NRC Research to Support Regulatory Decisions Related to Subsequent License Renewal Periods

C. E. (Gene) Carpenter, Jr.
Group Lead for Aging Management Issues
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Gene.Carpenter@nrc.gov

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

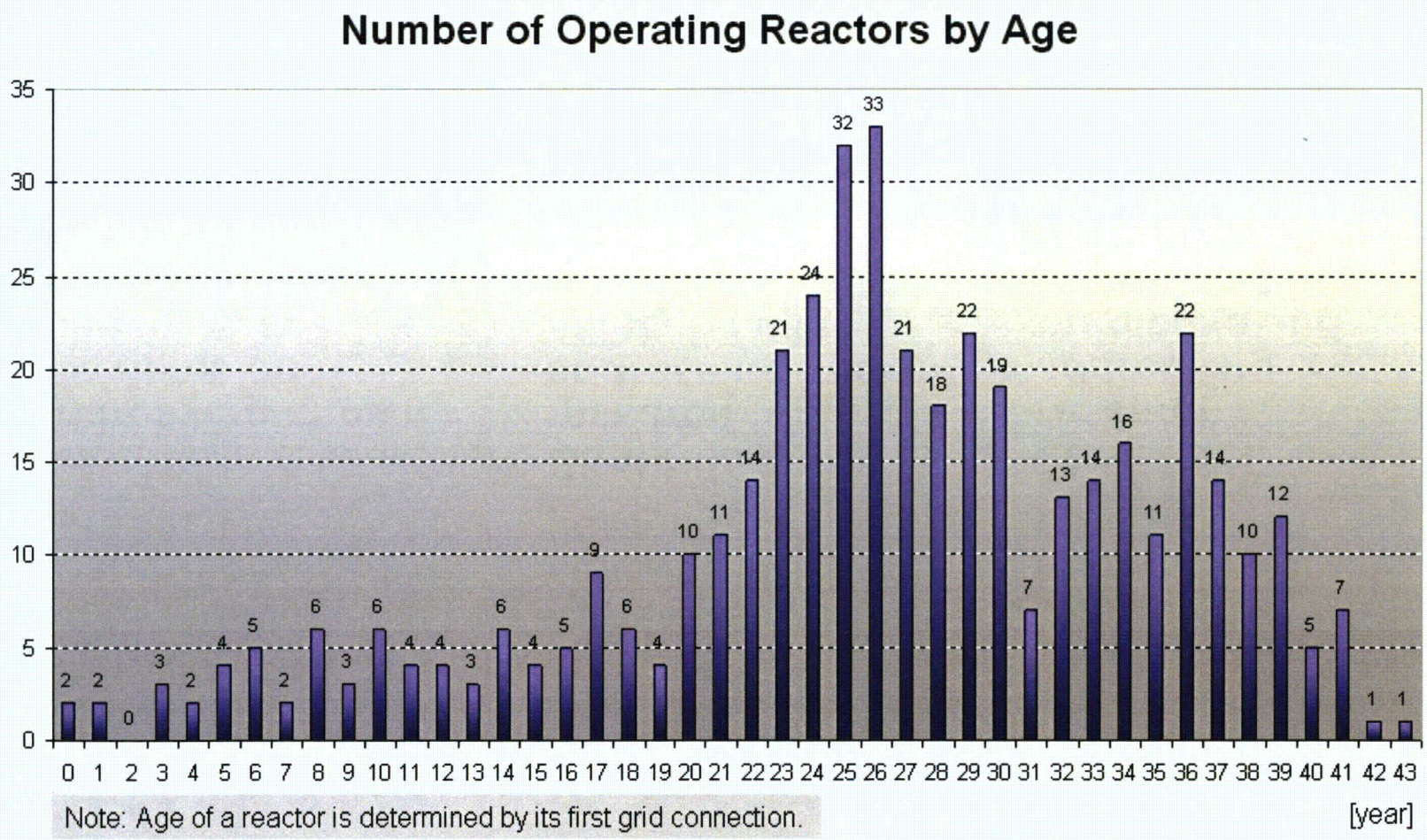
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

"I never think of the future, it comes soon enough."

Albert Einstein

Global Age of NPPs

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



Source: International Atomic Energy Agency; http://www.iaea.or.at/programmes/a2/

Integration of Domestic Nuclear Research Programs

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

INDUSTRY	NRC	DOE
• Profit motive / shareholder perspective • Short term research addressing known problems and managing costs / downtime	• Public health and safety protection perspective • Confirmatory research addressing known safety issues	• Long term national interest perspectives • Long term research addressing predictive and improvement opportunities
• Ex: IASCC – Better, faster weld repairs needed for reliability and reduce field repair times *Long Term Operability Program*	• Ex: Better testing and repair integrity assurance methods needed *Life Beyond 60 Program*	• Ex: Crack precursors and irradiation damage need to be understood for better predictions and future material selection *LWR Sustainability Program*

Individually, each program addresses a specific perspective; collectively, they address the majority of issues that need to be answered for safe extended operations.

NRC Aging Management Research

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Identify Degradation Scenarios Not Addressed in NUREG-1801, "Current Generic Aging Lessons Learned (GALL) Report"
  - Identify Inspection and Monitoring Programs and Associated Requirements for Highly Likely Degradation Scenarios
- Assess Results from Implementation of License Renewal Aging Management Programs and Recommend Improvements for Subsequent License Renewal Periods
- Develop Domestic and International Partnerships to Share Expertise, Capabilities and Resources Related To Aging Management Research

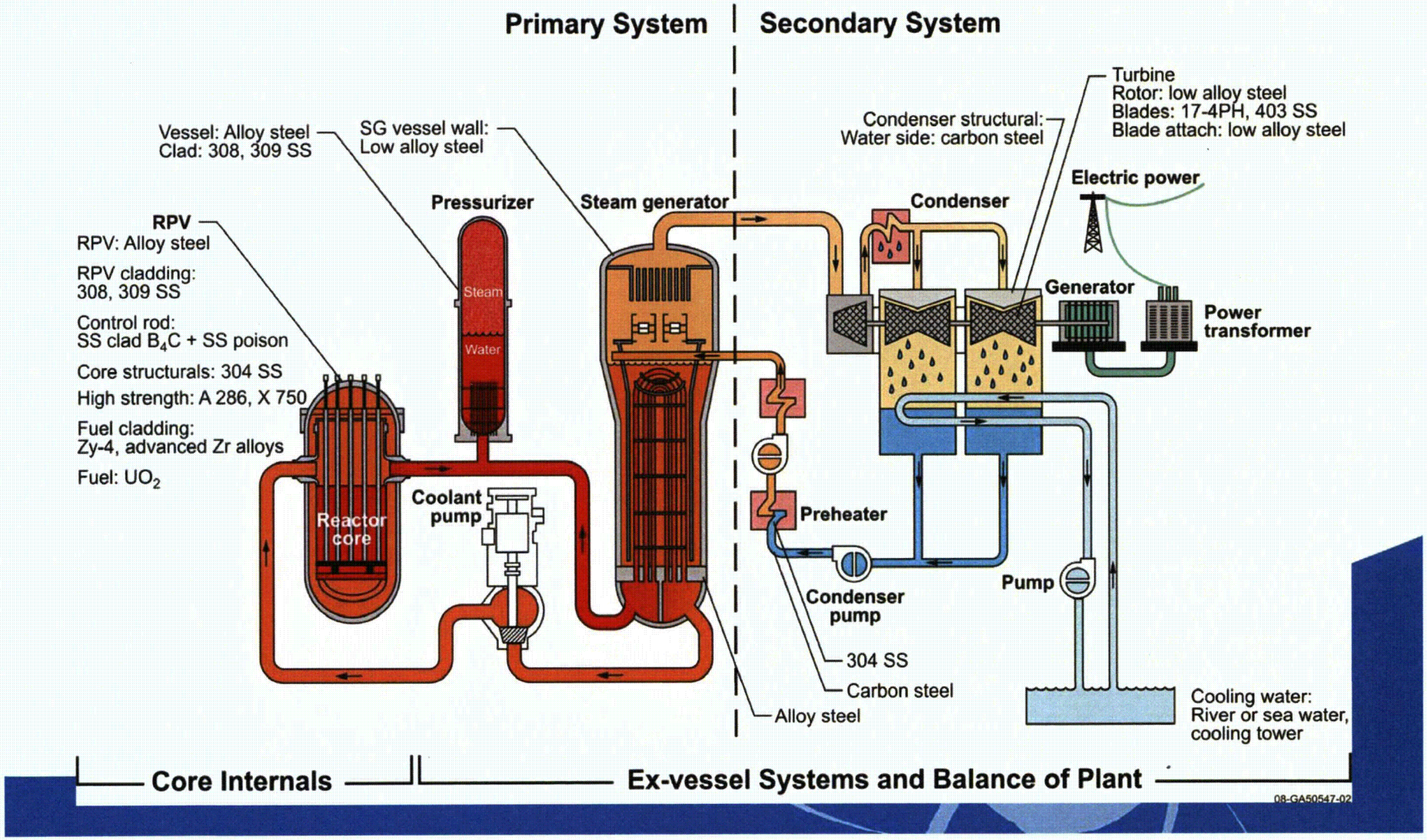
Materials Degradation Issues Key

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Extending safe operating life of NPPs will require comparing known modes of materials degradation, and identifying emerging degradation mechanisms, with expected service life to identify potential issues
  - Materials degradation can lead to increased maintenance, increased downtime, and increased risk
- Materials issues must be resolved for:
  - Reactor Pressure Vessels and Primary Piping
  - Core Internals
  - Secondary Systems
  - Weldments
  - Concrete
  - Cable insulation
  - Buried Piping

Aging R&D Areas

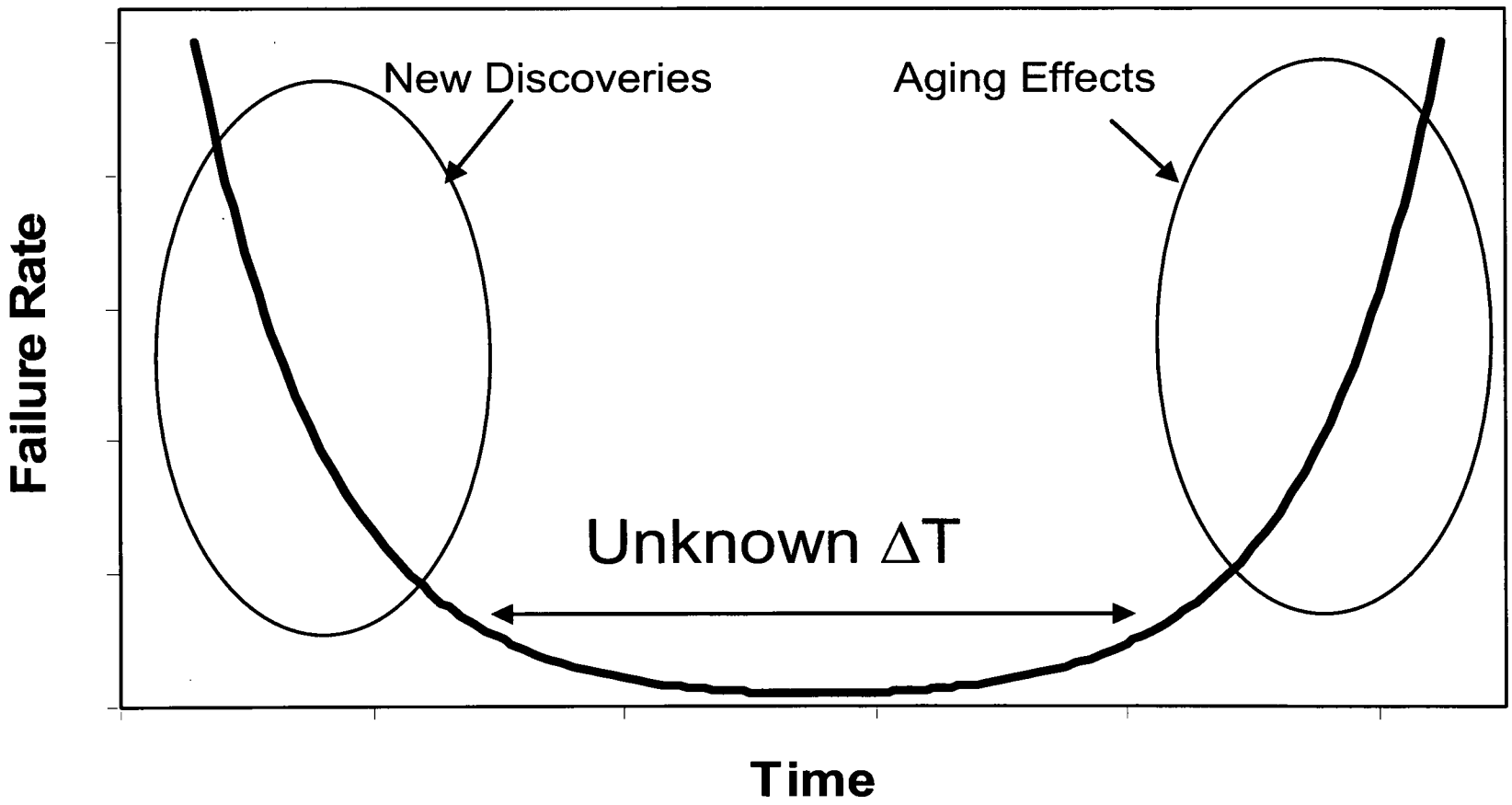
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



