US DOE LABORATORIES AND THE REMEDIATION OF FUKUSHIMA DAI-ICHI

Presented by Michaele (Mikey) Brady Raap, Ph.D.
Pacific Northwest National Laboratory
Vice President/President-Elect American Nuclear Society

American Nuclear Society – Trinity Section
Albuquerque, New Mexico
May 9, 2014

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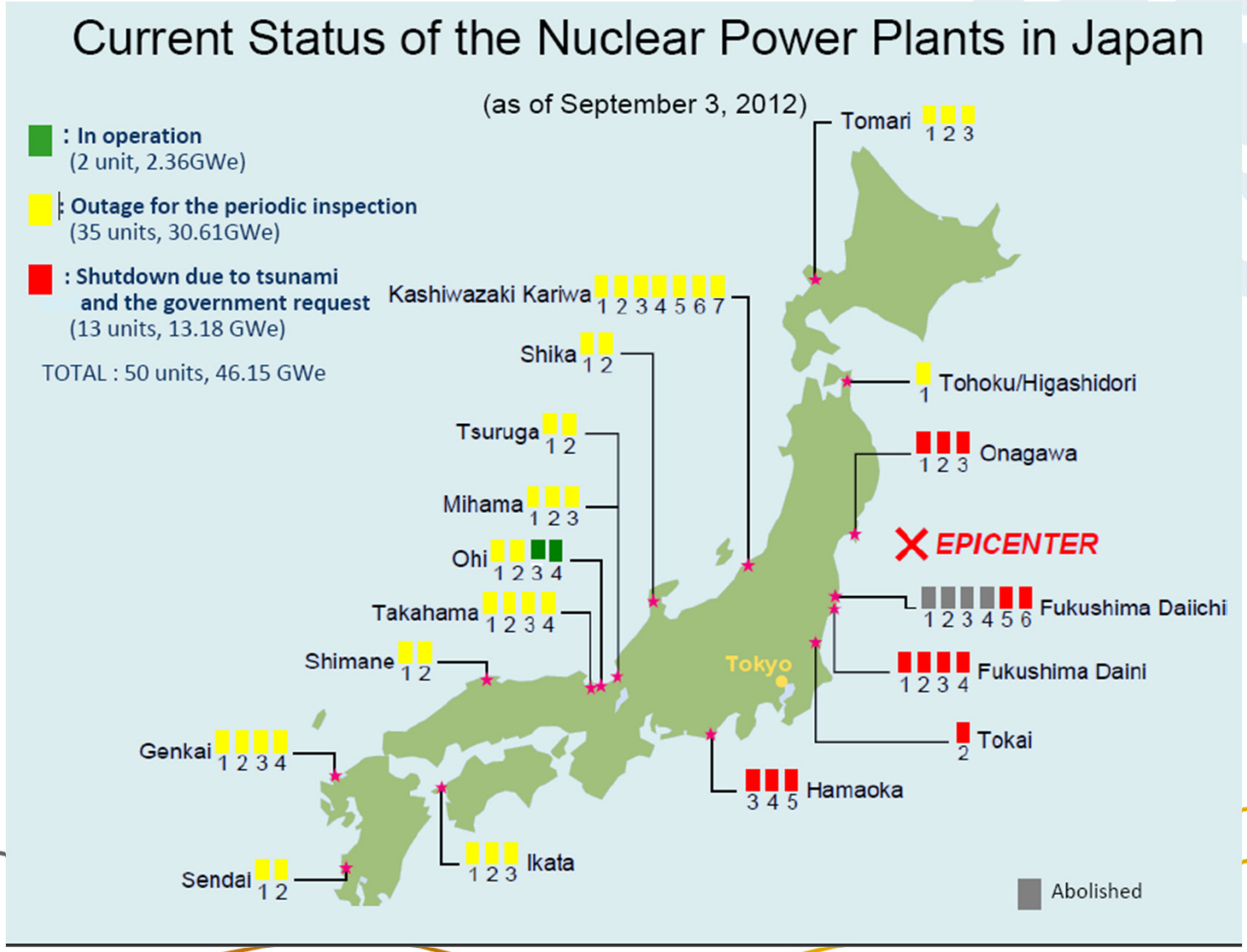
Structure of Presentation

- Opening Remarks
- General Comments/Overarching Impressions
- Site Visit
- Specific Technical Discussion Topics
  - Waste Management
  - Analytical Labs
  - Damaged Fuel & Debris Disposition
  - Grouting
  - Groundwater Control and Treatment
  - Community Revitalization
- Conclusions/Next Steps

Status of Japan's Nuclear Power Facilities



Before March 11, 2011:

- Japan is the third largest producer of nuclear power in the world
- Japan obtains ~30% of their electricity from nuclear power

Latest Information:

F1 Units 5&6 to be used for mockup testing

17 units submitted applications to NRA for restart

Ohi-4 last to operate Outage for PI 9/15/13

Japan is now the leading importer of LNG

Source: Japan Atomic Industrial Forum (JAIF) - http://www.jaif.or.jp/english/

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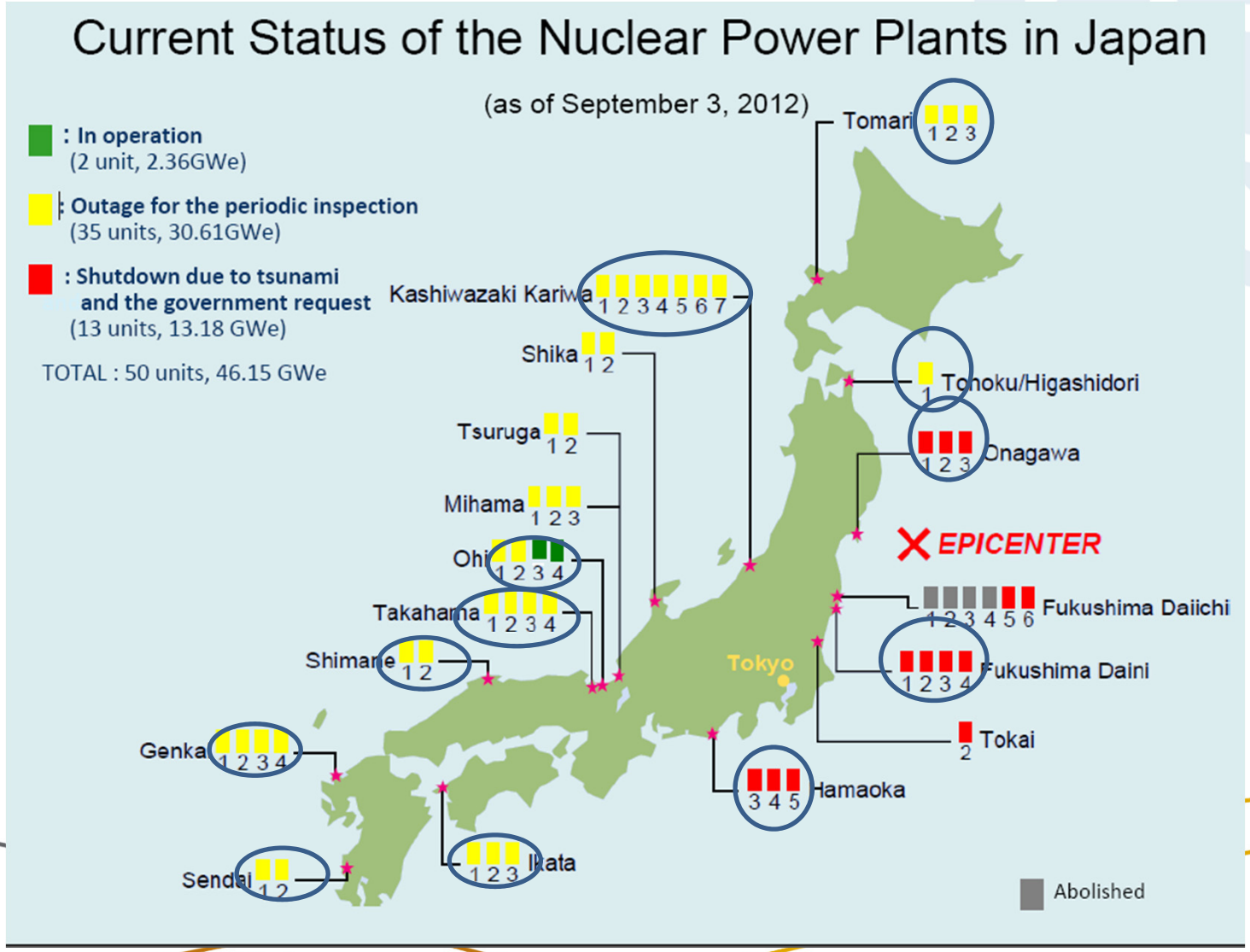

