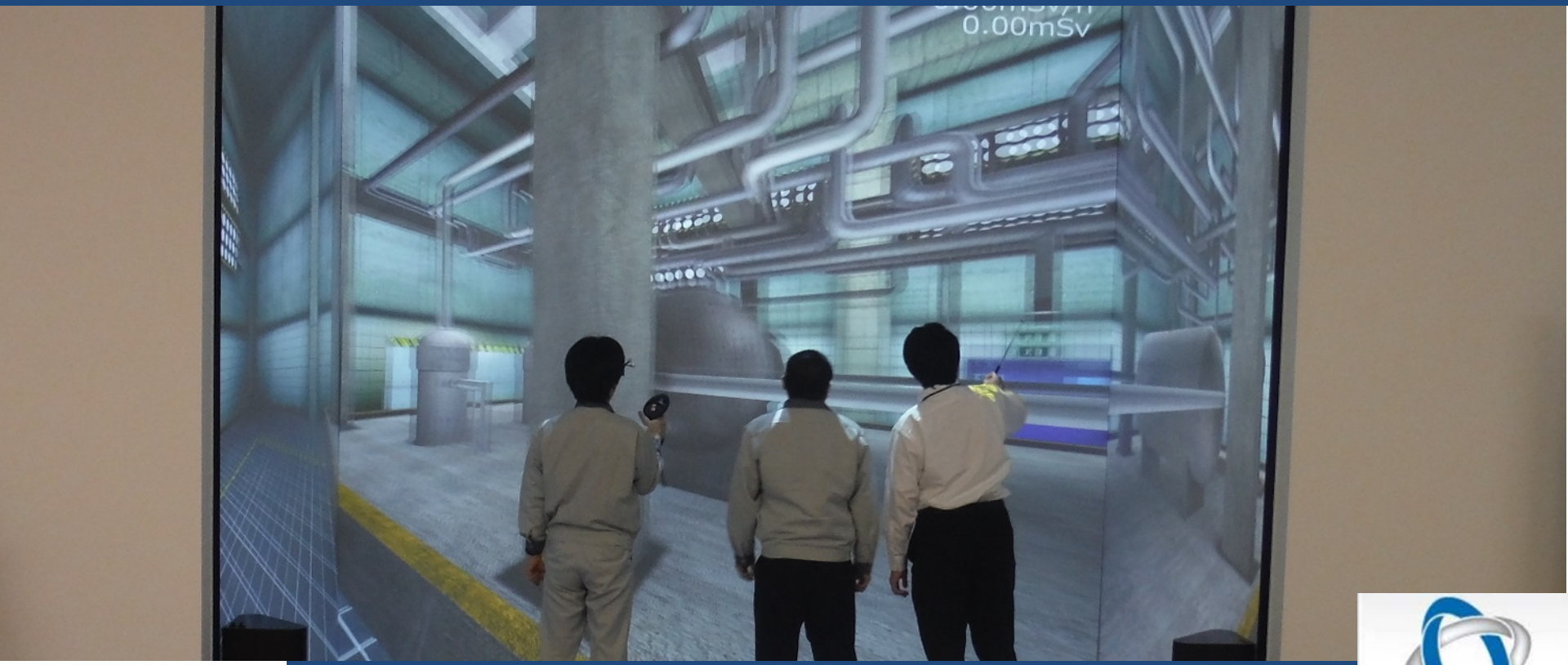
February 18, 2020 OECD/NEA Workshop on
PREPAREDNESS FOR POST-ACCIDENT RECOVERY PROCESSES: LESSONS FROM EXPERIENCE

Reflections on 9 years of JAEA R&D activities in Fukushima



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Japan Atomic Energy Agency (JAEA)

