EAFORM2017

6th East Asia Forum on Radwaste Management Conference

November 27-29, 2017

Hotel Granvia Osaka, 3-1-1 Umeda, Kita-ku, Osaka, Japan

Contents

EAFORM2017

6th East Asia Forum on Radwaste Management Conference

November 27-29, 2017

Hotel Granvia Osaka, 3-1-1 Umeda, Kita-ku, Osaka, 530-0001, Japan

General Objective of EAFORM

Safe, secure, and sustainable solutions to the management of spent nuclear fuels and radioactive wastes are critical to the viability and continuing peaceful use of nuclear power and other advanced nuclear applications. With no exception, current nuclear energy programs in the East Asian area are all faced with such challenges. Although each of these programs has developed its own technology base, implementation strategy, and infrastructure, the urgent need for further technology enhancement on radioactive waste management and implementation of radioactive waste disposal are becoming more essential to all. This is especially true after the accident at the Fukushima Daiichi Nuclear Power Plant. Enhancing international collaboration will benefit participants through the sharing of knowledge and expertise, as well as other intangible benefits such as public comprehension of safety issues and support for repository establishment.

Recognizing these facts, several East Asian research organizations agreed to hold the East Asia Forum on Radwaste Management (EAFORM) to enhance future cooperation. EAFORM is principally opened to all research organizations and others related to radioactive waste management. The purpose of EAFORM is to promote information exchange, to share knowledge, and to encourage international collaboration in a bilateral or multilateral mode.

Under this configuration, the “EAFORM Management Committee” was organized to develop activities aimed at strengthening the above purpose. The 1st EAFORM conference was held in Taiwan in 2006. The 6th EAFORM conference will be held in Osaka from November 27 to 29, 2017. Conference participants are encouraged to focus their submissions on the technical topics of this conference.

Organization of 6th Conference

■ Hosted by

Atomic Energy Society of Japan

■ Organized by

EAFORM Management Committee (*)

Division of Nuclear Fuel Cycle and Environment, Atomic Energy Society of Japan

* Currently, "EAFORM Management Committee" consists of following members (listed in alphabetical order)
  - Atomic Energy Society of Japan (Division of Nuclear Fuel Cycle and Environment, NUCE/AESJ)
  - China Institute of Atomic Energy (CIAE)
  - Chung Hwa Nuclear Society (CHNS)
  - Institute of Nuclear Energy Research (INER)
  - Korea Radioactive Waste Agency (KORAD)
  - Sandia National Laboratory (SNL) [Technical supporting member]