Aging Effects for Existing NPPs

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

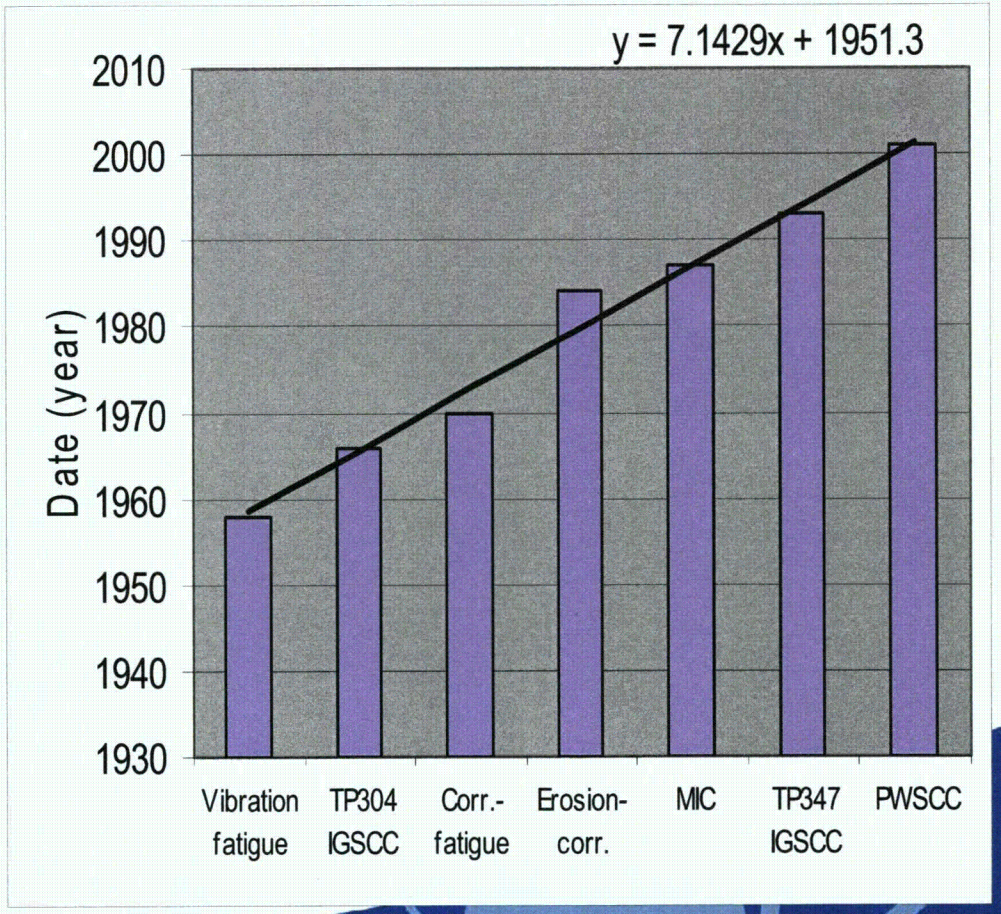
"Bathtub" Curve



Materials Degradation History

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- 1958 - Vibration Fatigue
- 1966 - IGSCC in 304 SS
- 1970 - Corrosion Fatigue
- 1984 - Erosion Corrosion
- 1987 - Microbial-Induced Corrosion
- 1993 - IGSCC in TP347 Stainless Steel
- 2001 - PWSCC
- ?????



Proactive Management of Materials Degradation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Develop information
  - Materials behavior
  - Mitigation or repair
  - Inspection or monitoring
- Proactively address potential future degradation
  - Avoid failures
  - Maintain integrity and safety
- Increase cooperation
  - Prioritize PMMD research with industry
  - Pursue additional international collaborations
- Evaluate existing requirements
  - Integrity of susceptible components
  - Inspection and monitoring regulations

Avoid Surprises e.g. V.C. Summer And Davis Besse

Expanded PMDA

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- NRC Developed NUREG/CR-6923, "Expert Panel Report on Proactive Materials Degradation Assessment"
  - Published February 2007
  - Scope encompassed passive components in primary, secondary and some tertiary systems of BWRs and PWRs, the failure of which could lead to a release of radioactivity or affect functionality of safety systems
- NRC updating and expanding PMDA to capture operating period beyond 60 years and to expand scope
  - EMDA will ascertain gaps in present level of understanding of materials degradation during subsequent license renewal periods
    - EMDA will look at materials in passive, long-lived systems, structures and components (e.g., RPV steels, concrete, cables, underground piping, etc.)
  - NRC and DOE LWRSP collaborating on developing EMDA

Metal Fatigue

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Analysis methodology could yield non-conservative results
- Potential delay in implementation of planned corrective actions to address aging
- Requiring license renewal applicants to demonstrate that their analysis results are conservative

Submerged Electrical Cables

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Cables not designed for continuous submerged service in electrical manholes
- Cable failure can disable safety systems
- Revised inspection procedures and program guidance to increase and expand inspection and test frequencies

Electric Cable Insulation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Cable failures worldwide increasing with plant age
- Cables provide power needed to operate equipment and transmit signals to and from the various controllers
- Research to confirm whether requirements for electrical equipment are being met through an extended period

Steel Containment and Liner Plate Degradation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Corrosion due to water leakage or contact with wood or foreign objects
- Potential impacts on structural integrity and leak tightness
- Obtained applicant commitments for additional inspections and increased maintenance; issuing advisory to other licensees

Neutron Absorber Degradation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Long-term use of neutron absorbers in spent fuel pools leads to deformation and degradation of the materials
- Potentially reduce safety margins and violate subcriticality requirement
- Developed new aging management program for neutron absorbing materials degradation

Refueling Cavity/Spent Fuel Pool Leakage

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Concerns regarding the impacts of historical water leakage from concrete walls and floors
- Potential effect on structural integrity and leak tightness
- Obtained commitments from license renewal applicants

Buried Piping

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Corrosion on soil side of piping
- Potential effects on system safety, releases of hazardous material
- Enhanced agency guidance to increase inspections and focus on key preventive measures

Prolonged Concrete Exposure to High Temperature and Radiation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Prolonged exposure to elevated temperatures and radiation facilitates chemical interactions and induces strains
- Compromise concrete performance
- Research on sufficiency of current methods to evaluate effects and the effects themselves

Reactor Vessel and Internals

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Irradiation embrittlement of vessels and internal components
- Life-limiting factor for the reactor vessel and internals
- Compiling a comprehensive database of worldwide embrittlement information and conducting research on conditions to which reactor vessel internals are exposed

AMP Assessments

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Staff is preparing to assess the ability of Licensees' Aging Management Programs to successfully detect and manage aging degradation of safety-related systems, structures and components

International Forum for Reactor Aging Management

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- IFRAM promotes worldwide cooperation to address NPP aging management issues
  - Cooperation includes sharing of data and specimens as well as facilitating joint research agendas and promoting work that addresses high priority issues and concerns.
- Participation in IFRAM provides an extended pool of resources and expertise to work on common problems
  - Promote global cooperation on management of reactor aging
  - IFRAM does not replace any existing cooperative efforts
- IFRAM's rationale is that:
  - Organizations worldwide share common challenges
  - Magnitude and scope of these challenges is beyond what any one organization can accomplish with their limited time and resources
  - Cooperation is a powerful tool to economize resources, save time and minimize needless duplication of efforts in addressing these challenges

Concept Behind IFRAM

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- IFRAM will consolidate available information, coordinate cooperation on activities, facilitate information exchange and provide opportunities to bring together different national and regional views on topics and, where appropriate, harmonize agreed-upon best practices
- IFRAM will cooperate with many parties and cut across numerous kinds of boundaries but it will not replace any cooperation efforts that currently exist
  - Its basic role is to facilitate research and information sharing
- IFRAM is <u>not</u> intended to be an NRC-led (or regulatory-led, utility-led, university-led, or research organization-led) entity
  - Since membership in IFRAM is open to all organizations, leadership roles will be given those members willing to support IFRAM's goals.

Conclusions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Research is necessary to establish basis for long-term operation of existing nuclear plants beyond 60 years, and this research will:
  - Answer safety questions on aging, reliability, and long-term operability of systems, structures and components
- Industry has lead role to drive the process and identify issue resolutions
  - Ultimately, life extension is utility business decision
- NRC ensures that safety-significant issues are identified and resolved in a timely manner
  - It is **not** NRC's responsibility to resolve any potential aging issues that may impact continued safe operation of existing fleet
  - NRC seeking to cooperate/collaborate with DOE, domestic industry and international partners in an integrated, holistic program to ensure long-term safety

FERC

Federal Energy Regulatory Commission

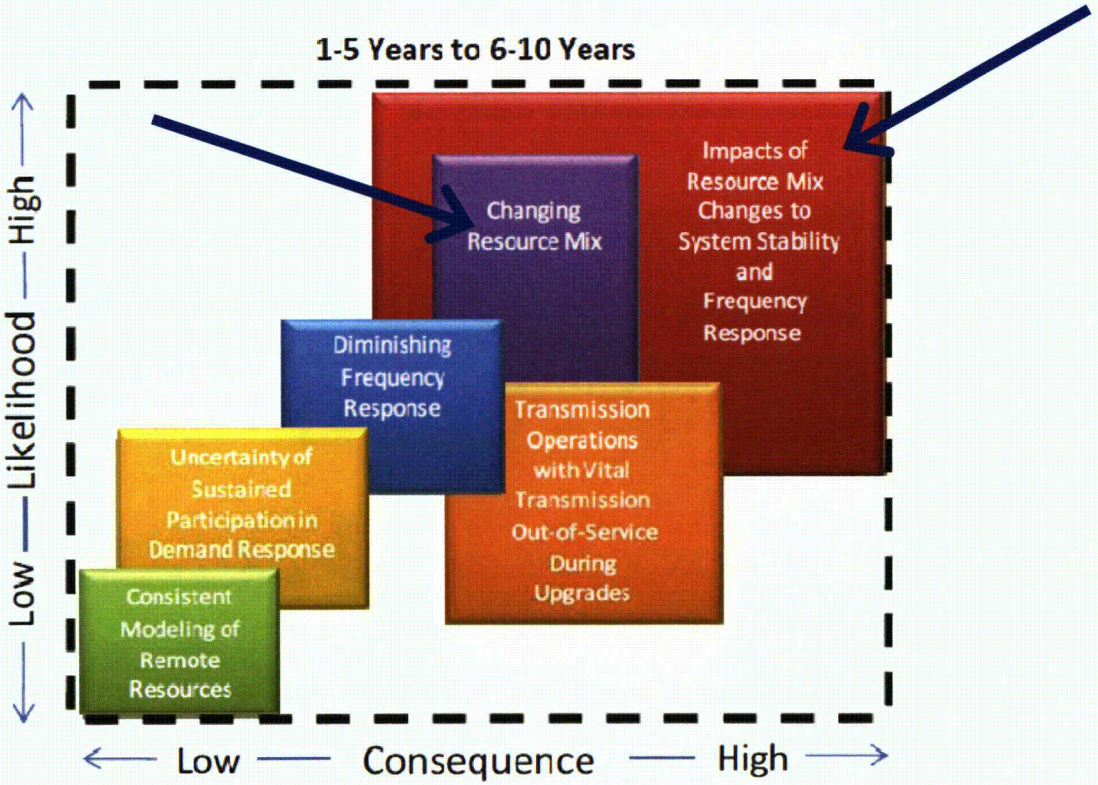
Reliability Implications of a Changing Generation Mix