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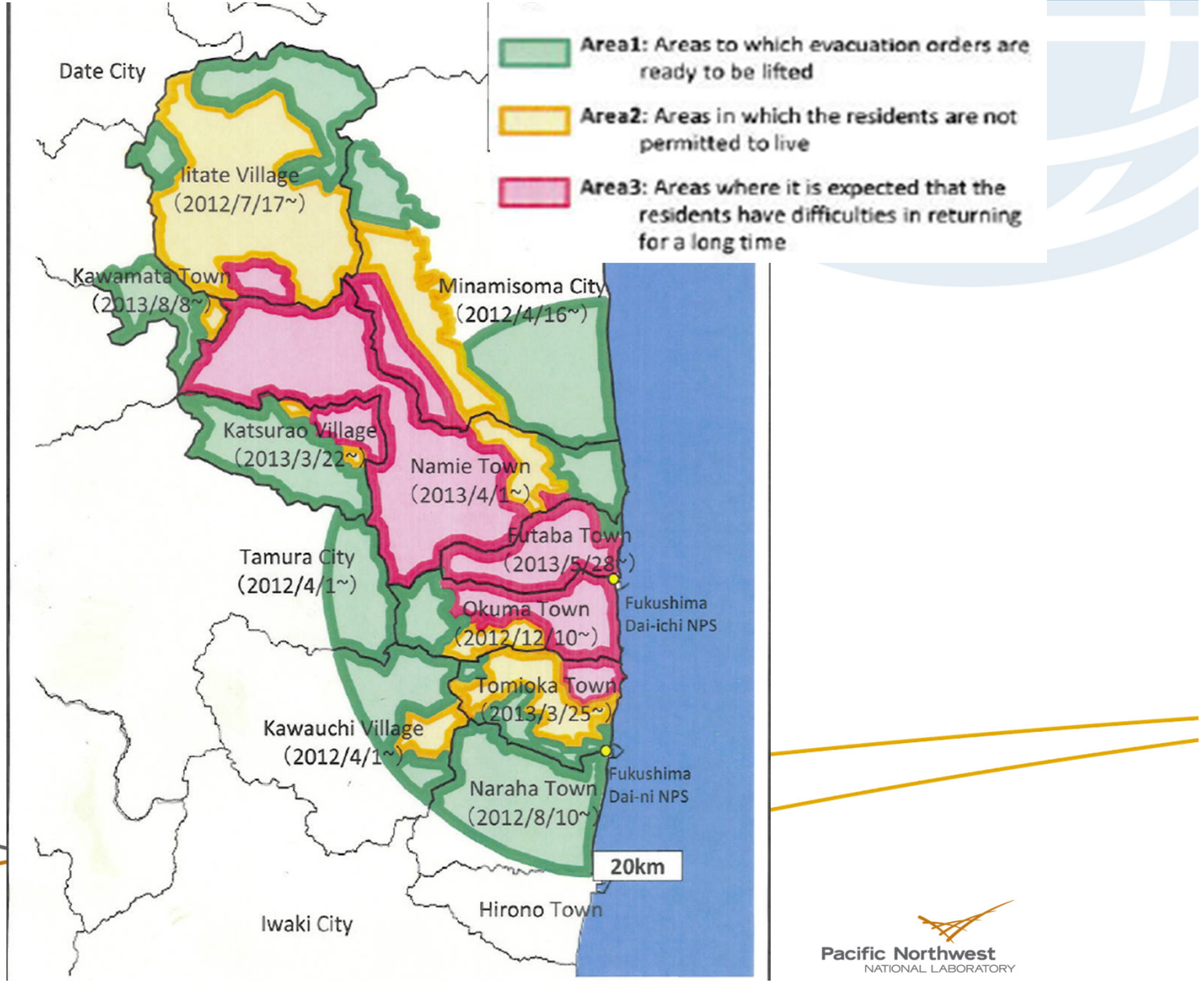
Exclusion Zone Map (August 2013)



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SRNL and PNNL Collaboration

- The Savannah River National Laboratory (SRNL) and Pacific Northwest National Laboratory (PNNL) have a contract agreement with Tokyo Electric Power Company (TEPCO) to provide technical assistance for the remediation of TEPCO's Fukushima Daiichi Nuclear Power Station.
- The DOE complex and specifically these two laboratories have significant experience in nuclear facility decontamination and decommissioning from nuclear material production remediation and cleanup efforts.
- The SRNL and PNNL collaboration offers a portal for TEPCO to access broad science and technology talent throughout the entire DOE national laboratory system.

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Applicability of U.S. Expertise to TEPCO's Seven "Items of Interest"

Prevention of Underground Water Contamination and Mid- and Long-term Monitoring, Safety Assessment Packages

Grouting-related Techniques)

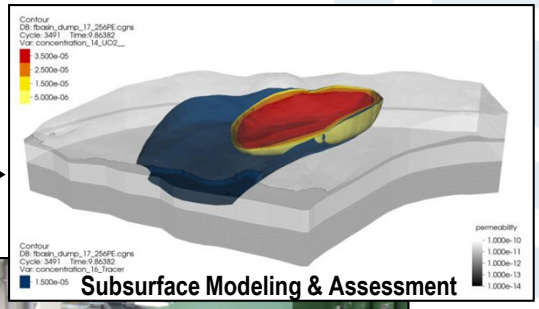
Rational Design of Newly Installed Lab(s) for Sample Analyses

Rational Waste Treatment/Disposal

Fuel Debris Removal, Packaging, and Storage

Salt (Sodium Chloride) Extraction from Liquid Waste

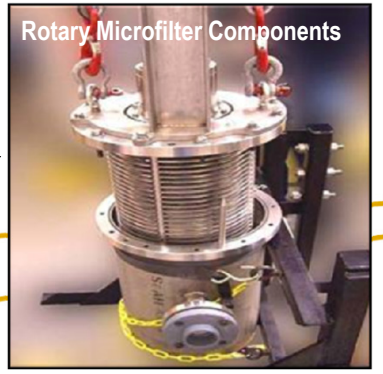
Vision for Revitalization of the Local Communities