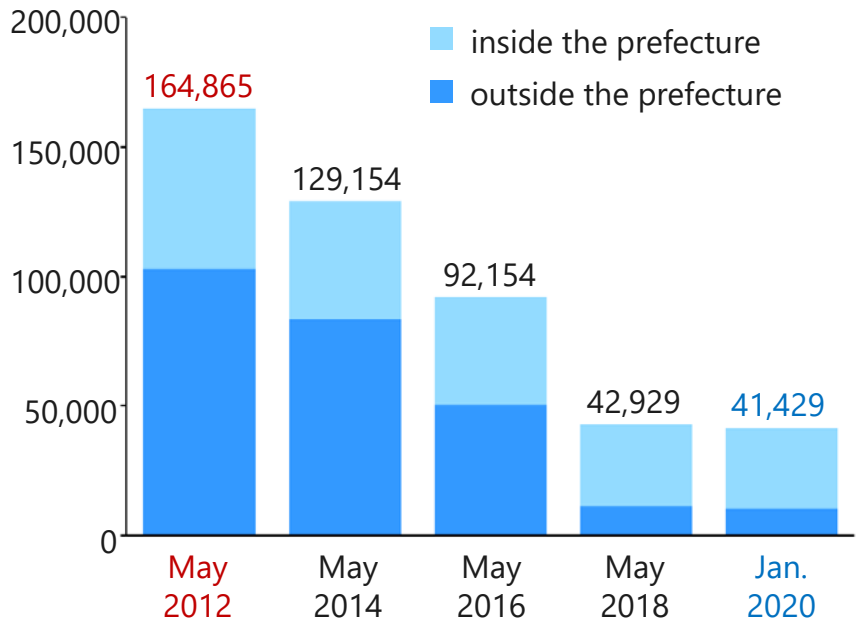
Evacuation status: population and area

◆**Evacuees:**

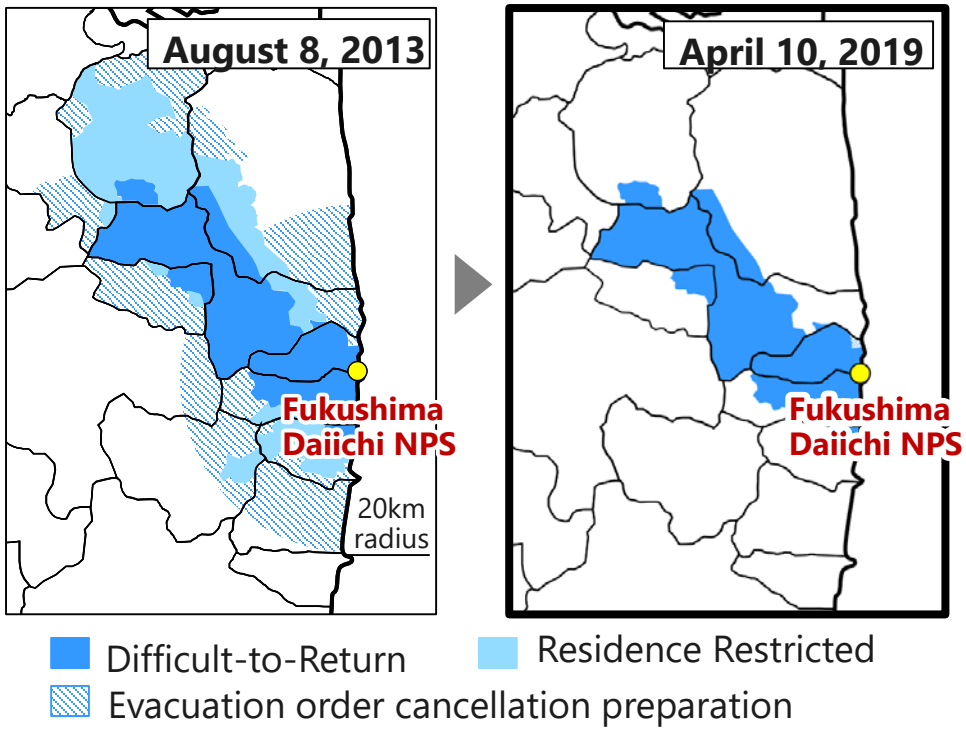
164,865 (peaked in May 2012) ➡ ~41 thousand

◆**Area size:**

8.3% (August 2013) ➡ ~ 2.5% of Fukushima Pref.



