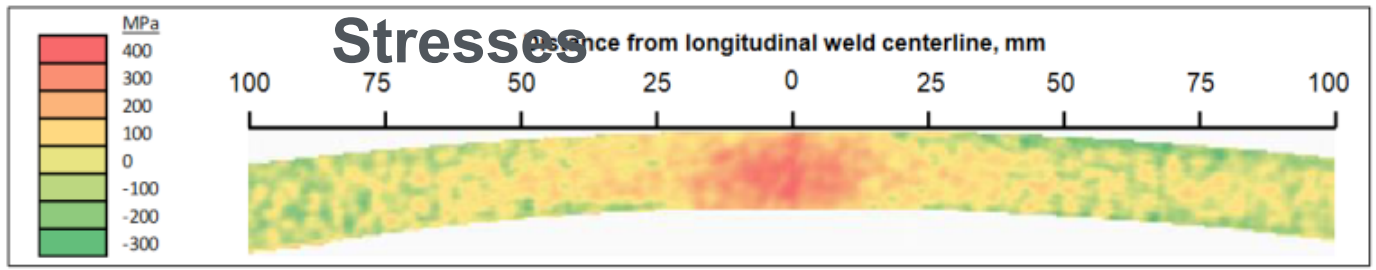
Turkey Point



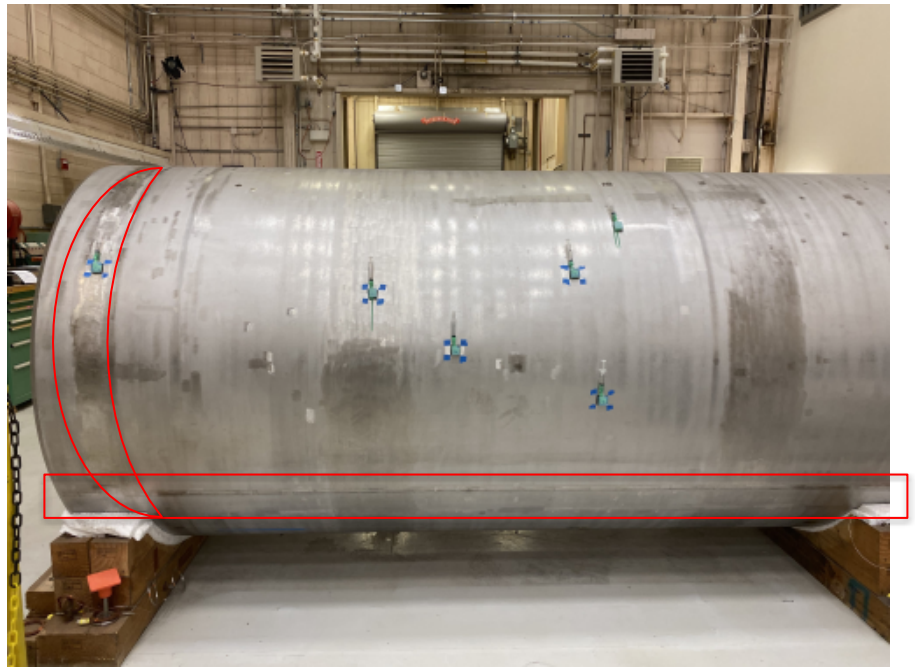
Where Do We Need to Consider Mitigation and Repair?

- Canister Locations
  - Welds and HAZ regions
    - A recent EPRI report stated, “Ensuring appropriate coverage is required for an effective mitigation operation. At a minimum, 100% coverage of welds and HAZ is necessary for mitigation.” and “Mitigating 100% of the welds and heat affected zone of the canister would likely eliminate the potential for CISCC.” [Chu et al., 2021]
      - With patch mitigation and repair, interfaces become important
  - Other locations?