Subsurface Modeling & Assessment


Modular Radiological Hot Cells


Low-Level Waste Treatment & Disposal


Spent Fuel Canister


Rotary Microfilter Components

TRI-CITIES WASHINGTON
TRI-CITY DEVELOPMENT COUNCIL

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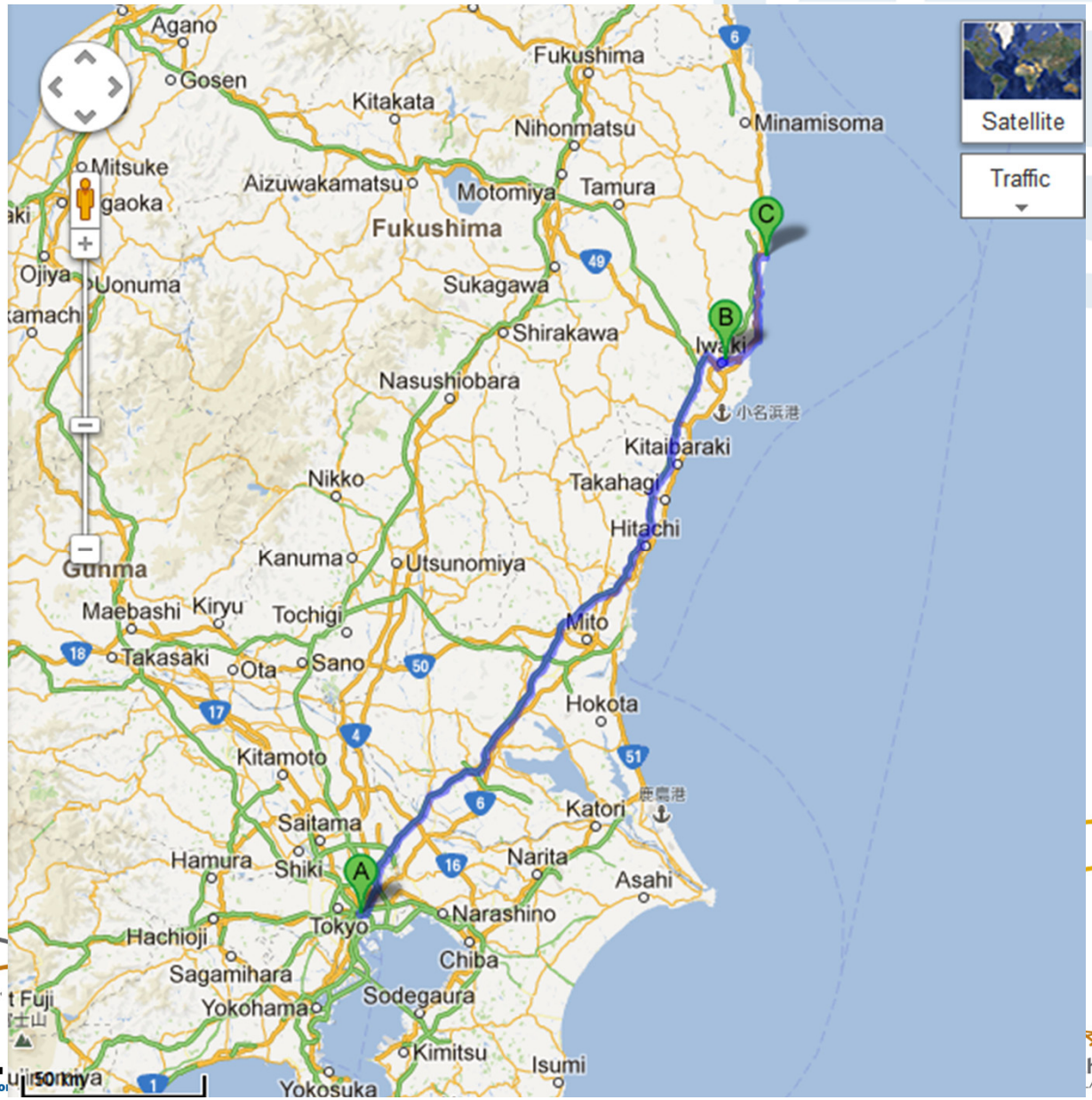
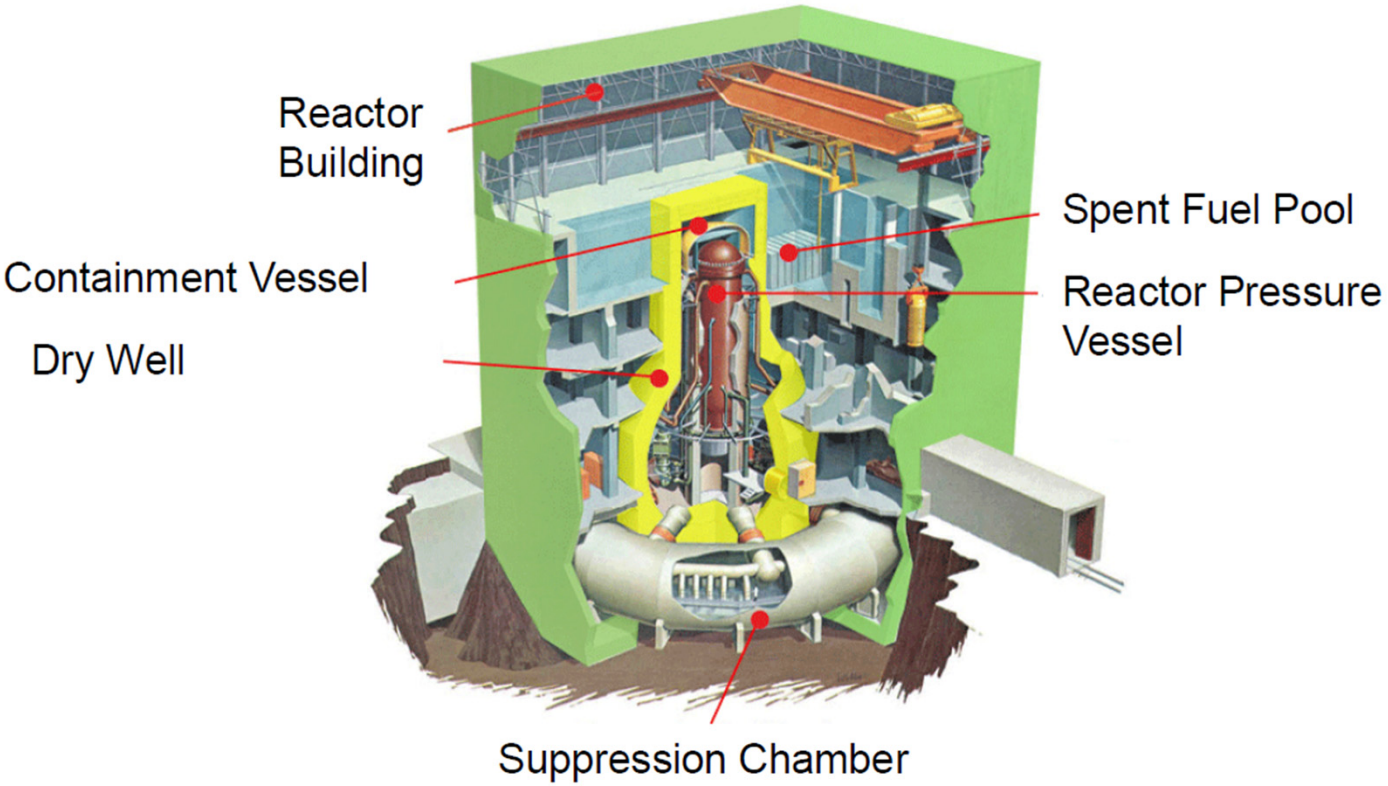
Travel Path


Agano
Gosen
Kitakata
Fukushima
Nihonmatsu
Minamisoma
Mitsuke
Aizuwakamatsu
Motomiya
Tamura
Fukushima
Ojiya
Uonuma
Sukagawa
Shirakawa
Nasushiobara
Kitaibaraki
Takahagi
Nikko
Hitachi
Gunma
Kanuma
Utsunomiya
Maebashi
Kiryu
Tochigi
Mito
Takasaki
Ota
Sano
Hokota
Kitamoto
Katori
Saitama
Hamura
Shiki
Narita
Asahi
Narashino
Hachioji
Tokyo
Chiba
Sagamihara
Sodegaura
Yokohama
Kimitsu
Isumi
Yokosuka
A
B
C
Satellite
Traffic

Fukushima Dai-ichi Site Visit, 27 October to 3 November, 2012

Basics of a Boiling Water Reactor



出典：http://nei.cachefly.net/static/images/BWR_illustration.jpg

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Unit 4 Spent Fuel Pool

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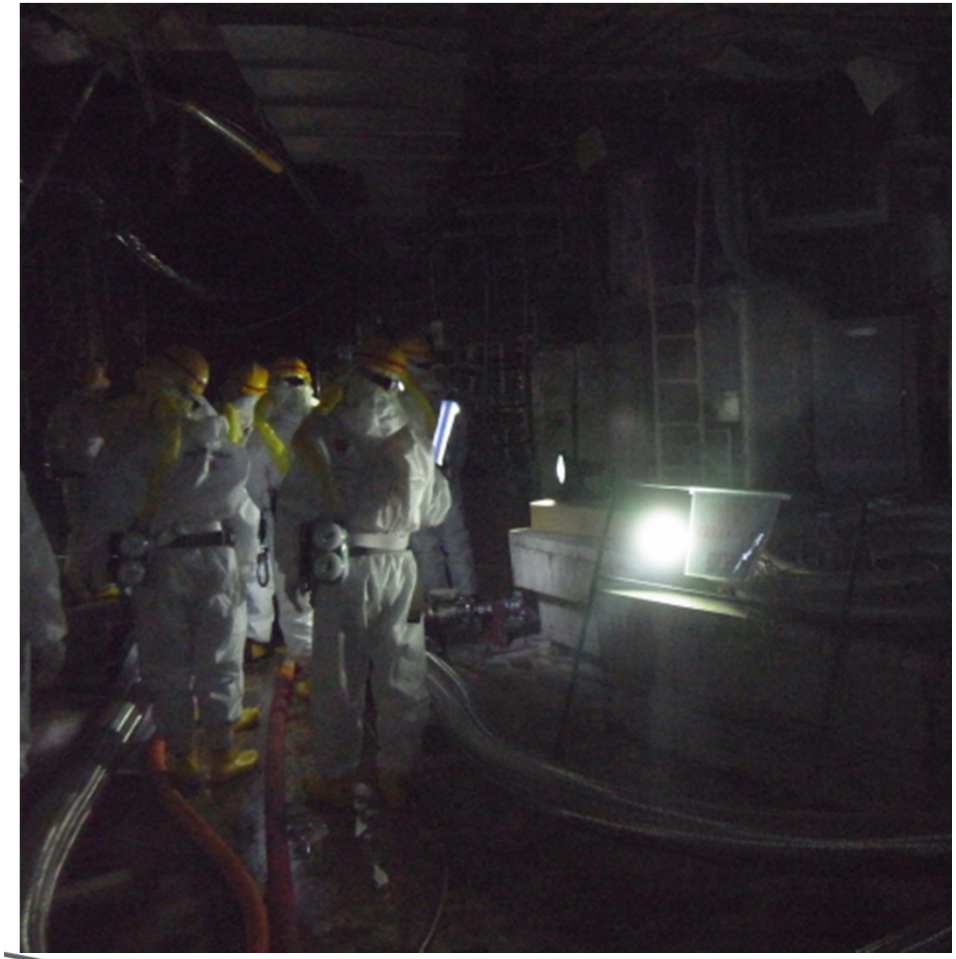
Lower Level of Reactor #4