Edited from "Steps for Revitalization in Fukushima 26th edition (Japanese ver.) <Aug. 5, 2019>" and "Damage Report <Jan. 10, 2020>" (Fukushima Prefecture) (accessed 2020/1/25)



Edited from "Evacuation Areas on August 8, 2013 and April 10, 2019". (Ministry of Economy, Trade and Industry of Japan) (accessed 2019/7/18)

Evacuation: for future reopening

Environmental cleanup has been initiated in the Difficult-to-Return zone, to enable lifting of the evacuation order in the future

Reopening will begin in Futaba Town on March 4, in Okuma Town on March 5, and in Tomioka Town on March 10 in 2020.

http://josen.env.go.jp/kyoten/index.html

Coming Soon: March 14, 2020

JR Joban Line reopens after 9 years

https://ja.wikipedia.org/wiki/%E3%83%95%E3%82%A1%E3%82%A4%E3%83%AB:JR_Joban_Line_linemap.svg

JAEA Fukushima R&D deployment

JAEA Okuma Analysis and Research Center open

2018

2017

JAEA CLADS open in Tomioka

JAEA Naraha Center open

2016

2015

Iwaki Office

2014

JAEA Fukushima Environmental Safety Center

Environmental Monitoring

2013

Fukushima Office

Decontamination Pilot Project

Internal Exposure Inspection

Interactive Public Meeting on Radiation/Health

2011

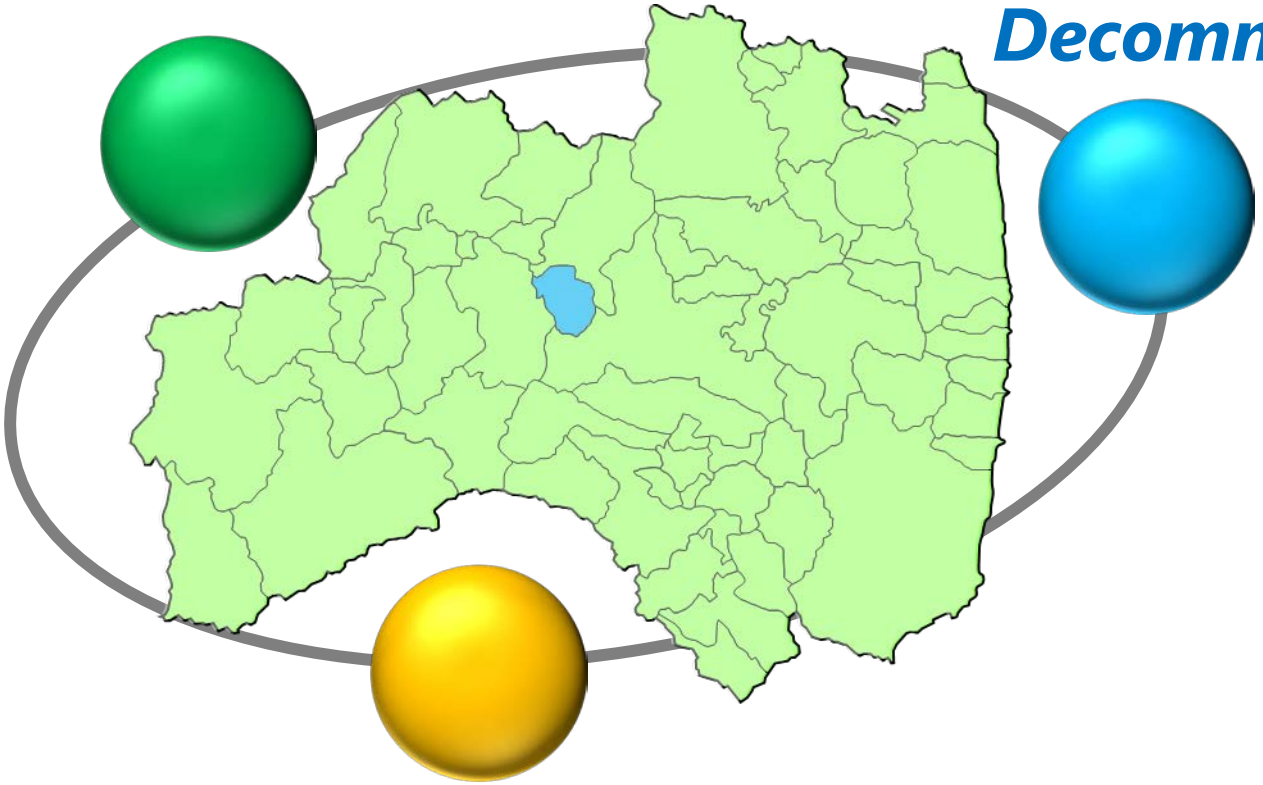
March 11, 2011

- Earthquake
- Nuclear Accident

The Three JAEA R&D Pillars

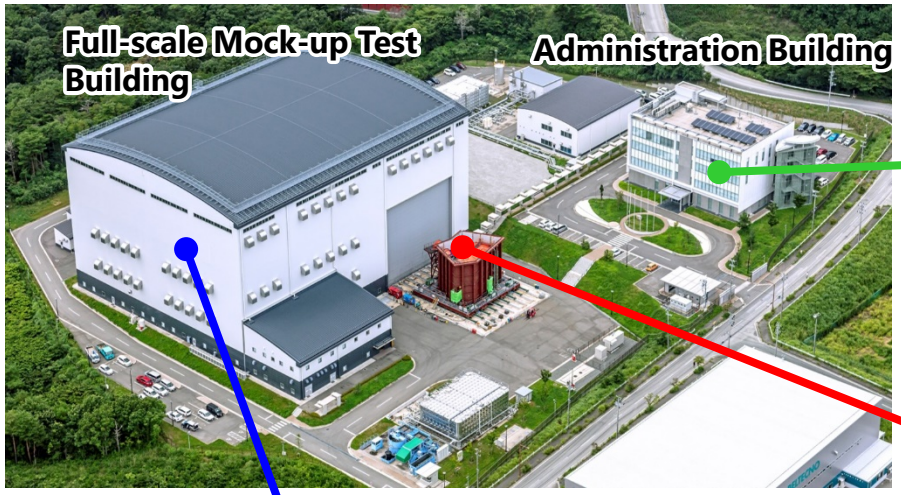
R&D for Environmental Restoration

R&D for Decommissioning



R&D Infrastructure building and human resource development

Decommissioning: Naraha Center for Remote Technology Development, NARREC



For worker training,

Robot simulator

Virtual Reality System

Full-scale mock-up test field

Full-scale test for remote control water leak stoppage in the reactor primary containment vessel (PCV)