David Andrejcak
Office of Electric Reliability
Federal Energy Regulatory Commission

FERC

Federal Energy Regulatory Commission

Emerging Issues



Source: 2010 NERC Long-Term Reliability Assessment

FERC

Federal Energy Regulatory Commission

Generation Mix Is Changing

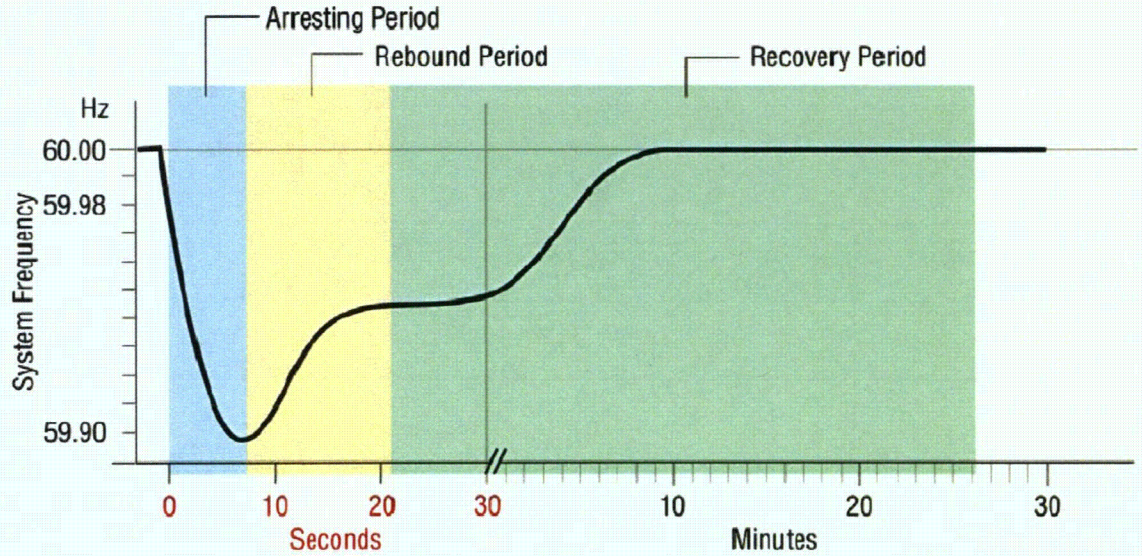
Fuel	2010	2019 Projected
Coal	31%	26%
Gas	29%	30%
Dual Fuel	11%	13%
Nuclear	11%	12%
Hydro	12%	9%
Renewables	1%	5%
Other	4%	5%
Total	100%	100%

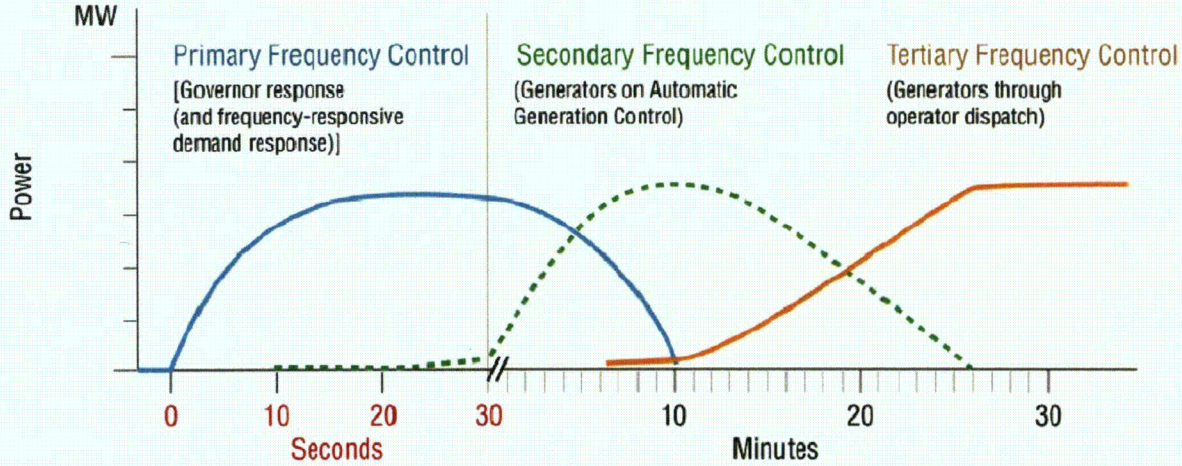
Source: 2010 NERC Long-Term Reliability Assessment

FERC

Federal Energy Regulatory Commission

Primary Frequency Control





FERC

Federal Energy Regulatory Commission

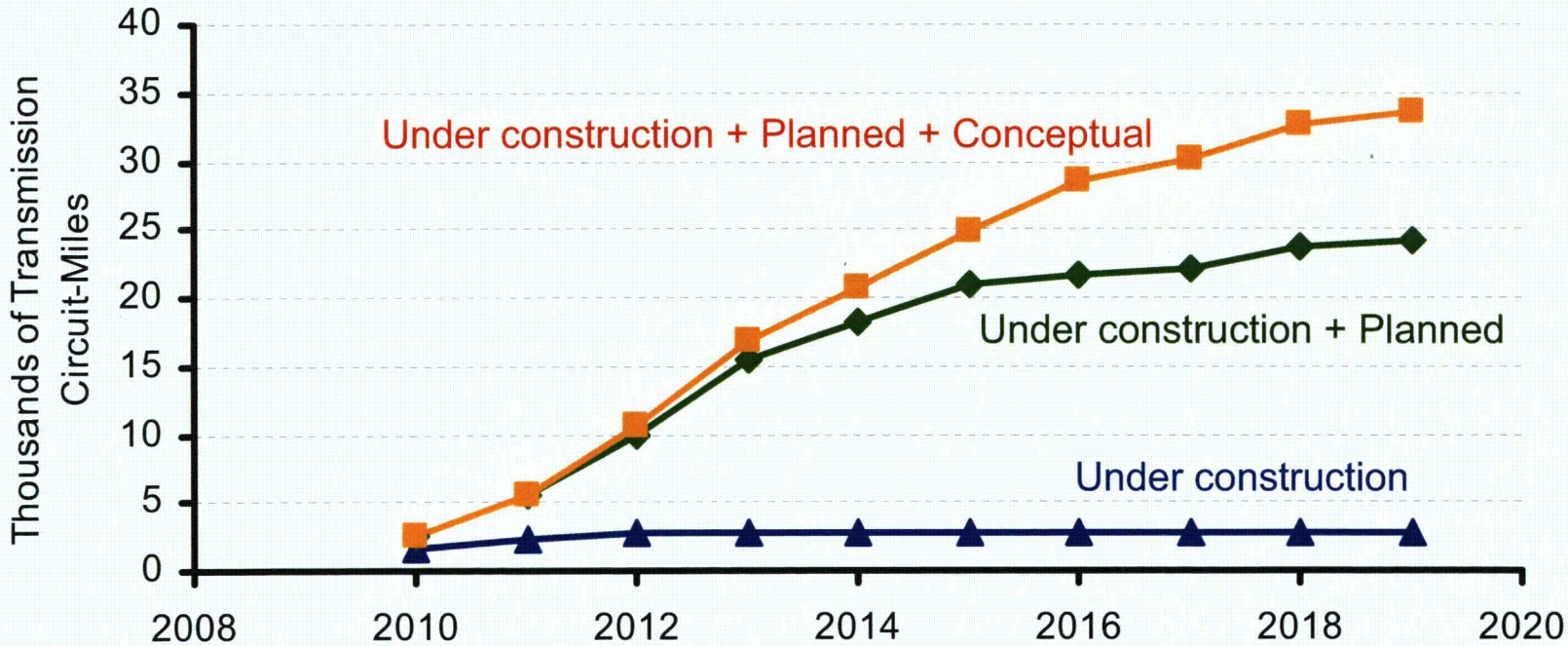
Operating reserves

- Larger generating units may require increased contingency reserves
- Planners and design engineers need to avoid single points of failure in plants or switchyards
- Ability to reduce generation during minimum load periods may be desirable

FERC

Federal Energy Regulatory Commission

Transmission



Source: 2010 NERC Long-Term Reliability Assessment

FERC

Federal Energy Regulatory Commission

Thank you

Clean Water Act Section 404 : *Introduction/Overview*

U.S. Nuclear Power Plant Life Extension Research and Development
February 22, 2011, Washington DC

PURPOSE

To provide an overview of Section 404 of the Clean Water Act for Federal, State, and Tribal persons seeking permits to dredge or fill waters of the U.S.

Background

- Rivers and Harbors Act of 1899
- EPA established in 1970
- Water Pollution Control Act Amendments of 1972
  - "...to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."
- 1977 Clean Water Act
  - Reauthorized and expanded '72 Act

CWA SECTION 404 PROGRAM

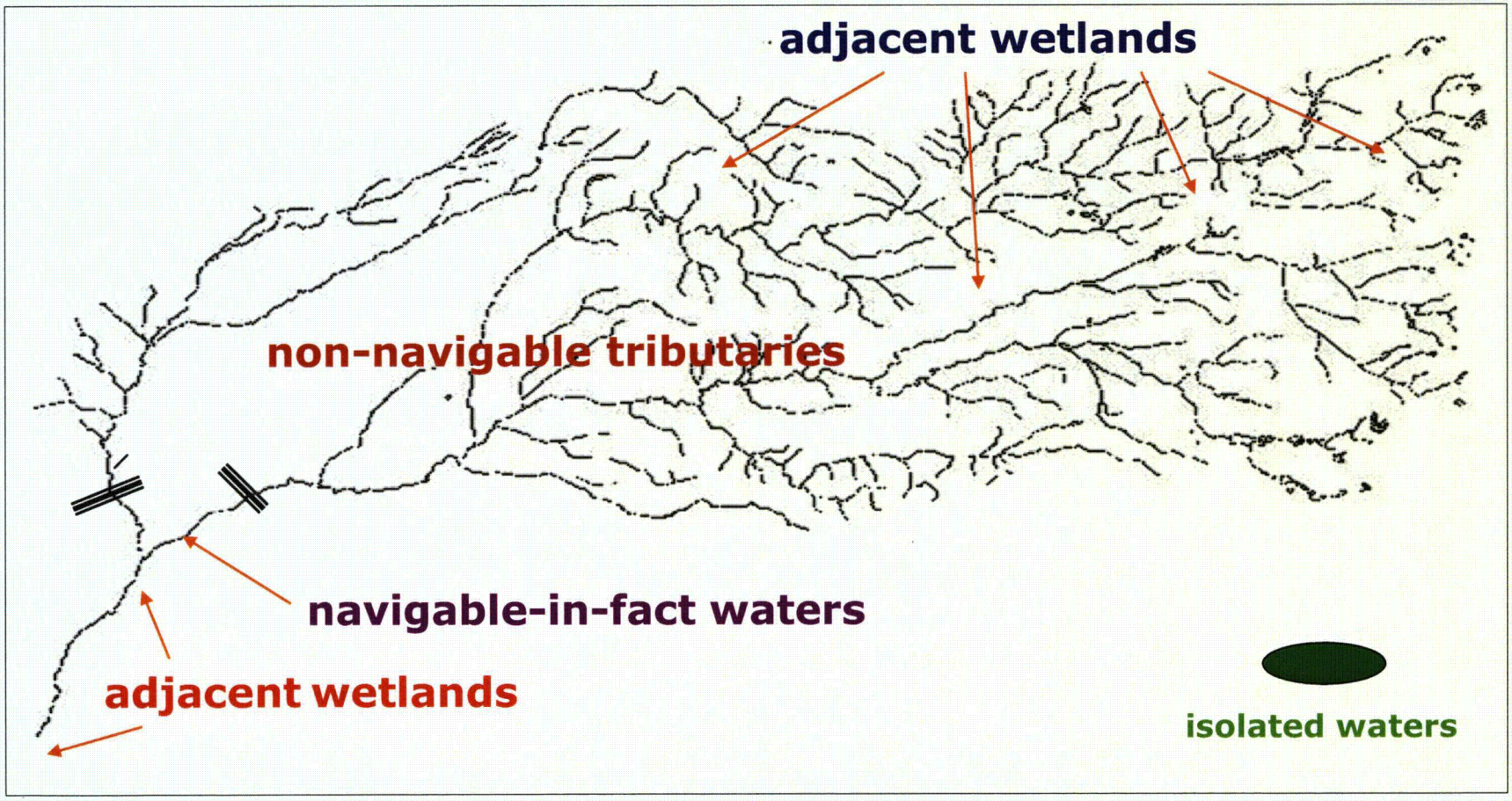
- Section 404 establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands.