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Environmental Remediation

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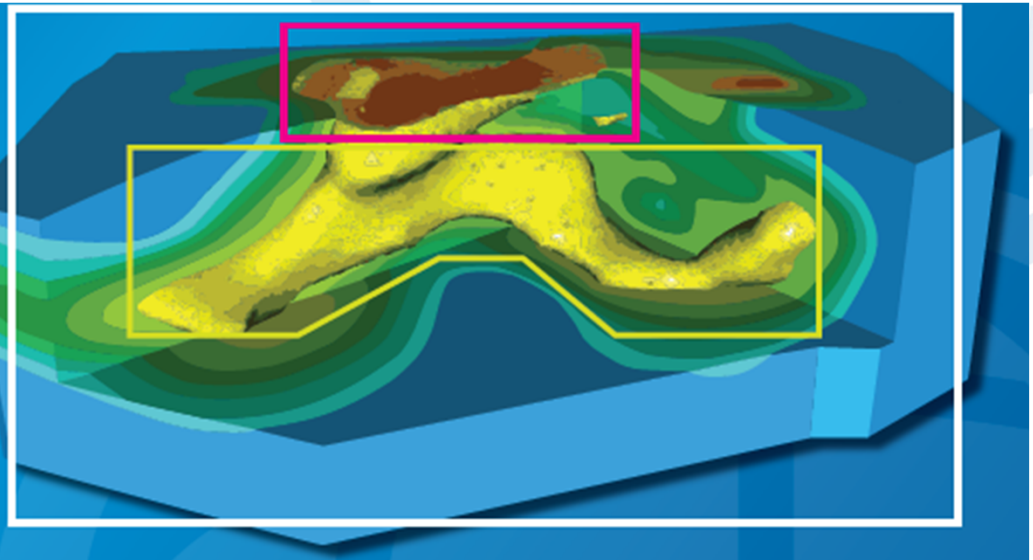
Groundwater

Groundwater & Soil Cleanup Solutions

for every contaminant zone
matched to the cleanup challenge
applied across all remedial investigation phases
(characterization, remediation and monitoring)



SOURCE ZONE
- Raman Spectroscopy[2,3]
- Geo VIS[2,3]
- Cone Permeameter[1,2,3]
- Laser Induced Flourescence[2,3]
- Hydrophohic Flexible Membrane (FLUTe)[2,3]
- Ribbon NAPL Sampler[1,2,3]
- Wireline Soil Sampler[2,3]
- Membrane Interface Probe (MIP)[2,3]
- In-Situ Chemical Oxidation[2,3]
- Six Phase Heating (ERH)[2,3]
- Thermal Detritiation[2,3]
- Electrical Resistance Tomography (ERT)[2,3]

PRIMARY GROUNDWATER / VADOSE ZONE
- Cone Sipper[1,2,3]
- VOC Headspace Sampling[1,2,3]
- Strata Sampler[1,2,3]
- CPT NaI Gamma Probe[2,3]
- GeoSiphon[1,2,3]
- PHoSTer (bio)[1,2,3]
- Sulfate Reduction of Metals[2,3]
- Base Injection[2,3]
- Hydraulic Fracturing Enhanced SVE[2,3]
- Edible Oil Injection[1,2,3]
- I-129 Capture with AgCl[1,2]
- Micro CED (Bio)[1,2]
- Horizontal Wells[2,3]

DILUTE PLUME / FRINGE
- BaroBall[1,2,3]
- Microblower[1,2,3]
- Monitored Natural Attenuation (MNA)[1,2,3]
- Enhanced Attenuation (EA)[1,2,3]

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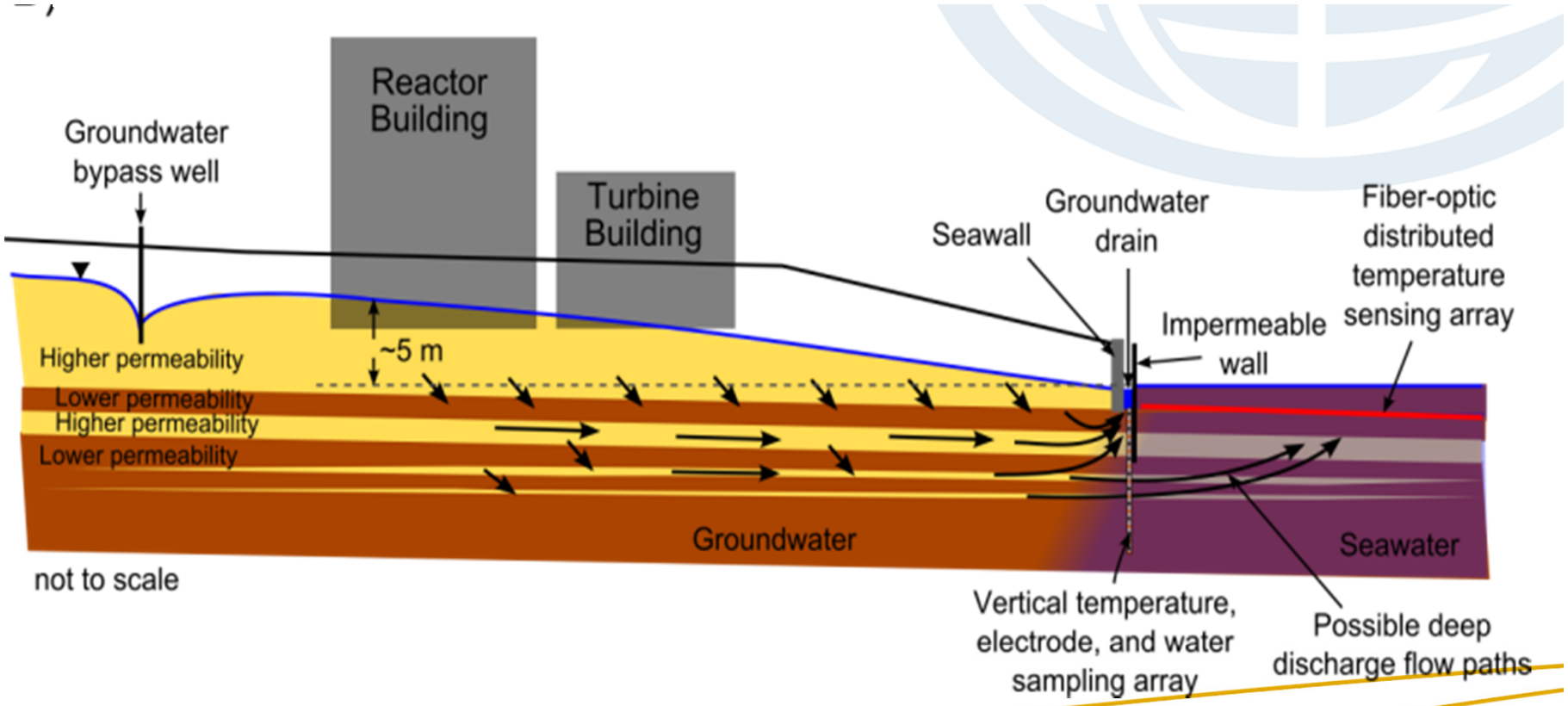
US Support to Groundwater Issues*

- Site and groundwater characterization that identifies the spatial distribution of contaminants,
- Developing a site conceptual model that includes reactive transport and fate models,
- Evaluating a phosphate-based permeable reactive barrier (Apatitite Sequestration)
- Technical support for assessing frozen soil barrier technology, and
- Develop a comprehensive monitoring plan