1/8 portion of the circular suppression chamber

Robot test field

Mock-up stairs

Robot test pool

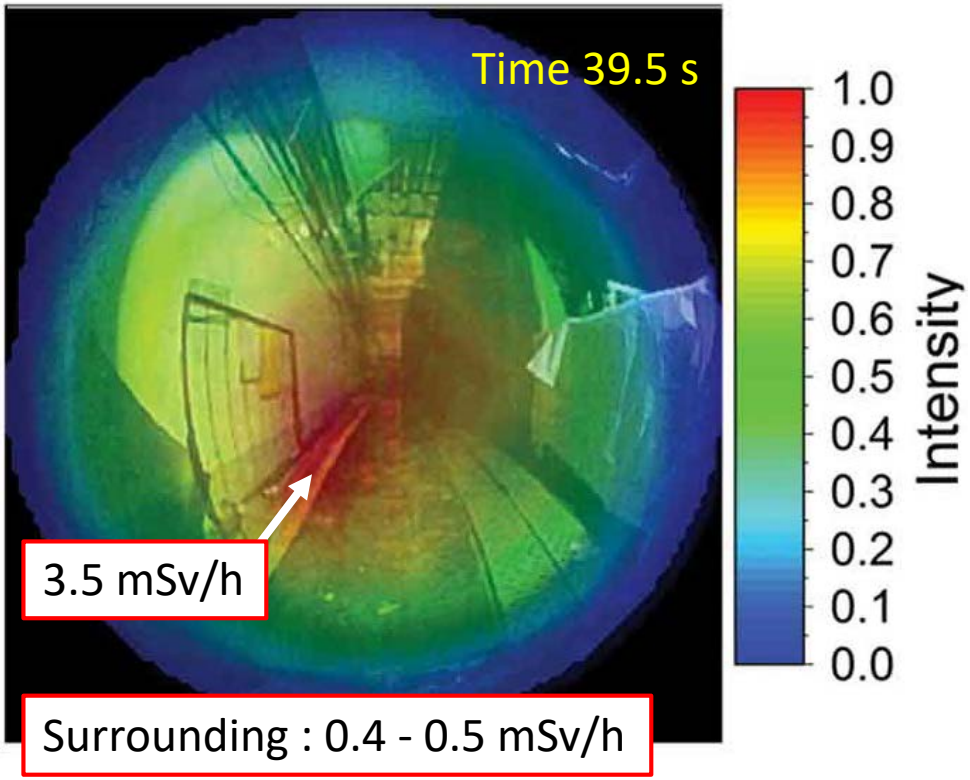
Motion capture system

Decommissioning: Cooperative Laboratories for Decommissioning Science, CLADS

Core of JAEA's R&D, acting as both an international research hub and a symbol of the shared international interest

Radiation distribution visualized in situ

Optical Image



Radiation Imaging

Decommissioning: Human Resource Development

Human Resource Development for decommissioning in Japan is:

- **prioritized to decommissioning of TEPCO's Fukushima Daiichi NPS**
- **mostly government-funded**
  - **MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY**
  - **MINISTRY OF ECONOMY, TRADE AND INDUSTRY**
  - **NUCLEAR REGULATORY AGENCY**
- **performed through collaborative R&D activities between research institutes, university/college, and academic societies**

JAEA is involved in the HRD through:

- ✓ **University summer schools on robotics, decommissioning robot competition**
- ✓ **Participation in and/or invitation to JAEA's international Fukushima Research Conferences, and to cooperative courses with scientific institutions**
- ✓ **Lectures at universities/colleges**
- ✓ **Hot facility construction/operation for engineers, characterization of radioactive wastes and fuel debris for radiochemists and technicians**

Decommissioning: Human Resource Development in Naraha

Decommissioning Robot Competition

17 colleges and 1 university competed
organized by
National Institute of Technology, Fukushima College
funded by MEXT
(December 15, 2019)

Robotics Summer School

The University of Tokyo

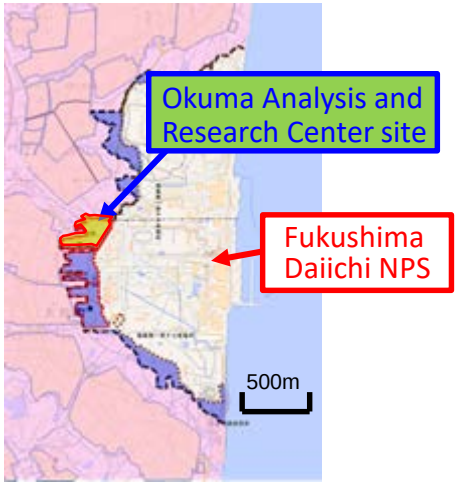
funded by MEXT
(August 8-10, 2016)