Conference Venue and Halls

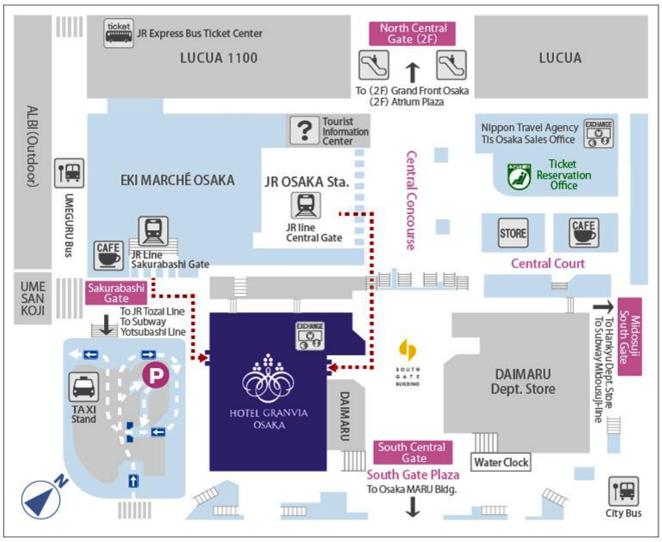
■Conference Venue

Hotel Granvia Osaka

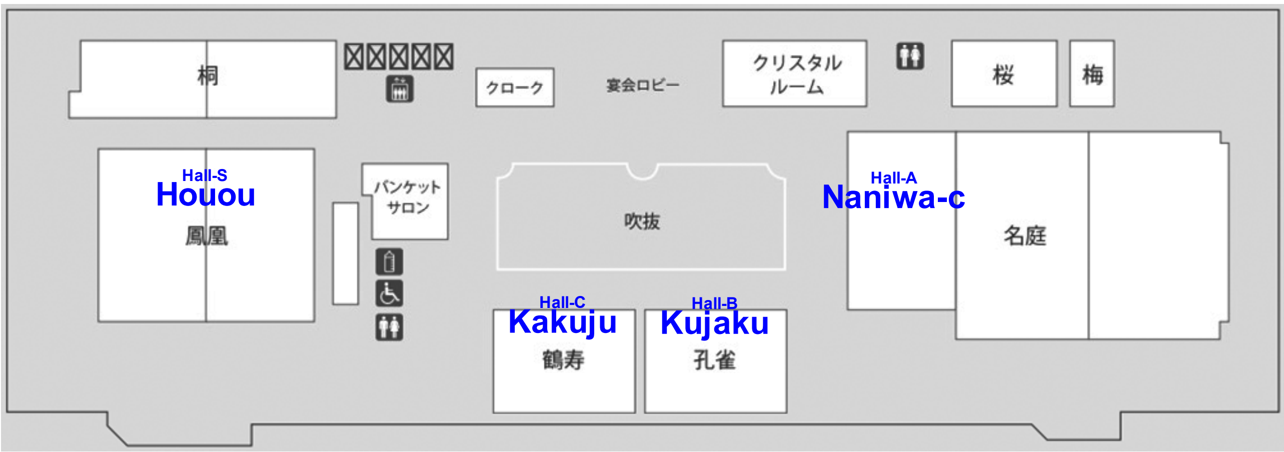
3-1-1 Umeda, Kita-ku, Osaka, 530-0001, Japan

http://www.hotelgranviaosaka.jp/maps/maps-transportation.htm

(+81)-6-6344-1235, granvia@hgo.co.jp



■Floor Map of the Conference Halls (20th Floor)



Time Table (Program Summary)

■On-site Registration Desk (20th Floor of Hotel Granvia Osaka)

Open between 16:00 to 20:00 on Sunday 26 November 2017

Open from 8:15 on Monday 27 November 2017

■Day 1: Monday 27 November 2017

Time			
08:15-09:00	**Registration (Local Space on the 20th floor)**		
	Hall S (Houou)		
09:00-09:10	**Opening Remarks** Mitsuo Takeuchi, Chair, The 6th EAFORM Organizing Committee		
09:10-09:50	**Plenary Session 1** (1) Katsumoto Yoshimura, Director, Technology Office for RWM and Public Relations Office for RWM, METI, Japan (2) Yaohiro Inagaki, Prof. (Kyushu Univ.) and Director, Division of Nuclear Fuel Cycle and Environment, AESJ, Japan *2 speeches will be provided (20min. Each)*		
09:50-11:10	**Plenary Session 2** (1) Ching-Tsuen Huang, Prof. (National Tsing Hua Univ.) and Chairman, Academic Committee on Radwaste Management, CHNS, Taiwan (2) Joo-Wan Park, Vice President of Radioactive Waste Project Division, Korea Radioactive Waste Agency (Korad), Korea (3) Todd R. Zeitler, WIPP Performance Assessment Technical Team Lead, Sandia National Laboratories, USA (4) (TBD from China) *4 speeches will be provided (20min. Each)*		
11:10-11:30	**Coffee Break**		
11:30-12:50	**Special Session: Toward Revitalization of Fukushima** *4 speeches will be provided (20min. Each)*		
12:50-14:00	***Lunch (Hall A, Hall B, Hall C)***		
Time	**Hall A (Naniwa-C)**	**Hall B (Kujaku)**	**Hall C (Kakuju)**
14:00-16:05	**Technical Session 1A** Radioactive Wastes Treatment *Chair; Hitoshi Owada* *3 Papers* *25 min. each including QA for 5min.*	**Technical Session 1B** Decontamination & Decommissioning-1 *Chair; Shinichi Nakayama* *5 Papers* *25 min. each including QA for 5min.*	**Technical Session 1C** Radioactive Waste Management Policies, Regulations and Programs-1 *Chair; Motoi Kawanishi* *3 Papers* *25 min. each including QA for 5min.*
16:05-16:20	***Coffee Break***		
16:20-18:00	**Technical Session 2A** SNF/HLW Disposal-1 *Chair; Shinzo Ueta* *4 Papers* *25 min. each including QA for 5min.*	**Technical Session 2B** Decontamination & Decommissioning-2 *Chair; Satoshi Yanagihara* *3 Papers* *25 min. each including QA for 5min.*	**Technical Session 2C** Radioactive Waste Management Policies, Regulations and Programs-2 *Chair; Kenichi Kaku* *3 Papers* *25 min. each including QA for 5min.*
18:30-20:30	***Welcome Dinner (Hall Naniwa)***		