*not finalized

Groundwater Challenges



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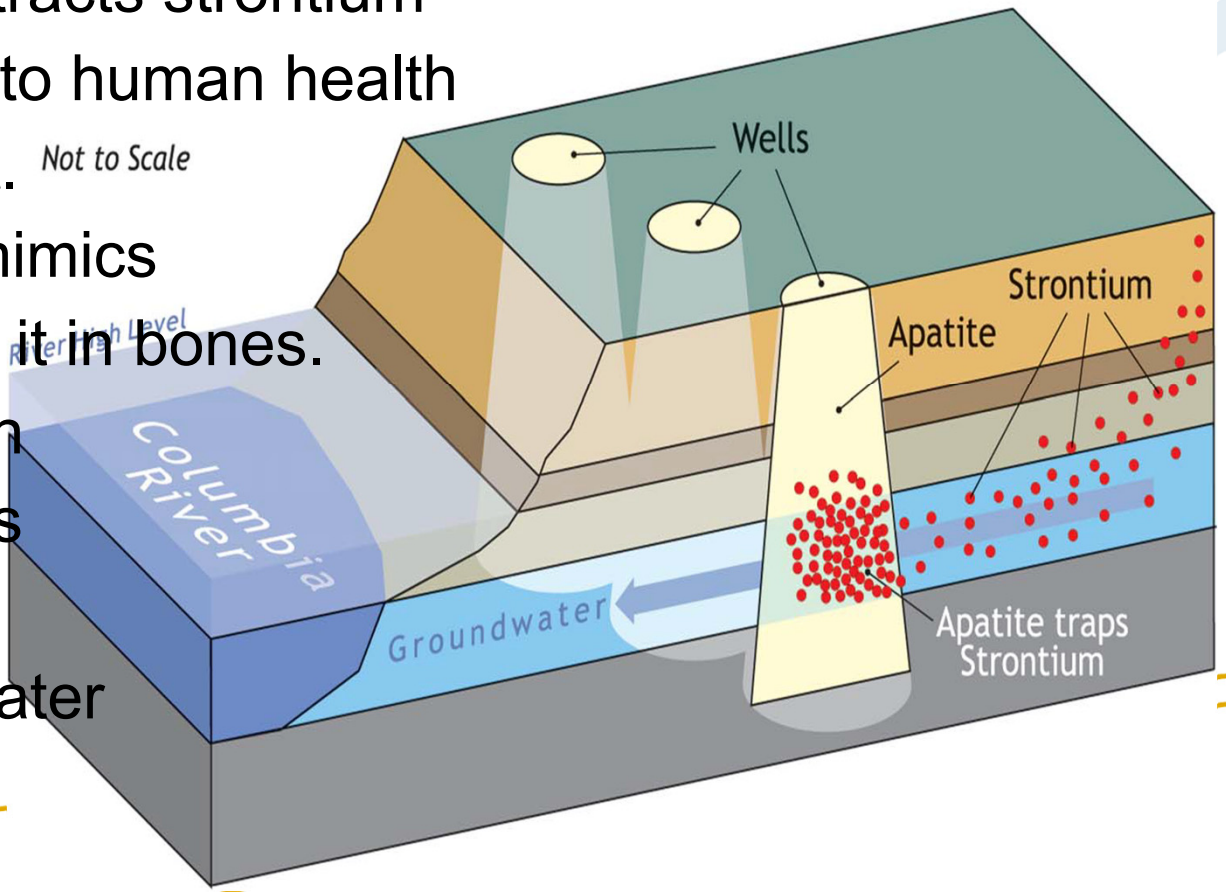
Apatite Sequestration

- **Apatite** is a common type of mineral with the ability to capture and hold radioactive and metal contaminants.
- Apatite chemically attracts strontium
- Sr-90 poses a threat to human health and the environment. Not to Scale radioactively toxic, mimics calcium by replacing it in bones.
- Monitoring has shown the apatite barrier has significantly reduced strontium in groundwater at Hanford



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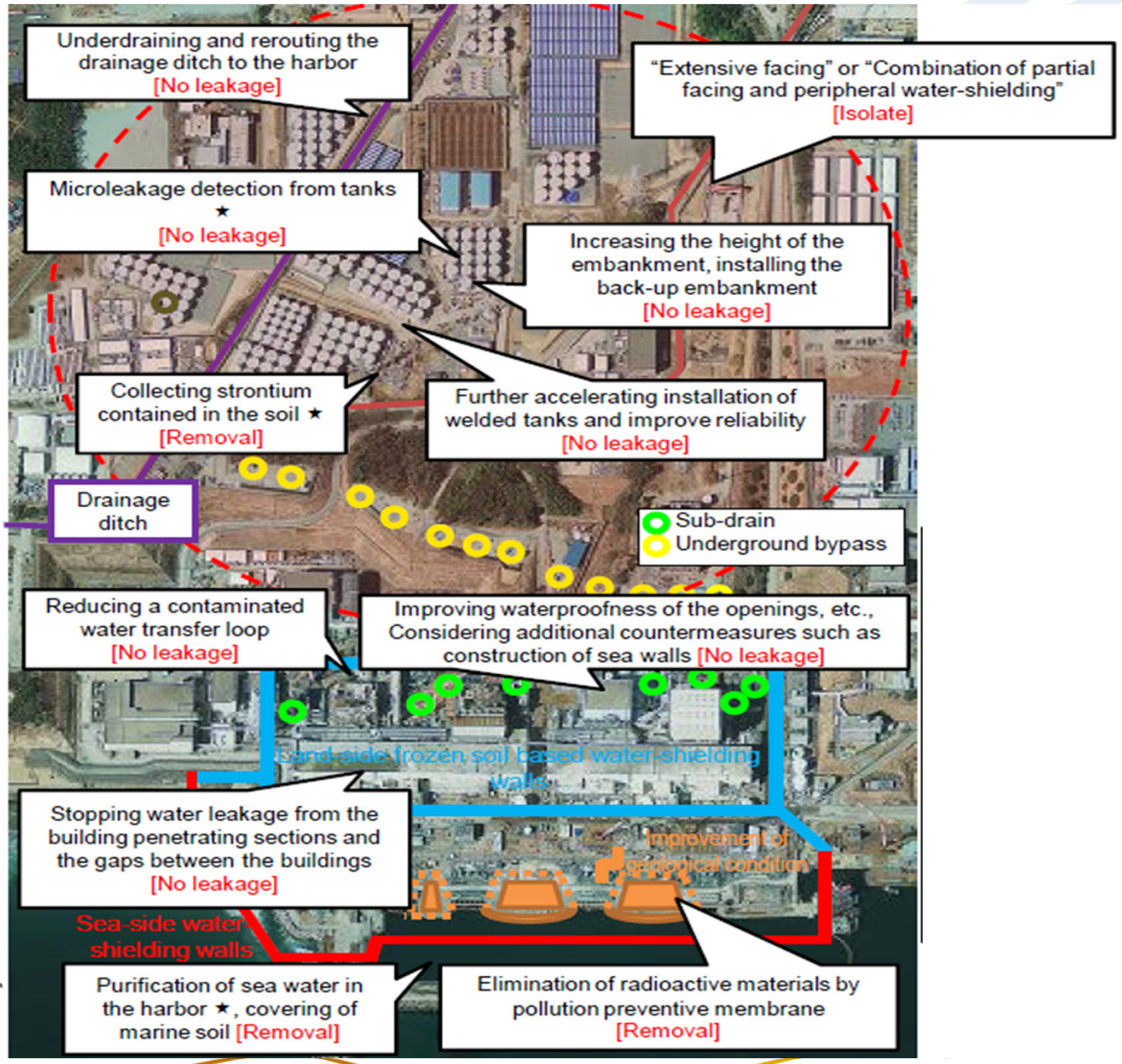

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Grouting Experience in D&D Activities