- Basic premise of the program is that no discharge of dredged or fill material can be permitted
  - if a <u>practicable alternative</u> exists that is less damaging to the aquatic environment or
  - if the Nation's waters would be significantly degraded.

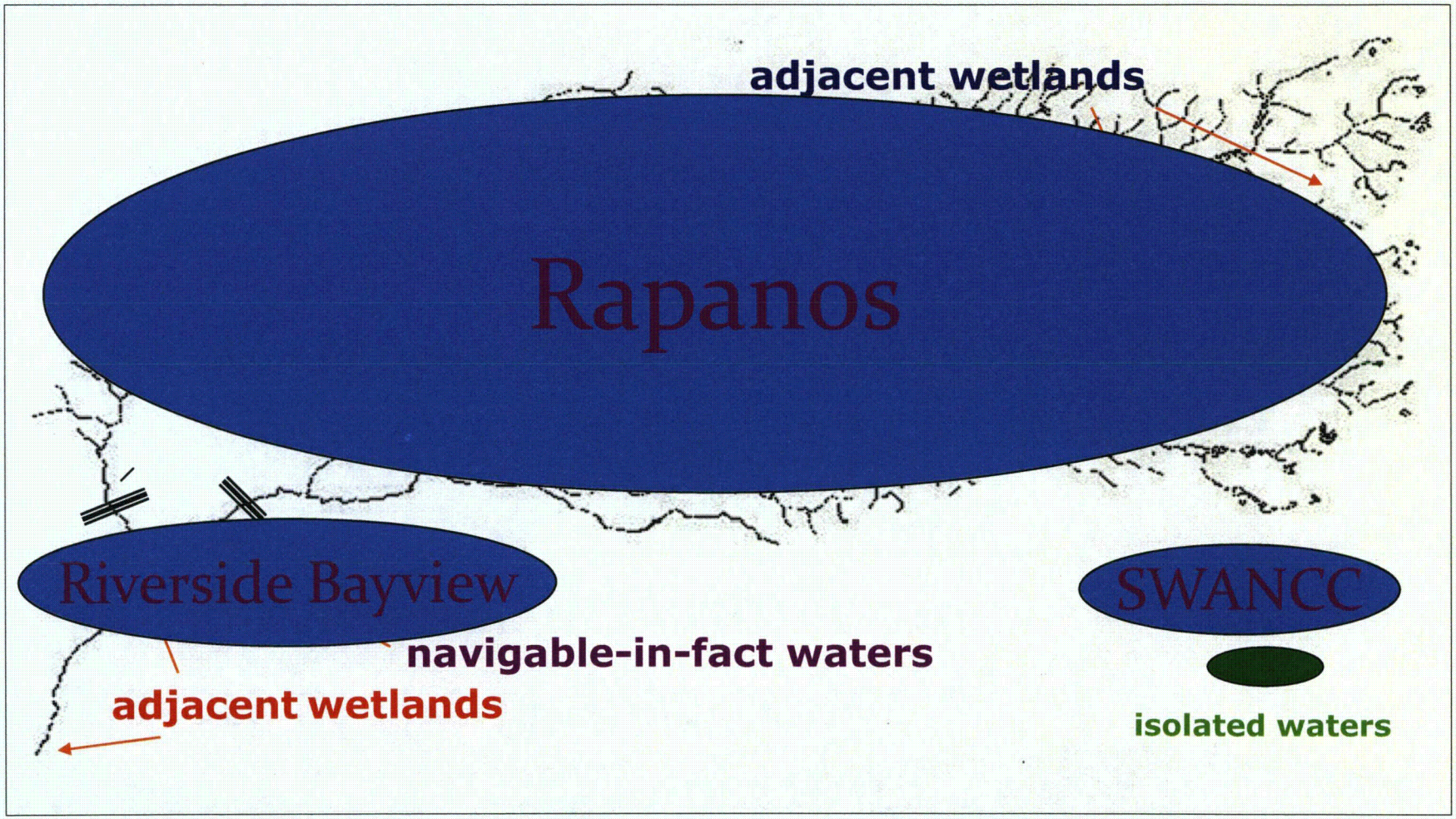
Regulatory Definition of "Waters of the United States"

- Waters used in interstate commerce in the past, present, or future with reasonable improvements
- Interstate waters and wetlands
- All other waters such as intrastate lakes, rivers, streams, wetlands, etc., the use, degradation, or destruction of which could affect interstate commerce
  - Presence of interstate travelers
  - Extraction of fish or shellfish
  - Use for industrial purposes
- Impoundments of waters of the US
- Tributaries of above waters
- Territorial seas
- Wetlands adjacent to above waters

"Waters of the United States": The Regulations in Graphic Form



CWA Geographic Jurisdiction: The Regulations Addressed by the Supremes



Reach and Scope of Section 404

- Section 301: generally prohibits the "discharge of a pollutant" unless authorized by Section 404 or by Section 402

- Section 502(12): discharge of a pollutant consists of 4 elements:
  - 1) "addition" of
  - 2) "any pollutant" to
  - 3) "navigable waters" from a
  - 4) "point source"

"Pollutant"

- **Key issue** for deciding 404 vs 402:
  Is it fill material or waste?

- **Broadly defined in § 502(6)**

  - Sewage
  - Garbage
  - Munitions
  - Cellar dirt
  - Agricultural waste
  - Incinerator residue
  - Dredged spoil
  - Biological materials

Fill Rule: 404 versus 402

Preamble:

- "EPA has never sought to regulate fill material under effluent guidelines"
- Discharges subject to an ELG "will continue to be regulated under section 402 of the CWA"

Rule Language:

- Silent on ELGs
- Specifically calls out mining related materials (with effect of fill) as fill material

Types of Section 404 Permits

- ***General Permits*** (minimal individual & cumulative impacts)
  - Include nationwide, state, regional and programmatic permits

- ***Individual Permits*** (>minimal impacts)
  - Public notice & agency review
  - Include standard permits and Letters of Permission

404(b)(1) Guidelines

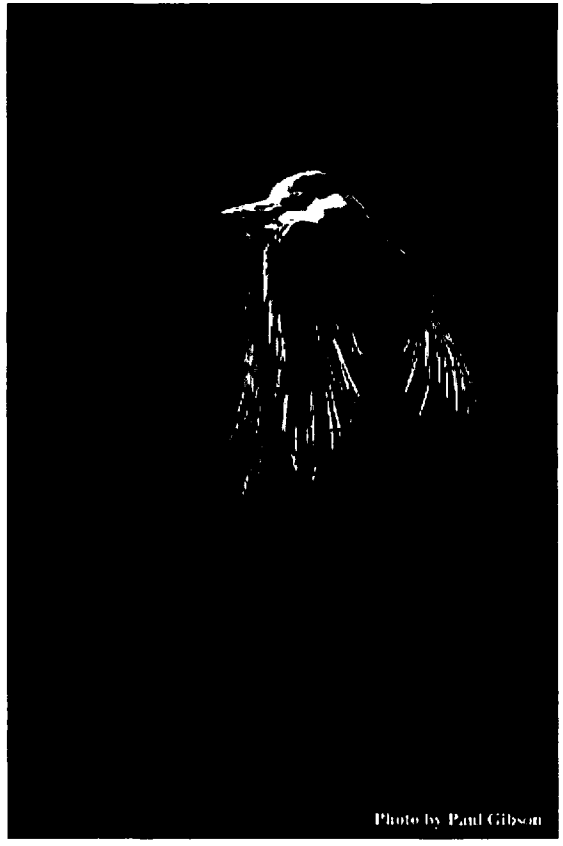
- Purpose is to restore chemical, physical, and biological integrity
- Prohibit discharges that result in unacceptable adverse environmental effects
- Binding substantive rules
- The burden to demonstrate compliance with the Guidelines rests with the permit applicant
- Applicable to Section 404 Program, Corps' Civil Works Program and State-assumed 404 programs

Section 404(b)(1) Guidelines

- Sequencing:
  - *Avoid* (select least environmentally damaging practicable alternative)
  - *Minimize* (reduce on-site project impacts)
  - *Compensate* (restore, create, enhance, or, in exceptional circumstances, preserve wetlands to offset impacts)
- Significant degradation
- Section 401 water quality certification, ESA
- Corps public interest review

General Restrictions established by Guidelines

- Alternatives Analysis
  - LEDPA required
- Significant degradation
- Measures to minimize adverse effects
- Must not:
  - violate WQ standards,
  - jeopardize T&E species
  - violate requirements protecting marine sanctuaries



Agency Roles and Responsibilities

U.S. Army Corps of Engineers

- administers day-to-day program
- makes individual and general permit decisions
- develops regulatory policy and guidance
- conducts or verifies jurisdictional determinations
- shares enforcement role with EPA
- ensures permits comply with 404(b)(1) Guidelines, NEPA, Historic Preservation Act, ESA, etc.

Agency Roles and Responsibilities

U.S. EPA

- develops environmental guidelines, policy, and guidance
- determines geographic scope of jurisdiction
- approves and oversees State assumption
- reviews permits
- maintains Section 404(q) "elevation" and (c) "veto" authority
- identifies exempt activities
- shares enforcement role with Corps

Permitting Process

- Application received by the Corps District, reviewed for completeness, and processed
- Public Notice Comment Period (typically 30 days)
- Comments evaluated and an EA or EIS prepared and/or public hearing scheduled if necessary
  - Sometimes, a 404 permit comes well after the NEPA process has begun. If appropriate, raise 404 issues in NEPA comments

Permitting Process

- Comments evaluated in context of 404(b)(1) Guidelines and public interest
- Permit decision
- Section 404(q) elevation and/or Section 404(c) "veto" *(optional)*
- Permit issued, revised or denied

Sections 404(q) & 404(c)

- 1992 MOA establishes a process to resolve differences and elevates permit decisions and policy issues to HQ level under Section 404(q)
  - For cases that involve unacceptable adverse effects on an aquatic resources of national importance (ARNIs)
  - Cause resource damages similar in magnitude to cases evaluated under 404(c)
  - The final decision on the need to elevate a specific individual permit case rests solely with the ASA(CW).
- Section 404(c) prohibits or restricts specification of defined area as disposal site

CWA Section 404(q)

...the Secretary shall enter into an agreement with the Administrator, the Secretaries of the Departments of Agriculture, Interior, and Transportation, and the heads of other appropriate federal agencies to minimize, the maximum extent practicable, duplication, needless paperwork, and delays in the issuance or permits under this section....