Measured Weld Residual Stresses



Bryan et al., 2016



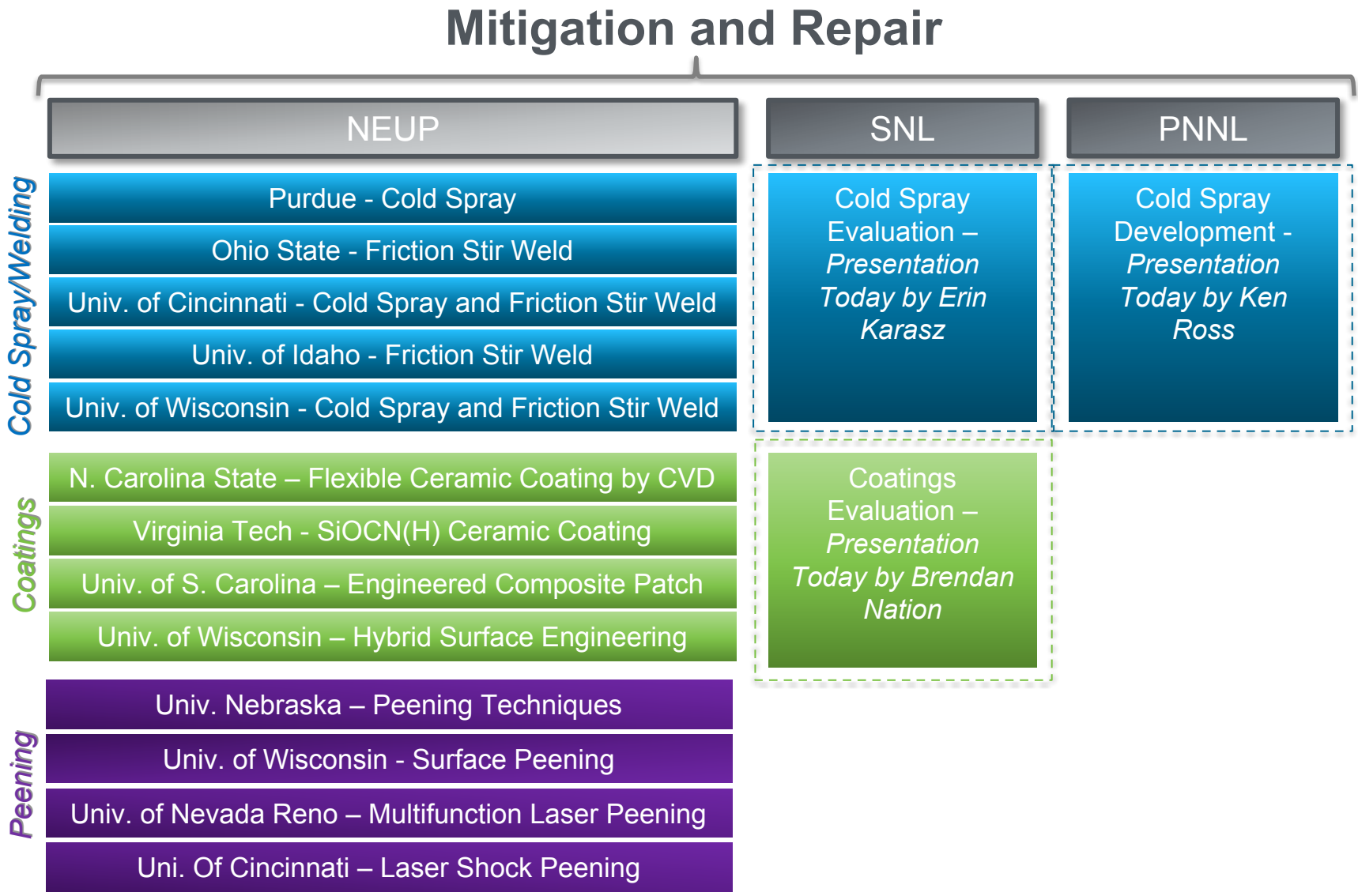
Chu et al., Dry Cask Storage System Welded Stainless Steel Canister Repair and Mitigation Guidance for Application and Acceptance. 2021 Technical Report. EPRI Report 3002020975

Bryan et al., FY16 Status Report: SNF Interim Storage Canister Corrosion and Surface Environment Investigations. 2016. FCRD-UFS-2016-000429

How Do We Mitigate and Repair?