General Separations Area Consolidated Unit

R-Reactor Basins

Grouting K East Basins

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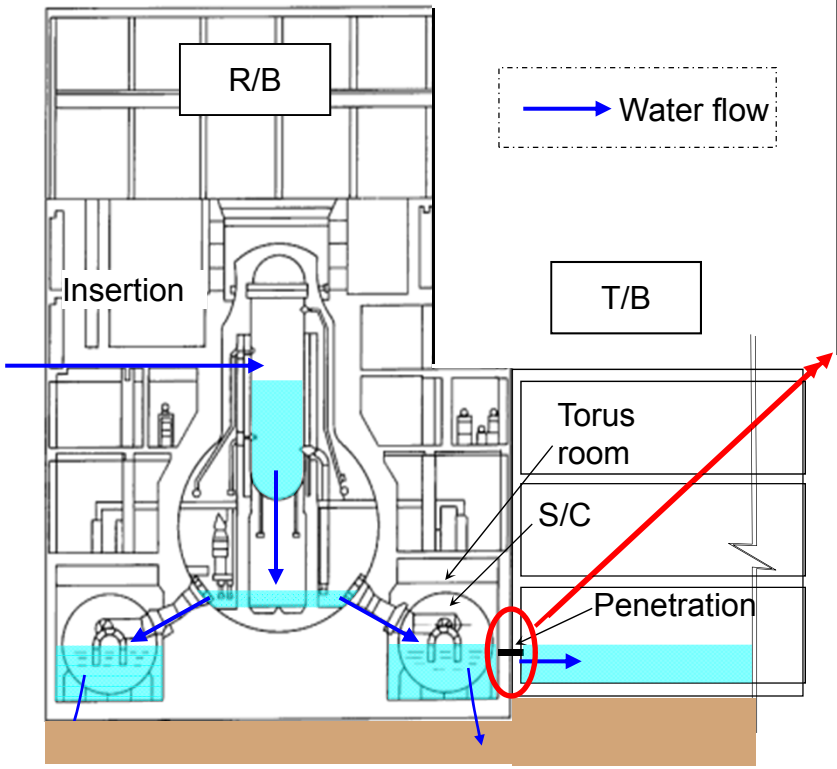
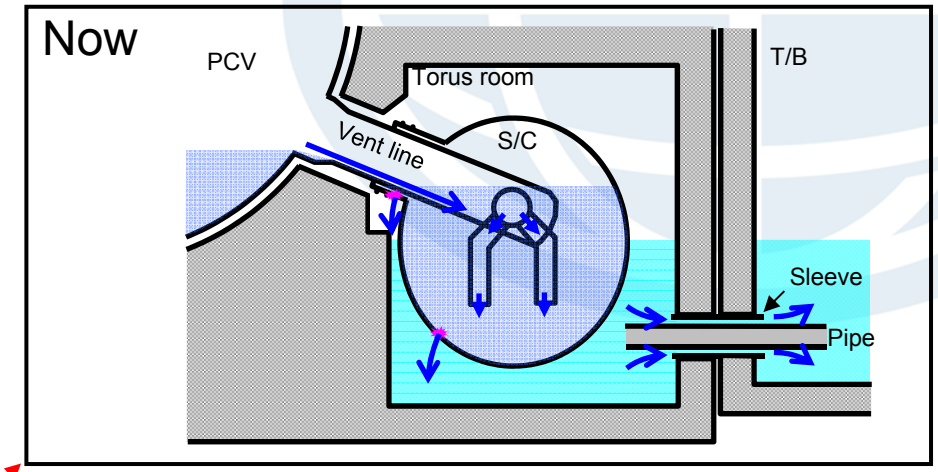
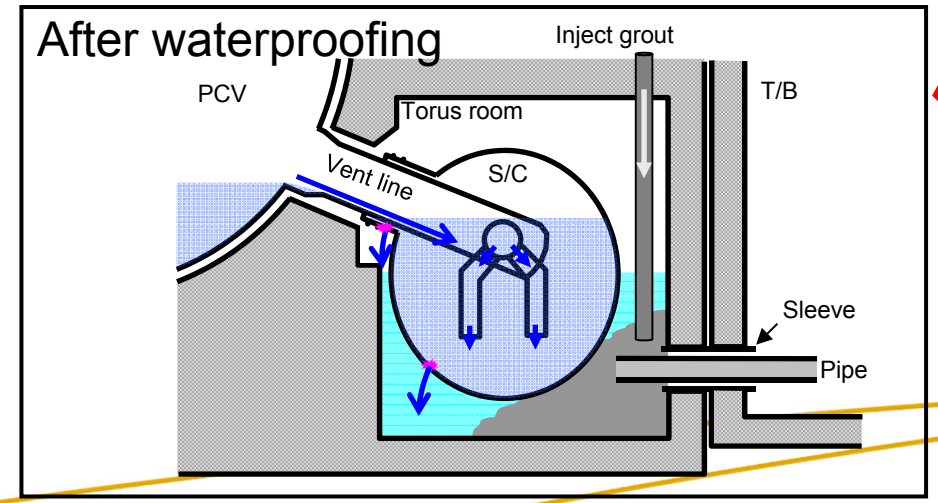
Grouting Challenge: Sealing Leak Paths Between the Reactor Building and the Turbine Building



Assumed leak route into T/B





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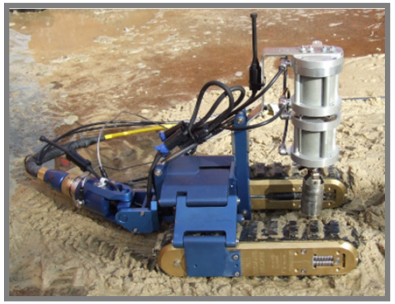
Grout-Related Tasks

- Develop test plans, test data, design and selection of materials and configurations, implementation strategies and methods, and repair techniques.
- Support testing at the U.S. National Laboratory facilities as well as supporting this type of ongoing and future work in Japan
- Provide DOE designs and/or input on high and low viscosity grouts for sealing leaks.
- Potential leak sites and sealing locations including: (a) drywell-SC vent line, (b) SC downcomers identified by TEPCO, (c) entire Torus Room (d) penetrations between the TR and TB, and (e) groundwater flowing into the building through openings.

Sample Analysis

In-Tank Residue Sampling → Sample Characterization → Statistical Analysis of Results

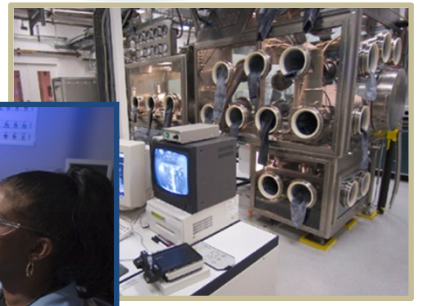
Tank tops provide limited access into tanks to retrieve waste samples.

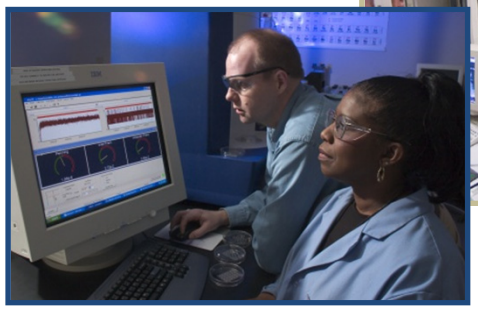


Sampling waste residue from tank floors requires specialized equipment with robotic operation and high maneuverability.

Remote handling of samples in Shielded Cells reduces personnel dose to normal background levels. Each shielded cell window is equipped with two robotic manipulators and three feet of lead glass shielding.

Samples are “digested”; then highly dilute aliquots are sent to radiological laboratories for analysis. 35+ elements, 60+ radionuclides, and various other critical waste constituents/ properties are quantified. Significant development is performed to establish methods for quantifying ultra-low activity nuclides amidst high-yield fission and activation products.





Cl-36, Nb-94, Pd-107, Pt-193, and Pa-231 are examples of ultra-low level nuclides for which new methods have been developed. Following characterization, statistical analyses are performed to test data homogeneity, identify variances, and quantify upper 95% confidence limits.