- Goal: minimize duplication and needless paperwork in issuance of permits
- Timely permit decisions

1992 MOA: Part IV Elevation of Individual Permit Decision

- For cases that involve **unacceptable adverse effects** on an **aquatic resources of national importance** (ARNIs)
- What is an ARNI?
  - Cause resource damages similar in magnitude to cases evaluated under 404(c)
  - Previous cases elevated under 404(q)
- Assistant Secretary for Army (Civil Works) (ASA(CW)) has final decision on the elevation request

Individual Permit Decision Elevation Procedures (continued)

Step 1: 3(a) letter ("**may effect**")

- This letter must be signed by the RA (or designee) within the basic or extended comment period

Step 2: 3(b) letter ("**will effect**")

- This letter must be signed by the RA and thus requires Regional communication between staff and Regional management
- Within 25 calendar days of end of comment period

Step 3: DE alerts RA

- Notice of Intent (Day 0)
  - Day 0 --- receipt of PN, notification docs
  - if there is any question as to timing, contact Corps
- RA engages in discussion with the DE in an attempt to resolve outstanding issues

Step 4: RA decides whether to request higher level review

- Within 15 calendar days of the NOI
  - if so RA must notify DE by faxed letter if higher level review is sought
- DE holds permit in abeyance pending HQ elevation
- This starts 20 calendar day clock for EPA HQ to complete elevation packet

Individual Permit Decision Elevation Procedures (continued)

Step 5: Assistant Administrator for the Office of Water (AAOW) decides whether to request ASA(CW) review

Step 6: ASA(CW) reviews AAOW request

Step 7: If denied, EPA decides whether to initiate 404(c) action

CWA Section 404(c)

...The Administrator (now delegated to AAOW) is authorized to prohibit the specification (including withdrawal of specification) of any defined area as a disposal site and he/she is authorized to deny or restrict the use of any defined area for specification (including withdrawal of specification) as a disposal site...

- **Prohibit or restrict specification** of defined area as disposal site
- 404(c) process starts in the Regions; ends at HQ
- The ensure avoidance of unacceptable adverse effects
- May be used before, during or after Corps action on a permit application
- May be used in absence of permit application
- **EPA has the final decision and burden of proof**

Section 404(c)

- Under Section 404(c), EPA must determine that the discharge of dredged or fill material will have an **unacceptable adverse effect** on either:
  - Municipal water supplies;
  - Shellfish beds and fishery areas (including spawning and breeding grounds);
  - Wildlife; or
  - Recreational areas.

Section 404(c) Process

- Region's Letter of Initiation ("15-day letter"): intent to issue a public notice
  - RA states intention to issue a Proposed Determination to withdraw, prohibit, deny, or restrict

Section 404(c) Process

- Region's Proposed Determination
  - If within 15 days of LOI no satisfaction; PD can be issued
  - PD must be published in Federal Register
  - PD does not represent a judgment; merely that RA believes issue should be explored (non-conclusive)
  - Public Comment period/public hearing
  - If appropriate, withdraw PD (EPA HQ has option to review)

Section 404(c) Process

- Region's Recommended Determination
  - RA forwards RD and administrative record to AAOW
  - Within 30 days of receipt AAOW initiates action

Section 404(c) Process

- EPA Final Determination
  - Within 60 days of the receipt of RD and administrative records – AAOW makes FD affirming, modifying or rescinding RD
  - Notice of FD must be published in Federal Register

Back to the Beginning

- **Section 404 applies when you have:**
  - A discharge
    - More than "incidental fallback"?
  - Of dredged or fill material
    - Fill rather than waste?
  - From a point source
    - Bulldozer or similar equipment, or channelized?
  - Into waters of the United States
    - Meets any of the Supremes' standards?
- **Consider each of these in turn, to decide if the CWA applies and a section 404 permit needed**

Questions?

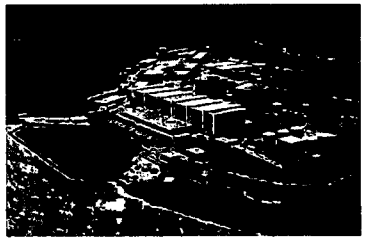
Abu Moulta Ali
Environmental Scientist
Wetlands Division
Office of Wetlands, Oceans, and Watersheds
Moulta-ali.abu@epa.gov
(202) 566-1068
http://www.epa.gov/owow/wetlands/

CENG

a joint venture of

Constellation Energy

EDF



DOE/EPRI/CENG NPLED Project Activities at Ginna and Nine Mile Point 1

Workshop on Nuclear Plant Life Extension Research and Development

Mark Flaherty
Manager, CENG Fleet Nuclear Engineering

February 22, 2011

Agenda

- Origin of Project
- Summary of Project Activities to Date
- Project Results

CENG
a joint venture of
Constellation Energy EDF

Origin of Project

- After the 1st Life Beyond 60 Workshop in 2008, new NEI Life Beyond 60 Working Group (LB60WG) was formed
- LB60WG developed a list of potential technical challenges for operation past 60 years
- Presented to DOE, EPRI, and the NRC – became the Issue Tracking Table (ITT)
- In August 2009, EPRI Long Term Operability (LTO) Project Advisors recommended the selection of a pilot plant for ITT issue evaluation

CENG
a joint venture of
Constellation Energy EDF

Origin of Project (cont'd)

- EPRI collaborated with DOE's Light Water Reactor Sustainability (LWRS) Program to form the Nuclear Plant Life Extension Demonstration (NPLED) Project
- Early in 2010, the CENG CEO and CNO met with EPRI and offered Ginna and NMP1 as pilot plants for the project
  - Wanted to provide a means to evaluate technical challenges that could adversely affect the business decision for application to operate beyond 60 years
- In the signed CENG, DOE, and EPRI agreement, the project scope focused on 2 areas identified in the ITT
  - Reactor Vessel Internals (RVI)
  - Containment
- Initial duration of the project was set at 3 years with the option of duration expansion

CENG
a joint venture of
Constellation Energy EDF

Summary of Project Activities to Date

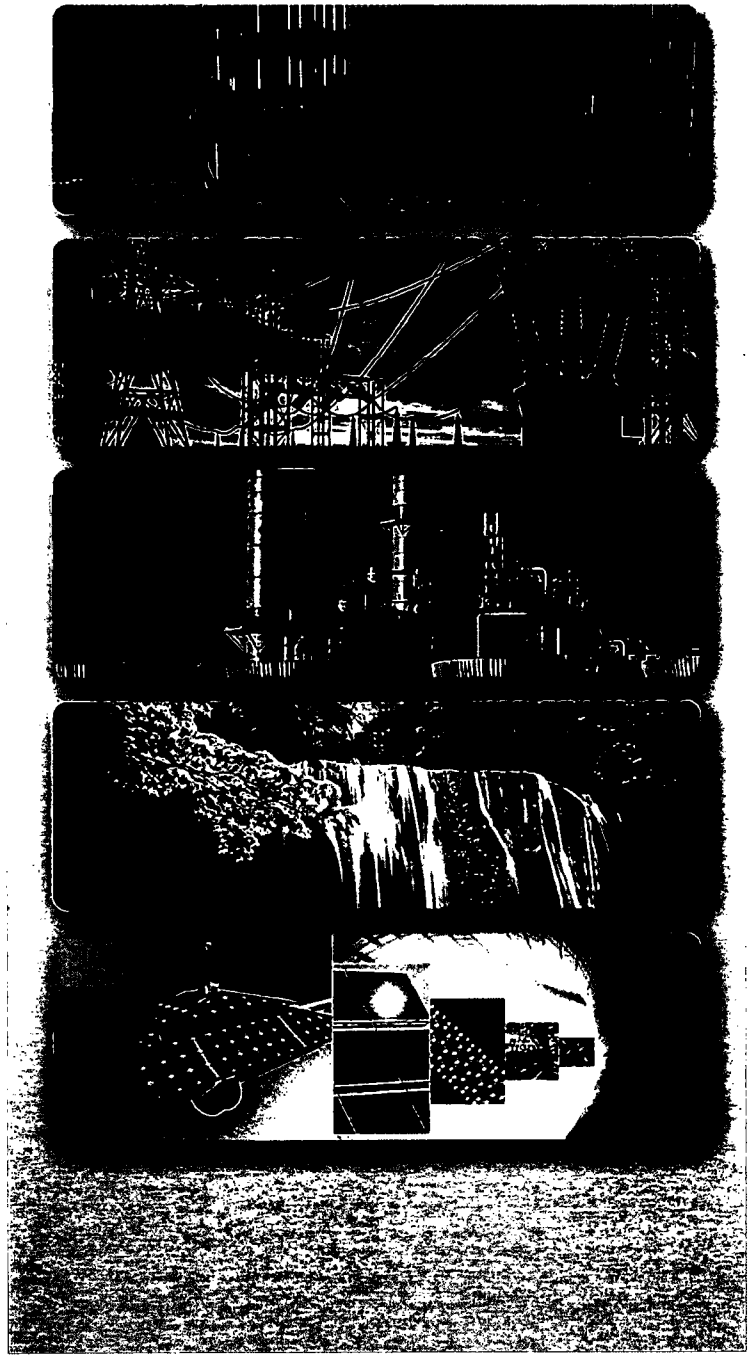
- Planning meetings between DOE, EPRI, and CENG
  - Currently conducting weekly calls
- EPRI/Lucius Pitkin data collection
- Observations of Ginna inspections/tests
- Significant EPRI/Lucius Pitkin interfacing with Ginna Subject Matter Experts
- Conduct of methodology demonstrations at Lucius Pitkin offices/lab (10/10) and Lehigh University (12/10)

CENG
a joint venture of
Constellation Energy EDF

Project Results

- This is a research project
  - CENG is not planning to use the results from this project for any aspect of plant operation
  - CENG is not planning to use any project data as input for any future License Renewal Applications that may be generated for CENG plants
- Focus is on risk identification and mitigation

CENG
a joint venture of
Constellation Energy EDF



ELECTRIC POWER RESEARCH INSTITUTE

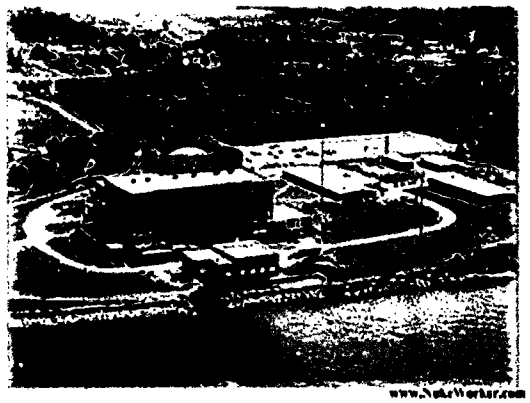
Workshop on Life Beyond 60

EPRI/DOE/CENG Demonstration Plant Project: EPRI Perspective

Rich Tilley
Sr. Project Manager
LTO Project

February 22, 2011

Agenda



- Constellation Demonstration Project
  - Joint effort with EPRI, DOE, CENG – Nuclear Plant Life Extension Demonstration Project
    - General agreement regarding effort and coordination
  - Planned activities for Ginna and NMP1
    - Outages related activities for 2011
    - Longer term efforts
  - EPRI role and deliverables

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Project Description

- DOE Light Water Reactor Sustainability ("LWRS") Program, EPRI's Long Term Operation ("LTO") Project and Constellation will jointly investigate the technical issues and demonstrate, as appropriate, analysis methods necessary to support nuclear plant life extension to 80 years.
- Constellation's Ginna and Nine Mile Point Unit 1 nuclear power stations will be used as the pilot plant sites due to their age and representation of the PWR and BWR technologies.
- **Work specifically for license renewal application submittals is not expected.**

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Technical Focus

- Specific technical areas for 80 years of life include:
  - Identify potential life-limiting issues
  - Additional time-dependent aging mechanisms
  - Additional aging management requirements
  - Life Cycle Management methods
  - Refurbishment and modernization opportunities
- DOE focus on science and understanding of general (US nuclear fleet) application and impact
- EPRI focus on expansion and refinement of current guidance approach for extended life (40 to 60 years)
- **Guidance for beyond 60 years to be jointly developed and reviewed**

© 2011 Electric Power Research Institute, Inc. All rights reserved.