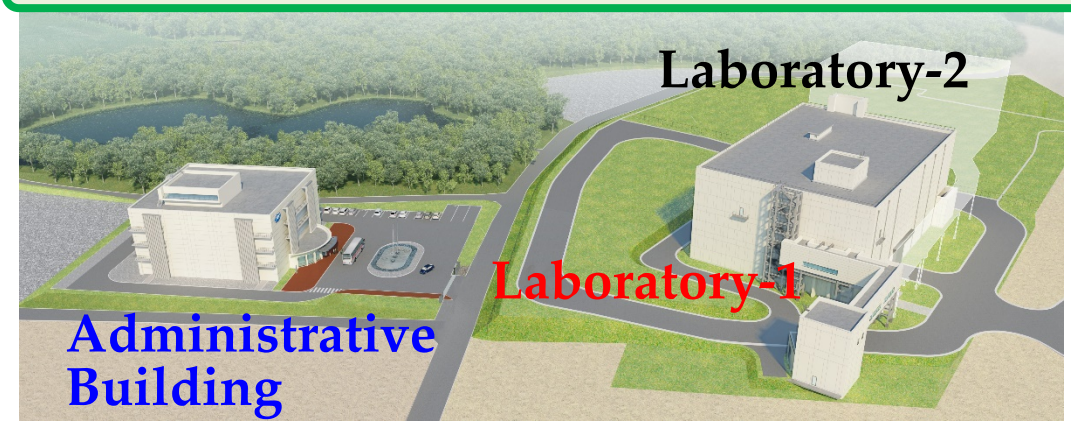
Decommissioning: Human Resource Development in Okuma

JAEA Okuma Analysis and Research Center

- is a first large scale hot laboratory constructed in Japan during the past 30 years, to deal specifically with post-accident radioactive wastes (> 1 Sv/h @ surface) and fuel debris, and
- is a world unique facility specific to severely-damaged nuclear reactors

- could play an essential role in terms of human resource development for;
  - ✓hot facility construction,
  - ✓hot facility maintenance,
  - ✓analysis technicians, and
  - ✓radiochemists





Laboratory-1
under construction (December 2019)

Radioactive Wastes at 1F

Volumes of radioactive wastes generated by the severe nuclear accident at TEPCO 1F are vast and both chemically and radiochemically complex. These wastes can be chemically and physically unstable substances with a variety of physical forms and wide range of specific activities

- The entire 1F site was contaminated, generating the following contaminated wastes:
  - All physical structures, machines and equipment
  - Devices for contaminated water treatment and resultant secondary waste, and for decommissioning
  - Soil and vegetation
  - Miscellaneous, e.g. on-site vehicles
- The site is in a dynamic state
  - Radioactivity distribution varies with weathering and decay
  - Radiolysis generates hydrogen gas during storage

Needs devoted R&D, in addition to extensive use of proven technology

Decommissioning: Human Resource Development in CLADS Tomioka

Gathers
- **expertise internationally,**
- **scientists and budding scientists internationally**

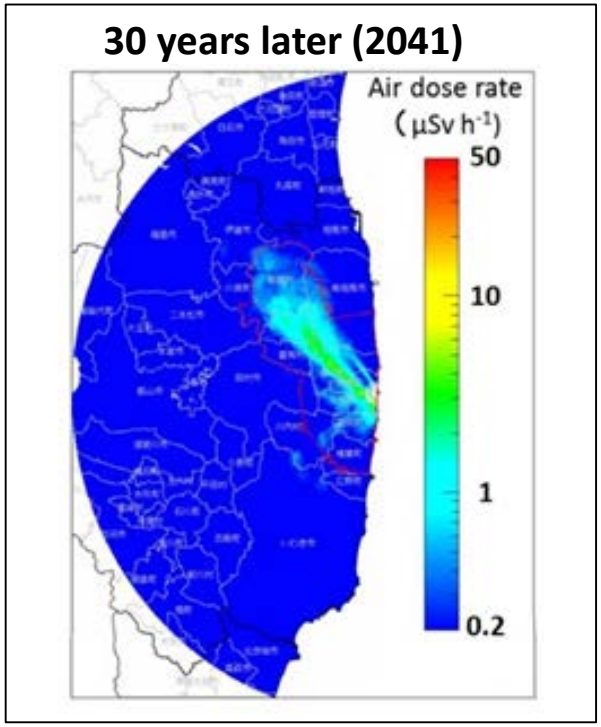
through collaborative R&D:

- ✓ **Participation in and/or invitation to JAEA's international Fukushima Research Conference**
- ✓ **Collaborative research programs with domestic/international research institutes; England, Russia, France, USA**
- ✓ **OECD/NEA NEST program**

Fukushima Research Conference on post-accident waste management safety (2016)

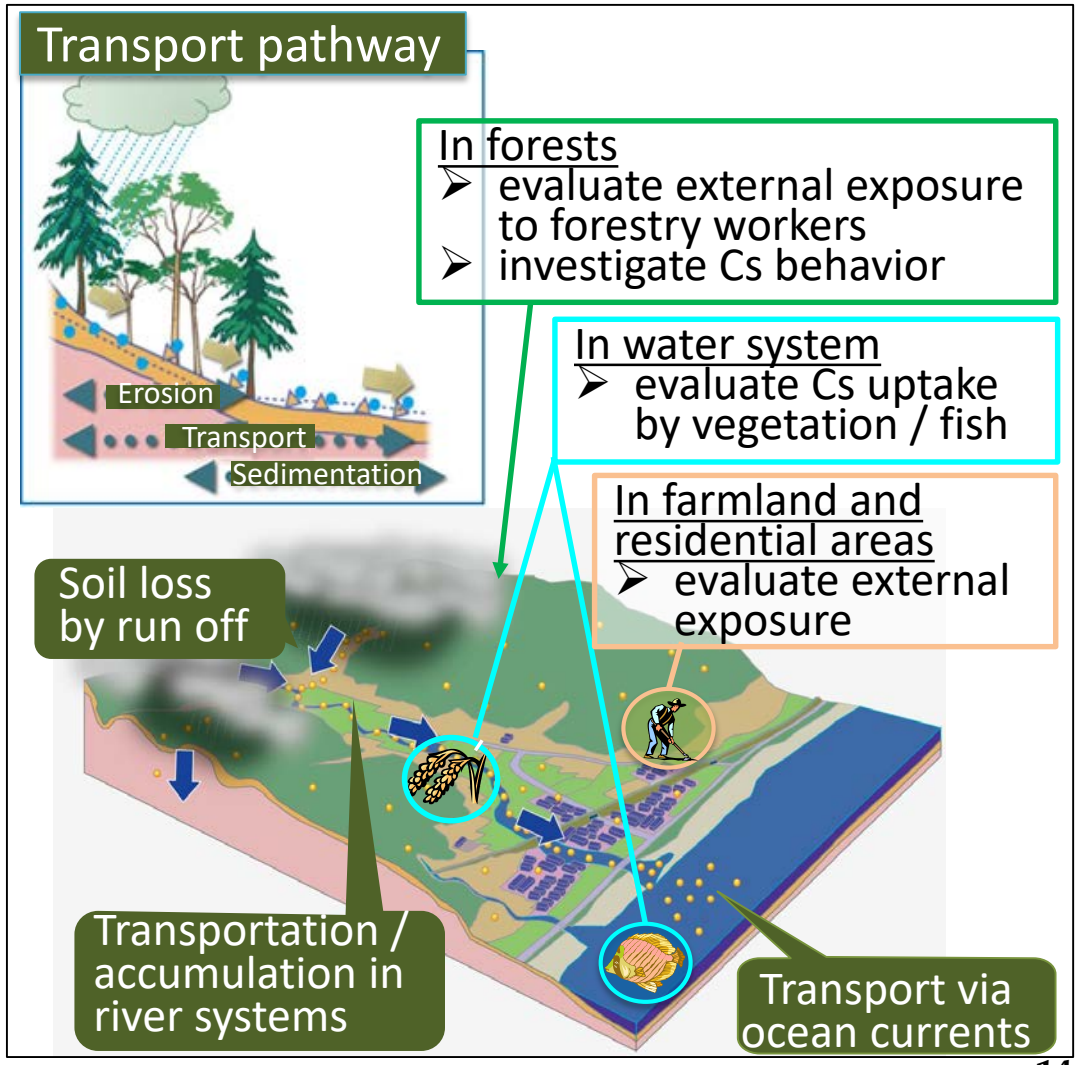
Environmental Radiation Research

Technology development on environmental radiation monitoring and mapping



Prediction of Air Dose Rate Distribution

Environmental science on cesium behavior



Communication: Human Resource Development

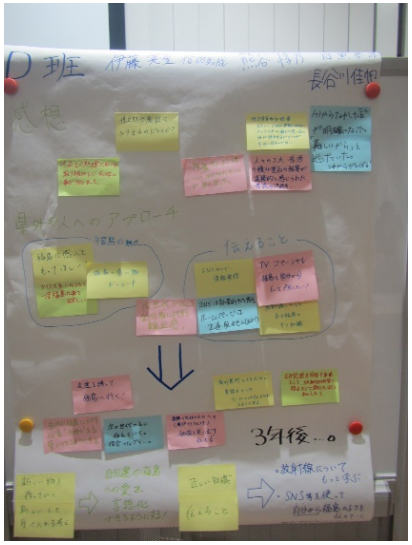
JAEA's Question-And-Answer Session on radiation and health since 2011
- Interactive Public Meeting on Radiation/Health -

- Briefings on radiation, and face-to-face discussions with parents and teachers, answering their questions on radiation and its health effects, upon their request from Fukushima prefecture schools (kindergartens to junior high).
- 250 sessions held since July 2011, for a total of about 21,000 residents.

- **JAEA staff members contributed by providing textbook information on radiation, and peace of mind, however,**
- **JAEA staff members also did recognize their sometimes limited ability in communication of radiation/science to the public [LESSON LEARNED]**
- **Difficulties in communicating such complex scientific principles could partially explain the cause of subsequent mistrust of experts by the Japanese public that still persists today**

Communication: Human Resource Development

- Schools in Fukushima have got started on a variety of educational activities on energy/radiation since the accident
- JAEA, following the Question-And-Answer Session, have been involved in educational activities; presiding over classes or participating in dialogues
- JAEA aims to provide scientifically sound nuclear/radiation science to future generations so they are able to relay the facts of the post-Fukushima accident situation to others in Japan