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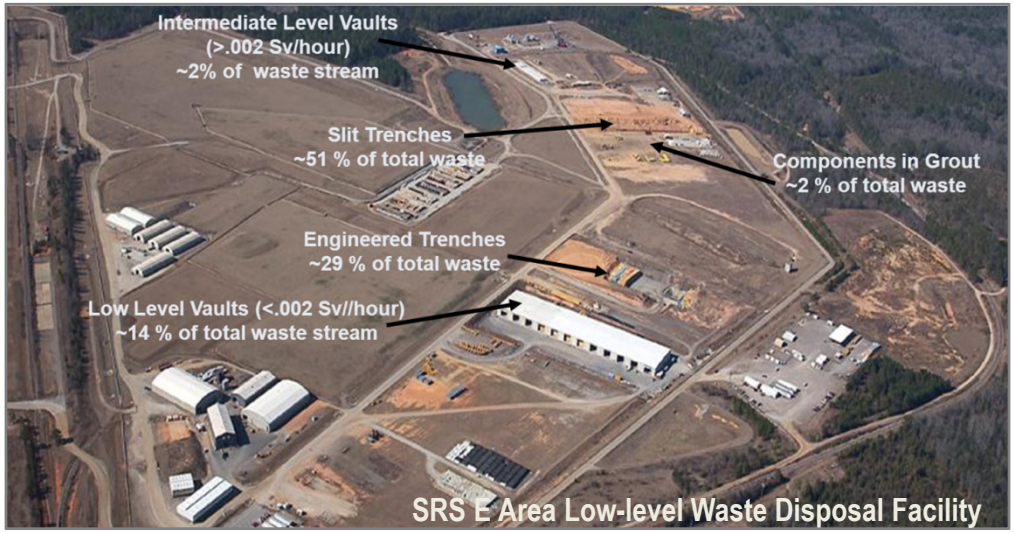
Environmental Remediation and Waste Disposal: Low- and Intermediate-Level Waste Disposition



- **Waste Disposal Objectives**
  - Having an approved disposal facility and waste acceptance criteria will drive characterization, decontamination, segregation, encapsulation or treatment, packaging, and operational efforts in the field
  - Designed for radioactive, hazardous, and mixed wastes generated during cleanup activities – primarily contaminated soil and demolition debris

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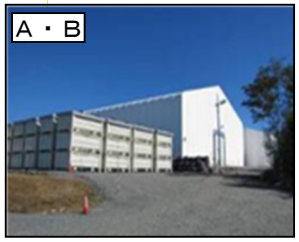
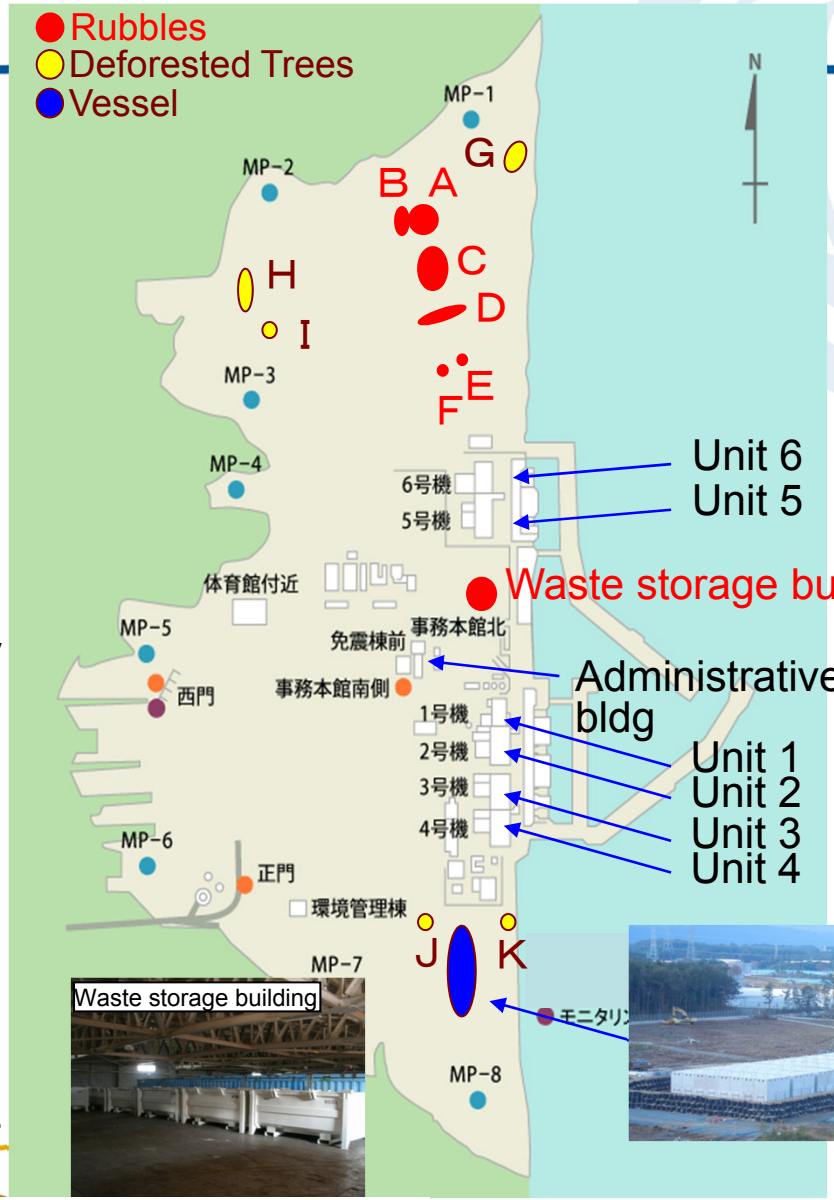
Waste Management Challenge: Layout and volume of waste

・Inside a temporary storage facility
・Volume of waste: 8,400 cubic meters



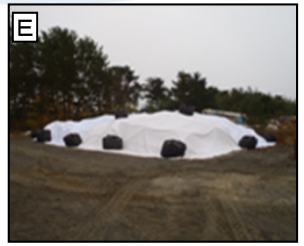
・Exterior of a temporary storage facility and containers
・Number of containers: 450

・Deforested trees
・Volume of waste: 11,000 cubic meters



・Containers in storage building
・Number of containers : 400

・Open-air storage rubble
・Volume of waste: 16,000 cubic meters



・Sheet covered rubble
・Volume of waste: 1,000 cubic meters

・Temporary storage for vessels
・Number of containers: 350

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March 11, 2011

February 18, 2014

Waste Management Activities

- Evaluate alternative waste forms for carbonate secondary waste resulting from the ALPS operations,
- Review and summarize nuclear reactor decommissioning strategies used in the U. S. (primarily at DOE facilities)

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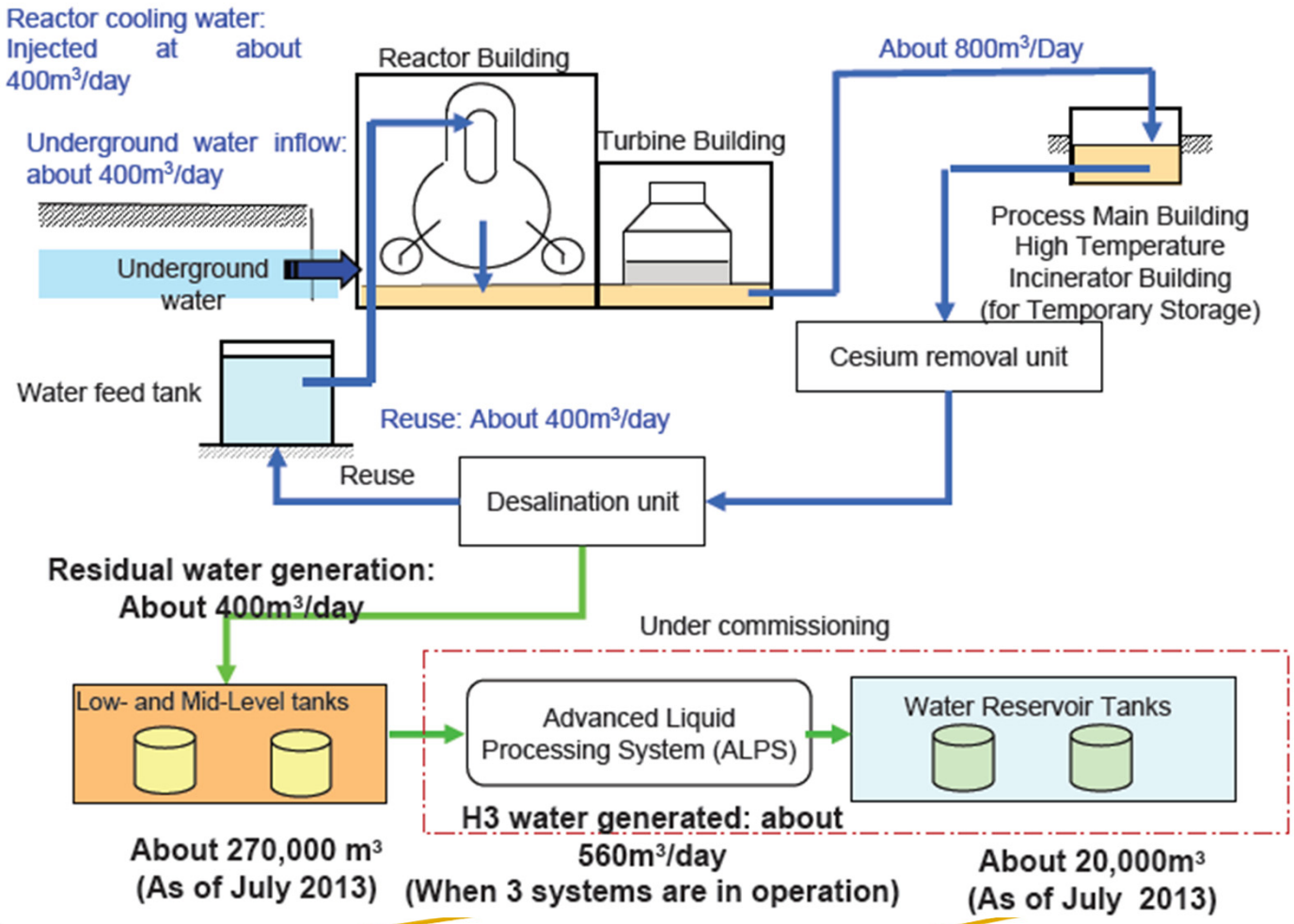
Challenges in Water Treatment