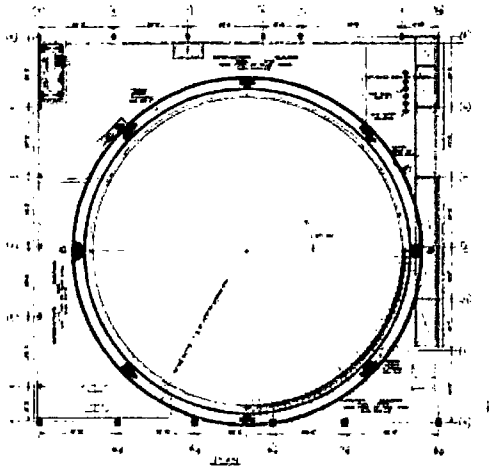
Baseline Considerations

- Ginna in extension to 60 years
  - Implementing inspection and assessment recommendations from EPRI Materials Reliability Program report (MRP-227) for operation to 60 years
  - Refueling Outages planned in 2011 and 2012

- NMP1 in extension to 60 years
  - Implementing inspection and assessment recommendations from EPRI BWR Vessel and Internals Program (BWRVIP)
  - Refueling Outages planned in 2011 and 2013

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Ginna Spring 2011 Outage Activities



- Specific Work Scope Established
  - Containment Assessment
    - Pre-outage activities at site are in progress
      - Strain measurements and digital image correlation work to assess new approaches and technologies
  - Internals Assessment
    - First application of MRP-227 guidance
      - Review inspections and results
    - Post irradiation examination of a sample of baffle bolts

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Inspection Plan – MRP-227

- **The development of screening criteria, with susceptibility thresholds for the eight postulated aging mechanisms relevant to reactor internals and their effects**
  - Irradiation-assisted stress corrosion cracking, stress corrosion cracking, stress relaxation and creep, thermal aging embrittlement, irradiation embrittlement, wear, fatigue, and void swelling
- **Categorization of PWR internals components (using the screening criteria) into categories based on significance of susceptibility to the aging effects.**
- **Functionality assessments based on representative plant designs of PWR internals components to determine the effects of degradation mechanisms on functionality so that these components can be managed appropriately.**
- **Note that MRP-227 will be applied to Ginna to confirm that operations will continue to be conducted in accordance with the current licensing bases for the reactor vessel internals**

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Ginna Aging Management Program

- **PWR internals components placed into four functional groups**
  - **Primary**: internals components highly susceptible to the effects of at least one of the eight aging mechanisms and requiring specific management of those effects
  - **Expansion**: components highly or moderately susceptible to at least one of the eight aging mechanisms but having a degree of tolerance to those effects
  - **Existing Programs**: components susceptible to at least one of the eight aging mechanisms and where existing AMP elements are managing those effects
  - **No Additional Measures**: the effects of all eight aging mechanisms are below the screening criteria
- **Demo Project will examine processes and results relative to assuring safety and reliability beyond 60 years of operations**

© 2011 Electric Power Research Institute, Inc. All rights reserved.

EPRI Objectives - Ginna

- Industry Guidance regarding Technical Bases and Confirmatory Actions for Potential License Extension beyond 60 Years
  - Vessel Internals
    - Feed updates to MRP-227 process
  - Vessel
    - Considerations for LB60 especially focused on surveillance program needs and understanding potential high dose effects
  - Containment
    - Enhanced assessment guideline planned
  - Other Plant Equipment as Deemed Appropriate
- Create a series of documents and periodic updates

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Nine Mile Point Unit 1 Spring 2011 Outage Activities

- Specific Work Scope Established
  - Vessel and Internals Inspections
    - Implementation of BWRVIP recommendations
  - Containment
    - Baseline
      - No specific issues currently identified
  - Longer term efforts
    - Disposition of current supplemental surveillance capsules (2)
      - Not part of BWRVIP Integrated Surveillance Program
    - Potential future outage action to assess cracking in top guide
      - Irradiation assisted stress corrosion cracking likely

© 2011 Electric Power Research Institute, Inc. All rights reserved.

NMP1 Aging Management Program

- Comparable approach to PWR process but guided by EPRI BWR Vessel & Internals Program
  - Defined inspection actions and acceptance criteria
- Demo Project will examine processes and results relative to assuring safety and reliability beyond 60 years of operations
- Deliverables will parallel those for Ginna
  - Internals
  - Reactor Pressure Vessel
    - Use and testing of remaining supplemental and original surveillance program capsules
    - Lead factor for supplemental capsules will place dose at > 60 year equivalent at 2013 outage and achieve > 80 year equivalent in additional 10 years of operation
  - Containment
    - Review and evaluation of planned activities per current life extension

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Summary

- Ginna and NMP1 now operating during extended life period
- Joint demonstration project will allow confirmation of current technical bases and expansion/refinement for additional life extension
  - Containment assessment is a unique opportunity evolving from this project
- Project is a proactive industry approach to supporting the technical bases for a potential LB60 license submittal
  - Science supported by field results

© 2011 Electric Power Research Institute, Inc. All rights reserved.

Together…Shaping the Future of Electricity

© 2011 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Constellation Pilot Plant Project

Ronald Johansen
Project Engineer

Light Water Reactor Sustainability

Workshop on Life Beyond 60

Washington DC
February 22, 2011

Light Water Reactor Sustainability R&D Program

Project Description

- The Department of Energy (DOE) in partnership with the Electric Power Research Institute (EPRI) and Constellation Energy Nuclear Group (CENG) will investigate the technical issues and demonstrate analysis methods to achieve nuclear plant life extension to 80 years.
- Issues and methods will be investigated and evaluated through the LWRS Program and EPRI Long Term Operation (LTO) Project.

LWRS
Light Water Reactor Sustainability

Project Description - continued

- The demonstration project will provide plant specific information, material samples, and associated environmental conditions for evaluation by the LWRS pathways. Ultimately, the work will lead to methods and processes to support life extension of nuclear plant.
- The demonstration project works with the EPRI Long Term Operation (LTO) for coordination of all on-site activities.

Project Description - continued

- Minimize overlap and gaps between the stakeholders and activities planned by the LWRS pathway leads and EPRI.
- Provide collaborative research opportunities for all ongoing programs
  - DOE-LWRS
  - EPRI-LTO
  - NRC-LB60
- Maximize the opportunities for shadowing maintenance and inspections to be performed by Ginna and Nine Mile Point plants

LWRS and the Constellation Pilot Project

LWRS Research and Development Pathways

- Materials Aging and Degradation Pathway (MAaD)
- Advanced LWR Nuclear Fuel Development
- Advanced Instrumentation, Information, and Control System Technologies
- Risk-Informed Safety Margin Characterization
- Economics and Efficiency Improvement

Development of Constellation Pilot Project Tasks

FY 11 Major Activities

- Review of existing work and opportunities at Ginna and NMP1
  - Corrective Maintenance
  - Inspections
  - Areas of Interest by Ginna and NMP personnel
- Comparison of opportunities to the LWRS research areas.

Constellation Pilot Project Focus Areas

Ginna

- Concrete
  - Containment - development of a Containment Inspection Guideline.
  - Radiation Effects on Concrete – Not performed due to inability to get samples of interest.
  - Shadow of existing maintenance – Identification of potential future areas of interest.

Constellation Pilot Project Focus Areas - continued

Ginna

- Reactor Metals
  - Baffle Bolt Replacement – specific irradiated materials of interest
  - Surveillance Capsule Specimens – specific irradiated materials of interest
  - Shadow of existing maintenance – Identification of potential future areas of interest.

Constellation Pilot Project Focus Areas - continued

NMP1

- Concrete
  - Shadow of existing maintenance – Identification of potential future areas of interest.
- Reactor Metals
  - Top Guide Sampling – under evaluation.
  - Supplemental and Original Surveillance Capsules – under evaluation.
  - Shadow of existing maintenance – Identification of potential future areas of interest

Ginna Baffle Bolts

- Many baffle bolts will be replaced to meet the intent of MRP-227
- Selected baffle bolts will be evaluated under contract by CENG and others will be evaluated under the LWRS Program
- Purpose of the evaluations is to determine the extent of any of the key degradation mechanisms
  - IASCC and traditional SCC
  - Irradiation embrittlement
  - Void swelling
  - High fluence phase transformations

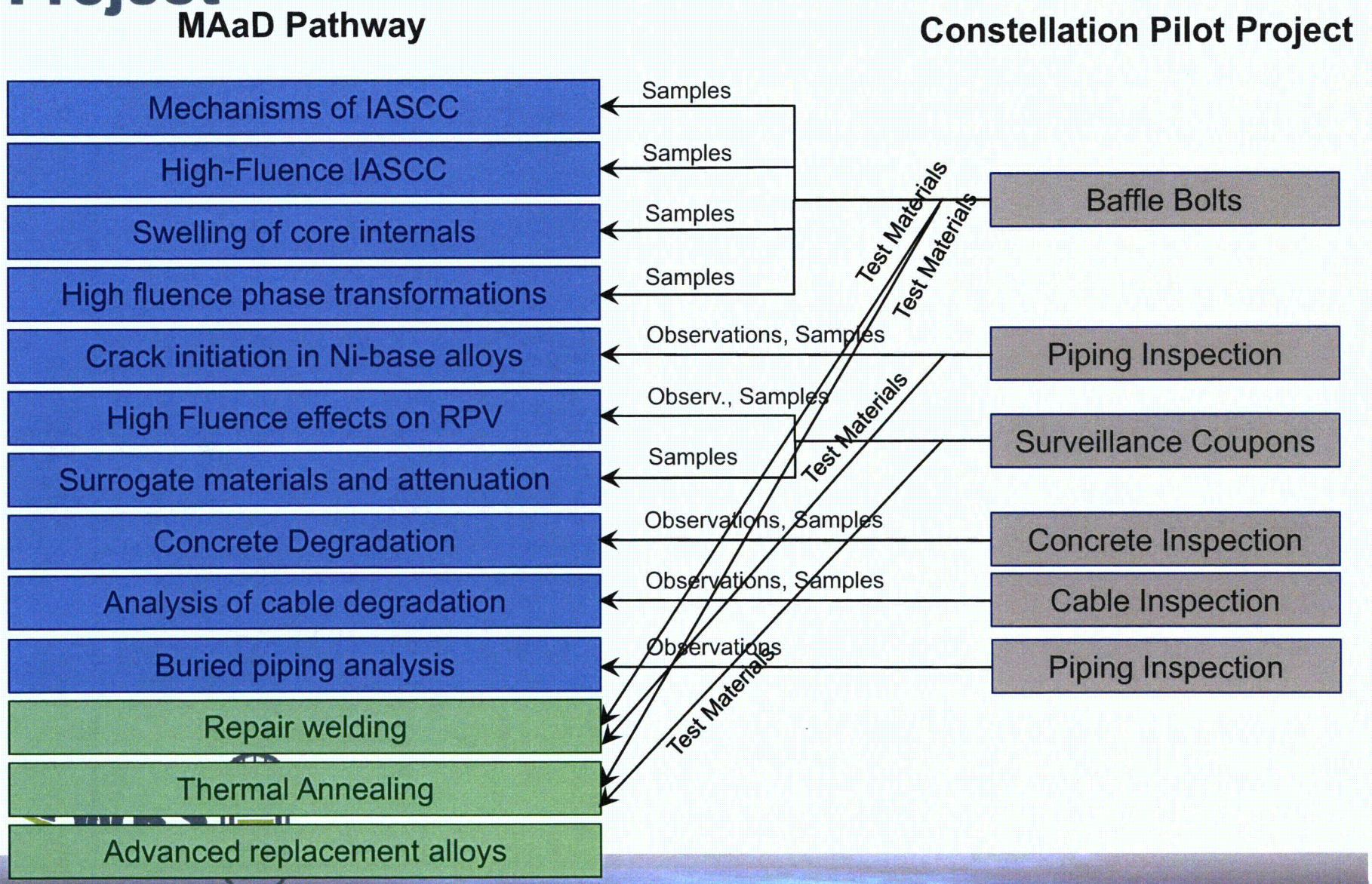
LWRS
Light Water Reactor Sustainability

Ginna RPV Surveillance Capsule Materials

- **Base and weld metal specimens tested under the RPV surveillance program will be selected to help understand the evolution of radiation embrittlement out to doses greater than 60 years**
  - Tentatively three capsules have been identified (three highest doses)
  - Remaining untested capsule will be assessed as to the optimum time to be pulled and tested
- **In addition to the traditional surveillance capsule mechanical property testing (Charpy V-notch and tensile), other investigations are being planned**
  - Fine scale microstructure using three-dimensional atom probe, small angle neutron scattering, annealing/hardness, and possibly others
  - Consideration of fracture toughness testing using reconstituted specimens to utilize the Master Curve methodology

LWRS

MAaD Pathway and Constellation Pilot Project



Constellation Demonstration
Augmented Containment Inspection

Workshop on Nuclear Plant Life Extension Research and Development

Tom Esselman
Principal, Lucius Pitkin, Inc.