- At the same time, the involvement of JAEA in educational activities and international dialogue forums, has lead to improved education and training of JAEA staff members, specifically for science communication purposes



“Lessons Learned”: my perception (1/2)

Environmental Cleanup

1. **Theoretical approaches to decontamination are not always appropriate**

   Contamination is “accident-specific”, and cleanup is “accident-and-site -specific”. Tools/equipment used for clean-up highly depends on land use, land features, local weather, water courses and so on and so forth. In addition, gaining the trust from local residents is extremely important

2. **Adopt a holistic waste management approach**

   Cleanup strategy should be “holistic”, and consider impacts of various end state options. Remediation after the 1F accident resulted in the generation of huge volumes of only very lightly-contaminated radioactive waste

3. **WM and EPR to be prioritized**

   It should be the responsibility of the nuclear industry to take waste management and emergency preparedness and responses into account when siting and designing nuclear facilities.

"Lessons Learned": my perception (2/2)

Emergency Response

Combined accident – defense in depth?

The military is essential for disaster relief, and reliable also for nuclear / radiation or similar serious accidents. They were a great help to Japan in 2011.

Note that their prioritized mission, at that time, was to save the lives of earthquake and tsunami victims, all at time when communications and critical infrastructure had been knocked out. Surveys of non-life-threating radiation was not.

Lessons learned

From the "Post-accident Recovery Process"

The 2011 accident happened in the technologically advanced democratic nation of Japan, in the fast and highly developed information age of the internet. This is one of features of the 2011 accident, that no previous nuclear accident had to deal with. The international scrutiny was intense and the pressure to act promptly great. There must be many lessons to be learned on how the recovery operations performed under such boundary conditions, not least the rapid dissemination of honest and understandable information