There are several different potential technologies that could be used on SNF canister, though most require R&D to ensure their viability

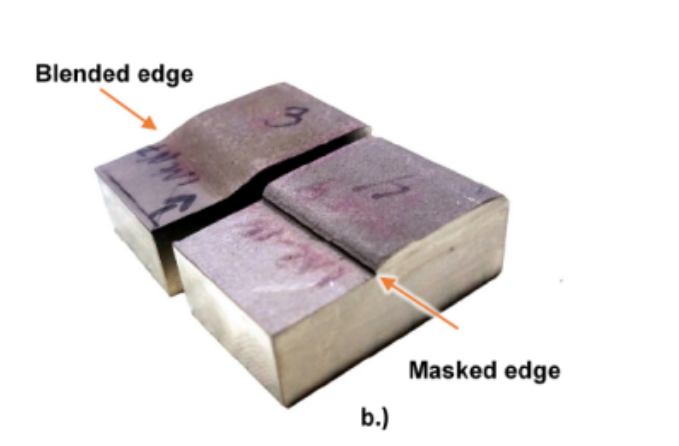
Golden Rule: Do no harm



How Do We Mitigate and Repair?

PNNL

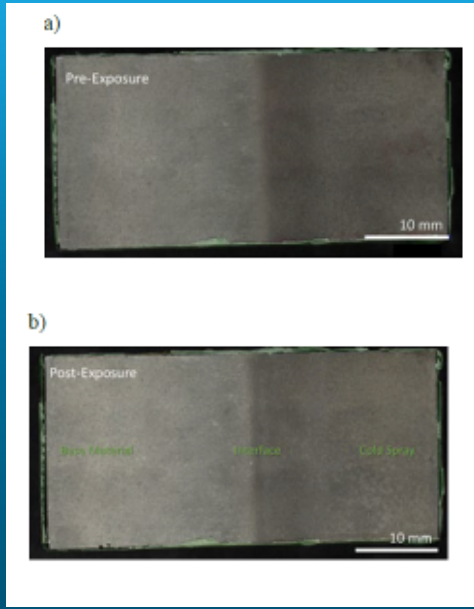
Cold Spray Development - *Presentation Today by Ken Ross*



DOE collaboration

SNL

Cold Spray Evaluation – *Presentation Today by Erin Karasz*



SNL

Coatings Evaluation – *Presentation Today by Brendan Nation*

Collaboration with Private Industry

Considerations for Storage and Transportation

- For mitigation and repair technologies to be implemented, there will be regulatory requirements
  - License Amendment Requests that summarize the changes being made to the canister to maintain compliance with the Final Safety Analysis Report and Certificate of Compliance.
    - This may be easier for some technologies than for others.
- Many considerations for how a technology can be implemented
  - Recent EPRI report summarized some of these considerations [Chu et al., 2021]
- Will the Mitigation or Repair technology require transportation to another site for application?
  - Must work with transportation team to identify specific requirements for this to be possible.

Considerations for Disposal

- Assuming the Mitigation/Repair was performed on **a canister destined for disposal**
  - Weld Techniques – generally falls within scope of performance assessment, especially if welding is performed with like or same material as the base metal
    - Weld residual stress could alter SCC susceptibility
    - Potential for galvanic effects, which may increased risk of corrosion and SCC
  - Coatings – typically organics have not been included in any repository performance assessment
    - Total amount of organic present on the canister
    - Impact of the organic materials on radionuclide transport
  - Must be in conversations with disposal researchers to ensure integration
- Assuming the Mitigation/Repair was performed on **a canister only used for storage**
  - None

Summary and Conclusions

- Identifying possible mitigation and repair techniques now is very important for minimizing the risk of CISCC as storage times increase.
- There are many active areas of research on the topic investigating a wide range of technologies
  - Differing technologies will allow for more comprehensive protection and possibly complimentary features
- There are significant considerations prior to implementation
  - Regulatory, application, disposal.
- There is a need to establish acceptance criteria that is comprehensive
  - Challenging due to the wide range of technologies considered.