February 22, 2011

Objective

- Prepare a Containment Inspection Guide to support operation beyond 60 years.
- Obtain information on containment integrity from the Ginna and Nine Mile Point plants.

Program Activities

- Program activities are selected to:
  - Demonstrate a linkage between a degradation mechanism that may occur and inspections or tests that are to be performed.
  - Provide inspections and tests that are quantifiably reproducible over a 40 year period.

Scope

- The scope includes concrete and other materials associated with a containment function.
  - Concrete containment structures including reinforced, pre-stressed, and post-stressed systems.
  - Tendons including wires, anchorages, shims, etc.
  - Drywell/torus/suppression pool.
  - Basements and foundations of the containment.
  - Concrete structures inside the containment.
  - Structural members housed within the concrete (RCS supports, embedments, etc.).
  - Containment liner, penetrations, and attachments.

Concrete Degradation Mechanisms

Degradation Mechanisms	Stressor	Effect	Augmented Tests Or Inspections At Ginna
Local Loss Of Moisture	Chronic Intermediate Temperature Exposure (>200°F)	Reduced Elastic Modulus and Rupture Strength	Measure strain near penetration. Measure concrete temperature at time of DIC.
Radiation Damage	Gamma Radiation (>10^{19} Rads)	Effects Cement Paste By Radiolysis Of Water. Reduction In Strength.	None proposed.
	Neutron Radiation (>10^{19} N/Cm^2)	Swelling of Aggregates. Reduction In Strength.	None proposed.
Leaching Of Calcium Hydroxide (Seen As Efflorescence)	Exposure To Water Through Cracks (Depends On Temperature And Chemistry)	Diminished Strength Of Cement Paste And Reduced Concrete Strength. Lowered pH And Subsequent Breakdown Of Protective Film On Rebar.	No augmented testing proposed. Latest inspection did not show any active areas of leaching or efflorescence. If detected in the future, samples could be collected and tested.
Chemical Attack	Magnesium And Sulfates Of Potassium, Sodium, And Magnesium.	Swelling Causing Cracking And Spalling, Leading To Reduced Strength.	None Proposed.
	Acids	Increased Porosity And permeability, Reduced Alkalinity	None Proposed.

Concrete Degradation Mechanisms

Degradation Mechanisms	Stressor	Effect	Augmented Tests Or Inspections At Ginna
Alkali-Aggregate Reaction	Some Constituents Of Aggregate Are Reactable In The Presence Of Moisture, With Chemical Compounds Present In Cement, Mostly Alkalis But Also Includes Potassium, Sodium, And Calcium Oxides.	Expansive Stresses And Severe Cracking	No augmented testing proposed. This is effectively covered by visual examination of outside surface in the existing IWL/IWE exams.
Carbonation	Carbon Dioxide From Air Reacts With Calcium Hydroxide In Cement In The Presence Of Moisture Producing Calcium Carbonate	Reduced pH, Rebar Corrosion	Carbonation test on containment exterior wall.
Abrasion	Heavy Load Traffic Exposure To Strong Wind Exposure To Turbulent flow And Cavitation	Pitting, Loss Of Cement And Aggregate Exposure	No augmented testing proposed. This is effectively covered by visual examination of the outside surface of the Containment in existing IWL.

Concrete Degradation Mechanisms

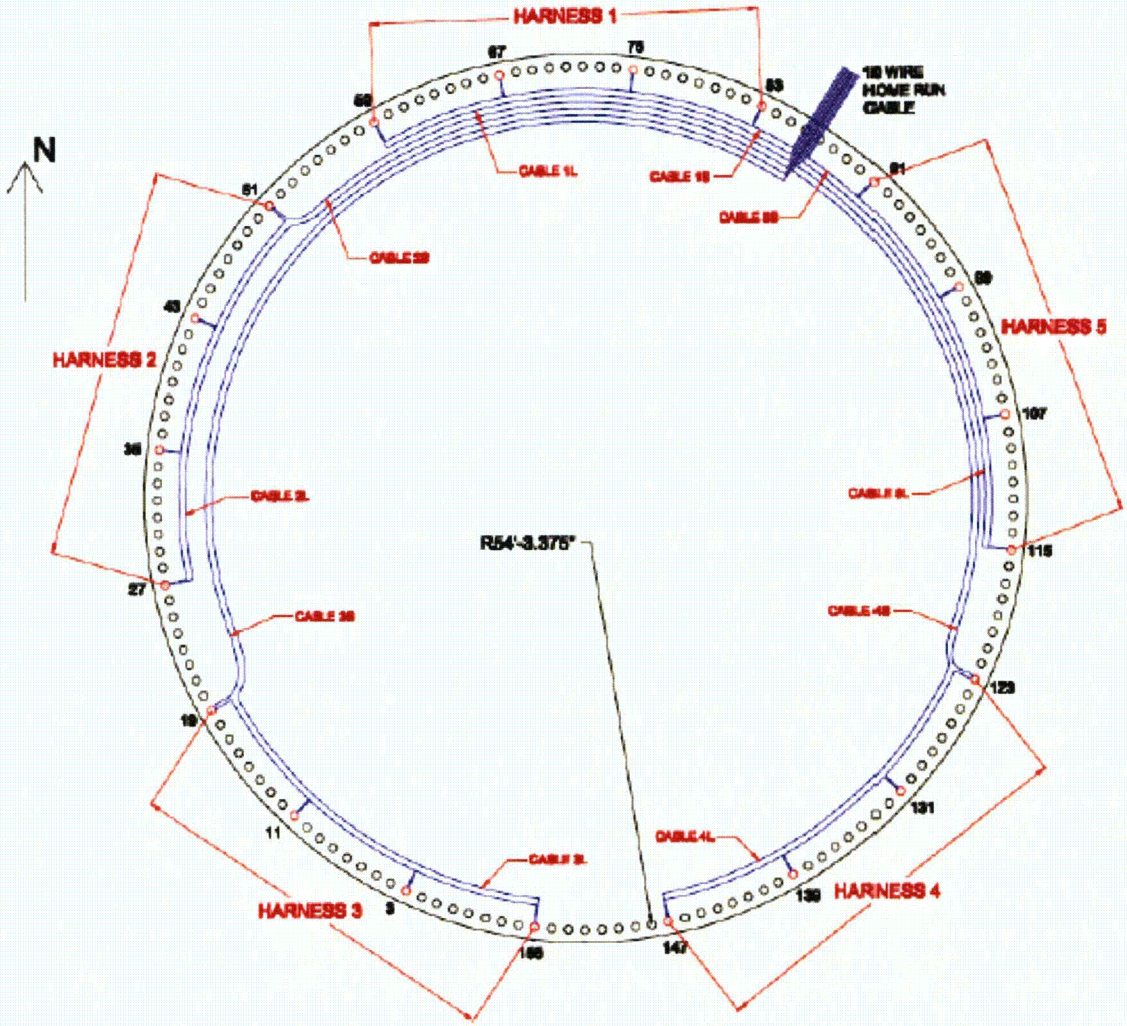
Degradation Mechanisms	Stressor	Effect	Augmented Tests Or Inspections At Ginna
Creep (Mostly In Prestressed Concrete)	High Loading Such As Under Tendon Anchors, High Temperature Such As Near Penetrations, Changes Of Moisture In Concrete	Cracking Along Cement/Aggregate Boundary And Continued Strain Under Constant Load Causing Loss Of Prestress.	Monitor tendon loads by strain gages. Measure strain at penetration.
Fatigue	Cyclic Loading, Including Loads From ILRT	Concrete Cracking And Creep Tendon Relaxation Loss of Bond With Rebar Surface Spalling And Internal Cracking	Measure strain of concrete during SIT. Monitor strain gage on rebar and concrete.
Overstress	Applied Load Loss of Prestress Settlement	Severe Cracking High Rebar Loads Wire Relaxation	Measure strain of concrete during SIT at high stress locations. Monitor strain gage on rebar and concrete.
MIC	Moisture Environment Such As Below Grade Exterior Walls	Cracking And Loss Of Cement.	None Proposed.

Summary of Augmented Inspection

- Tendon load monitoring with fiber optic strain gages.
- Rebar strain gage monitoring.
- Concrete surface strain monitoring with Digital Image Correlation.
- Rebar corrosion protection monitoring with carbonation test.

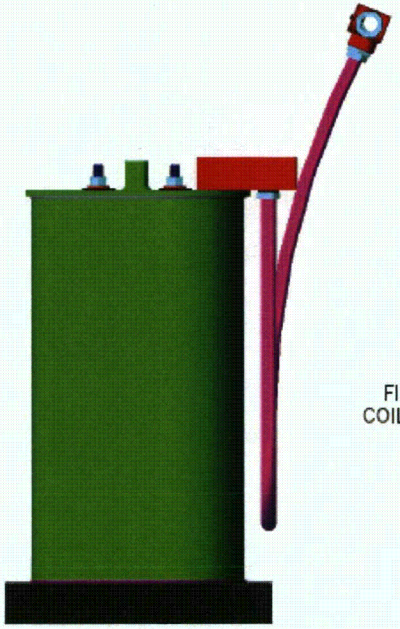
Tendon Monitoring

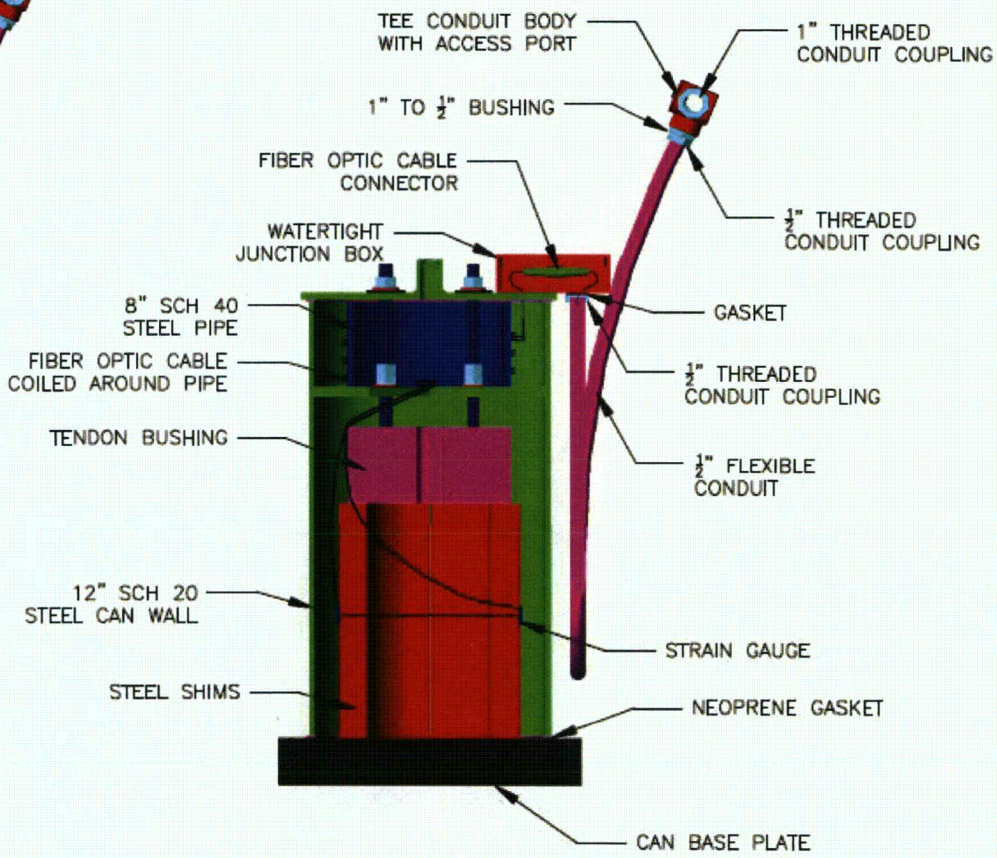
Fiber optic strain gages will be applied to the shims of 20 tendons.