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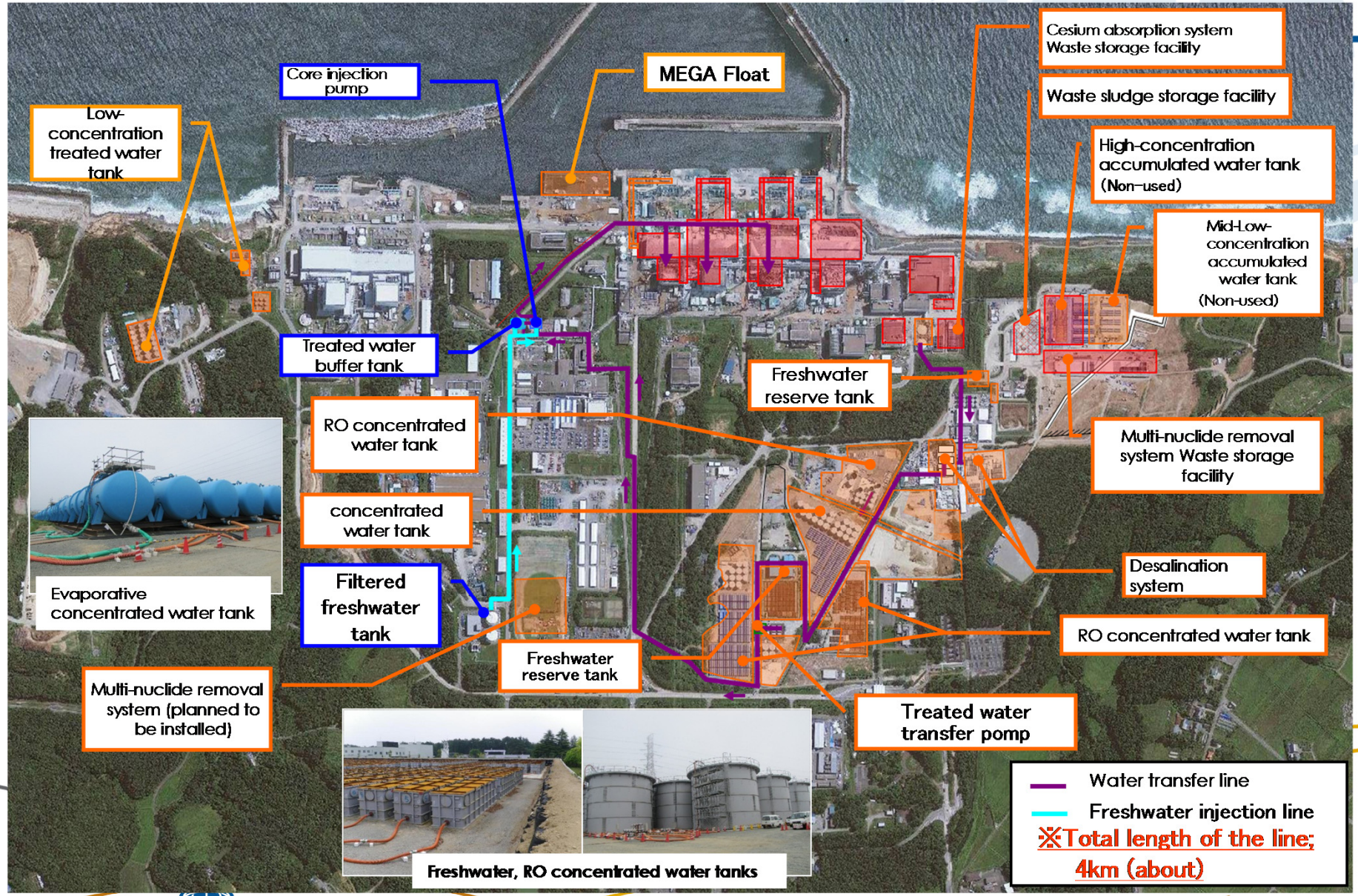

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1989 Tri-Party Agreement Covering Hanford Cleanup

Hanford Federal Facility Agreement and Consent Order

Tri-Party Agreement

Marked the Official Start of the Cleanup Mission (over 23 years ago)

- **Formal agreement between US Department of Energy, Environmental Protection Agency, and Washington State Department of Ecology (signed May 1989)**
- **Legally enforceable foundation governing Hanford cleanup**
- **Legal Agreement: roles, responsibilities and authorities of the three agencies**
- **Action Plan: methods for implementing cleanup actions, enforcing milestones**
- **Community Relations Plan: stakeholder involvement/input to cleanup**

TEPCO Press Release, 7 January 2012

Overview of the Fukushima Revitalization Headquarters

< Reference 1 >

President

Fukushima Revitalization Headquarters
Representative: Executive Vice President

Fukushima Division

Number of employees: As of January 1, 2013.
The number in the parenthesis indicates the number of employees added as of January 1.

Planning and General Affairs Department	Number of employees: 19 (19) Responsibilities: Plays a supervisory role, plans regional economic revitalization measures Location: J-Village
Fukushima Nuclear Compensation Office	Number of employees: 1,167 (4) Responsibilities: Compensation operations (Swift and smooth locally oriented compensation) Location: Fukushima City (Representative), etc.
Decontamination Promotion Office	Number of employees: 130 (33) Responsibilities: Decontamination operations (Human resources and technical cooperation for decontamination, etc.) Location: Fukushima City (Representative), etc.
Revitalization Promotion Office	Number of employees: 144 (19) Responsibilities: Revitalization promotion operations (Serves as liaison between TEPCO and local municipalities, promotes revitalization support activities, etc.) Location: Fukushima City (Representative), etc.
Fukushima Corporate Communications Department	Number of employees: 18 (5) Responsibilities: Corporate communications operations (Publicizes the statuses of nuclear/thermal/hydroelectric power stations in the prefecture and the progresses of compensation, decontamination and revitalization promotion, etc.) Location: Fukushima City

Development of cooperative relations with Inawashiro Power System Office, Hamadori Power System Office, Hirono Thermal Power Station, Hirono Thermal Power Plant Construction Office, Fukushima Daiichi Stabilization Center, Fukushima Daiichi and Daini Nuclear Power Stations

The Nuclear Challenge

- Despite resilient public support in the wake of Fukushima, there remains an unease about all things nuclear.
- Nuclear/radiation pushes many of our “rational fear buttons”
  - can’t be detected by senses or can cause ‘eventual’ death
  - dose reporting and health effects are difficult to understand
- Nuclear technology costs more and is utilized less than it might, while often externalities of “conventional” technologies are ‘overlooked’

ANS

ANS on Public Outreach

- How do we move forward? => Improve “nuclear literacy.”
- ANS focus on key groups: school-age children; our policymakers; the general public and the media.
- Requires sustained education
- Why should the ANS be a leader in this education effort?
  - Credibility: the general public trusts open-honest discussion of scientists and engineers, but is quite savvy and quick to disregard “industry messaging.”
  - Human Element: ANS members can engage in “broad” outreach.

ANS

Center for Nuclear Science & Technology Information

- Informing those outside nuclear about the facts
- Interacting with elected officials and the media
- Inspiring educators to include nuclear science in their classrooms
- Serving as the definitive source of credible information on nuclear issues

Center for Nuclear Science and Technology Information
An initiative of the American Nuclear Society

ANS

www.nuclearconnect.org

A Bright Future for ANS

ANS is going through a transformation, examining itself inside and out, to enhance our members experience and have a greater impact on the nuclear field

ANS

Thank you for joining ANS to:

Inform.

Engage.

Inspire.

ANS