■Day 2: Tuesday 28 November 2017

Time	Hall A (Naniwa-C)	Hall B (Kujaku)	Hall C (Kakuju)
08:30-10:10	**Technical Session 3A** SNF/HLW Disposal-2 *Chair; Morimasa Naito* *4 Papers* *25 min. each including QA for 5min.*	**Technical Session 3B** LLW/ILW Disposal-1 *Chair; Teruyuki Yamada* *3 Papers* *25 min. each including QA for 5min.*	**Technical Session 3C** *SNF/HLW Disposal-3* *Chair; Yoichi Yamamoto* *4 Papers* *25 min. each including QA for 5min.*
10:10-10:30	***Coffee Break***		
10:30-11:45	**Technical Session 4A** SNF/HLW Disposal-4 *Chair; Morimasa Naito* *3 Papers* *25 min. each including QA for 5min.*	**Technical Session 4B** LLW/ILW Disposal-2 *Chair; Minoru Emori* *2 Papers* *25 min. each including QA for 5min.*	**Technical Session 4C** SNF/HLW Disposal -5 *Chair; Hiromitsu Saegusa* *2 Papers* *25 min. each including QA for 5min.*
11:45-13:00	***Lunch (Hall S)***		
Time	**Hall A (Naniwa-C)**	**Hall B (Kujaku)**	**Hall C (Kakuju)**
13:00-14:40	**Technical Session 5A** SNF/HLW Disposal-6 *Chair; Hiroyuki Tsuchi* *4 Papers* *25 min. each including QA for 5min.*	**Technical Session 5B** SNF/HLW Disposal-7 *Chair; Takamitsu Ishidera* *4 Papers* *25 min. each including QA for 5min.*	**Technical Session 5C** SNF/HLW Disposal-8 *Chair; Tetsuo Fujiyama* *3 Papers* *25 min. each including QA for 5min.*
14:40-14:55	***Coffee Break***		
14:55-16:35	**Technical Session 6A** Radioactive Waste Management Policies, Regulations and Programs-3 *Chair; Hiroyoshi Ueda* *4 Papers* *25 min. each including QA for 5min.*	**Technical Session 6B** SNF/HLW Disposal-9 *Chair; Masamichi Obata* *3 Papers* *25 min. each including QA for 5min.*	**Technical Session 6C** SNF/HLW Disposal-10 *Chair; Soshi Nishimoto* *3 Papers* *25 min. each including QA for 5min.*
16:35-16:45	***Short Break***		
16:45-17:00	**Closing Session** Closing Remarks		

■Day 3: Wednesday 29 November 2017

One-day technical tour (optional)

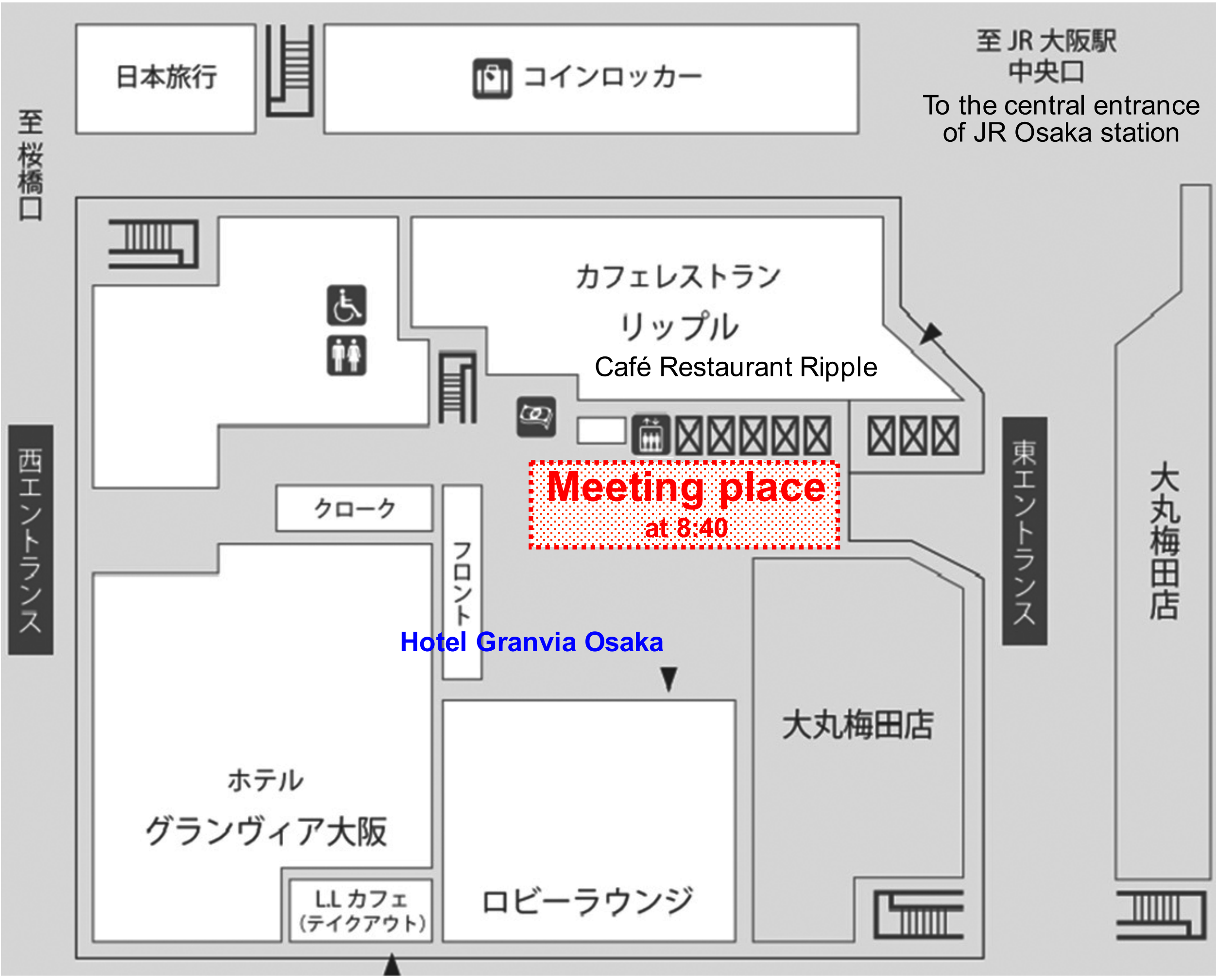
◆**08:40** Gathering & Departure from Hotel Granvia Osaka to;