Post-Tensioning Tendon

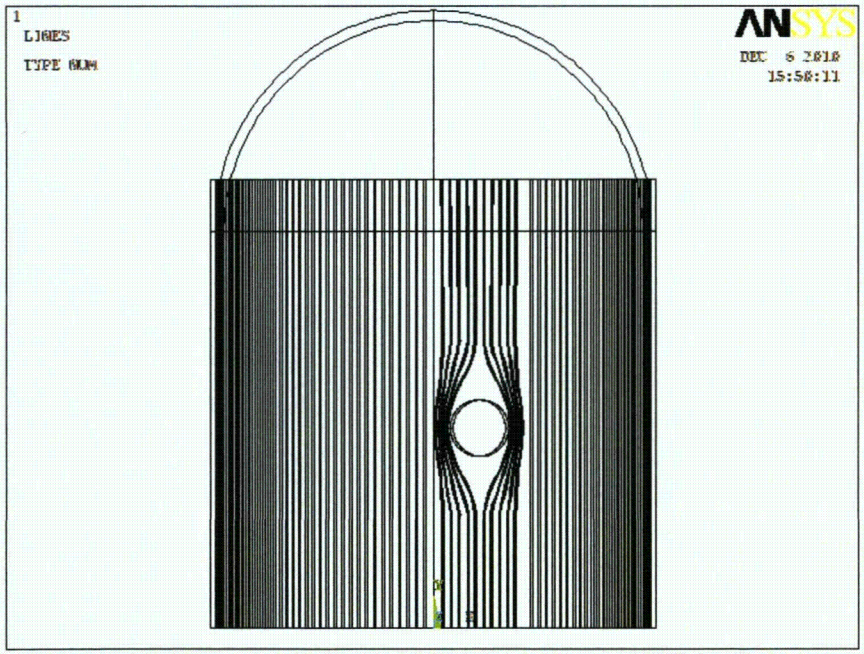
Can Covering the Tendons

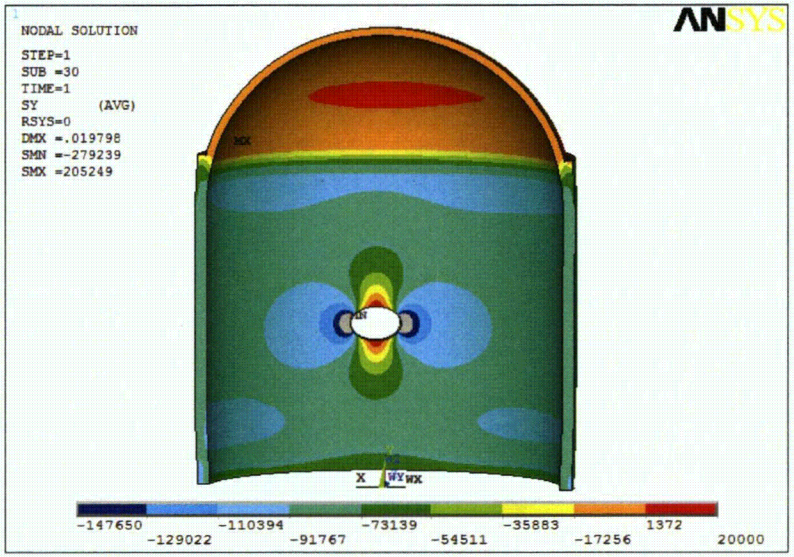


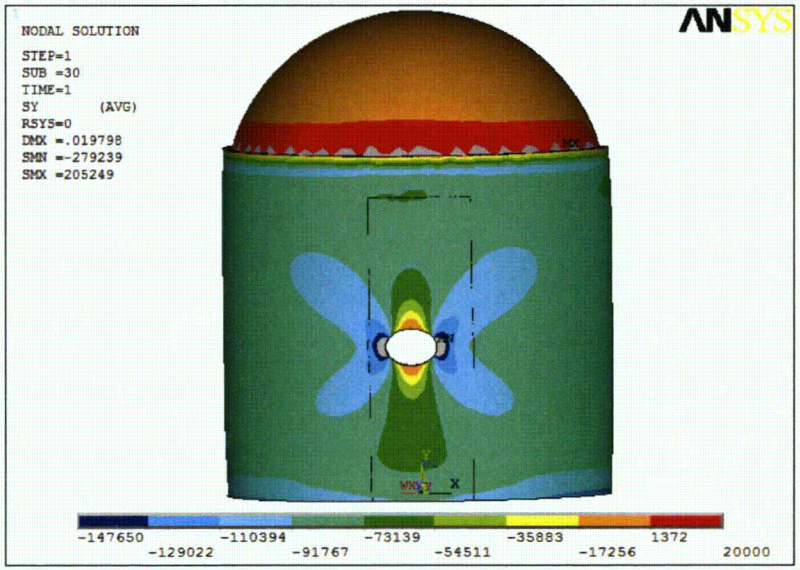


Tendon Monitoring

Structural Behavior during Structural Integrity Test (SIT)







Rebar Strain Monitoring

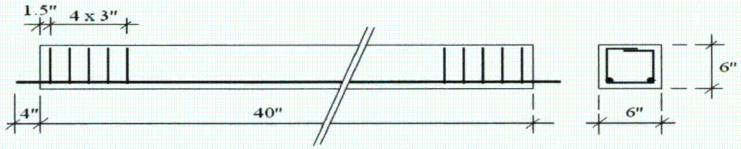
- Select one currently exposed rebar and install fiber optic strain gage.
- Install concrete strain measuring fiber optic gage in close proximity to the rebar strain gage.
- Monitor both with the tendon monitoring system.

Digital Image Correlation (DIC)

- DIC is a non-destructive non-contact technique to measure changes in shape and strain on structure surface.
- DIC requires that a pattern be painted onto the surface.
- High-strain locations selected for DIC.
- Can be used to demonstrate that concrete shape is not changing due to swelling or other degradation and that strain is appropriate during SITs.

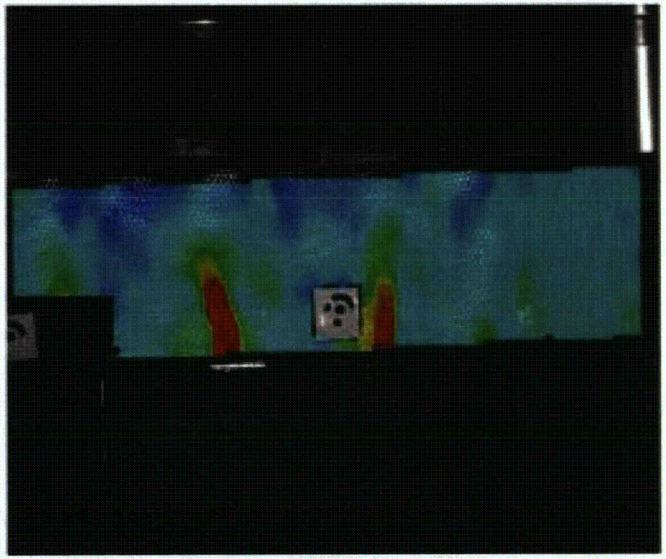
Digital Image Correlation (DIC)

Lab Qualification

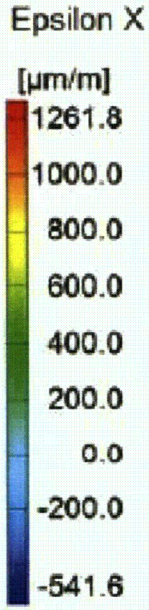


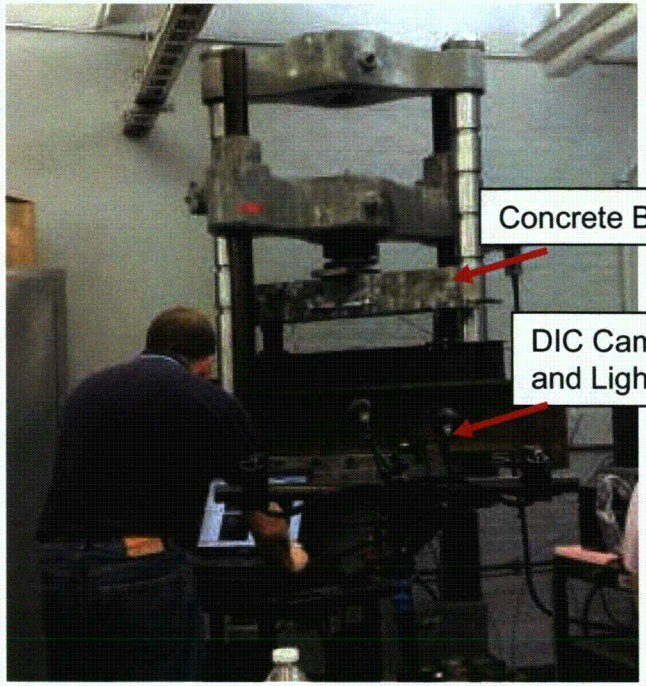
1. concrete compressive strength, fc, is 4,000 psi
2. steel yield strength = 40,000 psi
3. main rebar are #4 (0.5" diameter)
4. stirrups are #1
5. main rebar center is 1.5" from near concrete surfaces

Beam Second Loading Fri Oct 29



6000 lb





Concrete Carbonation Test

- Carbonation is a chemical reaction of Portland cement with the atmosphere that causes reduction in concrete pH.
- Reduction in concrete pH makes rebar more susceptible to corrosion attack
- Tests are performed on external surface concrete with holes drilled into the concrete.
- If depth of carbonation penetration is less than rebar cover, corrosion protection is adequate.

Containment Inspection Guide

- An improved understanding of behavior and the results from the Ginna and NMP inspections will lead into the preparation of the Containment Inspection Guide.
- The guide will provide a methodology for baseline inspections and examinations and follow-up inspections for long term operation.

NEI Perspective on Licensing Beyond 60

Julie Keys
Sr. Project Manager
jyk@nei.org

NEI
NUCLEAR ENERGY INSTITUTE

Background

- Operation beyond 60 years is needed to meet energy demands
- Currently licenses issued to 40 with 20 year extensions
- 40 was never a magic number

NEI

License Renewal Rule

- Basis of 10CFR54 is that CLB is adequate to ensure safe operation
  - Requires aging management reviews
  - Requires management of aging effects
- Goal is to maintain CLB to an acceptable level of safety during renewal period
- GALL Report used to provide NRC accepted aging management approaches

NEI

License Renewal Rule – Beyond 60

- Basis of 10CFR54 (CLB ensures safe operation) remains the same & Rule does NOT require revision to support long term, safe, continued operation
- GALL Report is used to provide NRC accepted aging management approaches
- GALL is informed by ISGs and undergoes periodic updates

NEI

Work Needed for Subsequent License Renewal

- Recognize nothing magic about year 61
- No show-stoppers identified to date
- AMPs are monitored for effectiveness and revised as needed based on OE and CAPs
  - Relationship of effectiveness reviews, OE Programs, and CAPs currently ensures no process gaps but may be implemented different at different plants
  - AMP effectiveness reviews may not be as transparent as they should
  - Industry needs to advertise improvements better

NEI

Work Needed for Subsequent License Renewal (cont)

- Some SSCs may have been engineered for a specific lifetime that is shorter than 80 years
  - Expand material degradation assessment
- Review AMPs to determine if they will continue to adequately manage aging such that there is assurance of the functionality of the SSCs within the scope of license renewal
- Implementation of programs should be reviewed to ensure they remain adequate

NEI

NRC/Industry LR Process Pilot

- A "tabletop" exercise has been outlined for Industry & NRC to review GALL & processes
  - Tabletop would critically evaluate the AMPs and their implementation for beyond 60
  - Identify where research is needed due to gap in knowledge
  - Meet NRC goals of transparency, openness & clarity in the licensing process
  - Align Industry and NRC expectations for subsequent applications

NEI

Conclusion

- No changes to existing rulemaking needed
- Programs in place for license renewal
- NRC and Industry must come to a common understanding of the adequacy of AMPs & Programs
- License renewal is a regulatory process and currently has a process to incorporate new information into current programs

NEI