1) HOKUDAN EARTHQUAKE MEMORIAL PARK (http://www.nojima-danso.co.jp/)
2) The Great Hanshin-Awaji Earthquake memorial museum (http://www.dri.ne.jp/en)
3) Short break at (stop by) KOBE KITANO IJINKAN-GAI (http://www.kobeijinkan.com/)

◆**17:45** Return back to Hotel Granvia Osaka (expected time)

1st Meeting place at 08:40 is "**Meeting place** (see following floor map)" on the Grand floor of Hotel Granvia Osaka

[Floor Map of the Grand Floor (1st floor) of Hotel Granvia Osaka]



Program

■Day 1: Monday 27 November 2017

Plenary Session 1 9:10-9:50 [Hall S] Chair, Reiko Nunome (NUMO)

Status of Radioactive Waste management in Japan

Chair, Reiko Nunome (NUMO)

(1) **Nationwide Map of Scientific Features for Geological Disposal of High-Level Radioactive Waste in Japan**
Katsumoto Yoshimura (Director, Technology Office for RWM and Public Relations Office for RWM, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, Japan)

(2) **How to Integrate Various Research Fields for Reasonable and Reliable Radwaste Management**
Yaohiro Inagaki (Prof. (Kyushu Univ.) and Director, Division of Nuclear Fuel Cycle and Environment, AESJ, Japan)

Plenary Session 2 9:50-11:10 [Hall S]

Status of Radioactive Waste management in Taiwan, Korea, China and USA

Chair, Reiko Nunome (NUMO)

(1) **Current Situation of Radioactive Wastes Management in Taiwan**
Ching-Tsuen Huang (Prof. (National Tsing Hua Univ.) and Chairman, Academic Committee on Radwaste Management, CHNS, Taiwan)

(2) **Status of High-level Radioactive Waste Management Program in Korea**
Joo-Wan Park, Vice President of Radioactive Waste Project Division, Korea Radioactive Waste Agency (Korad), Korea

(3) **Recertification of WIPP: From Submittal of the CRA-2014 to an EPA Recertification Decision**
Todd R. Zeitler (WIPP Performance Assessment Technical Team Lead, Sandia National Laboratories, USA)

(4) (TBD from China)

Special Session 11:30-12:50 [Hall S]

Toward Revitalization of Fukushima

Chair : Motoi Kawanishi (ASANO TAISEIKISO ENGINEERING Co.)

(1) **Technical Strategy for Decommissioning of the Fukushima Daiichi NPS**
Kazuyuki Kato (Managing Director, Technological Strategy Group, Nuclear Damage Compensation and Decommissioning Facilitation Corporation)

(2) **Study on Post-Accident Waste Management Scenarios for Fukushima Daiichi Nuclear Power Station**
Satoshi Yanagihara (Prof. (Univ. of Fukui) and Executive committee member, Review Committee on Decommissioning of the Fukushima Daiichi Nuclear Power Station, AESJ)

(3) **JAEA's R&D for Decommissioning of Fukushima Daiichi Nuclear Power Station**
Shinichi Nakayama (Director General, Fukushima Research Institute, JAEA)

(4) **Distribution of Radionuclides Nearby the Fukushima Daiichi Nuclear Power Station**
Terumi Dohi (Assistant Principal Engineer, Fukushima Environmental Safety Center, Fukushima Research Institute, JAEA)

Technical Session 1A 14:00-16:05 [Hall A]

Radioactive Wastes Treatment: Source Term & Waste Treatment

Chair ; Hitoshi Owada (RWMC)

1A-1 High-frequency Melting Technology of Radioactive Metal Waste
Nobutake Horiuchi, Takeshi Nishikawa, Naoto Sasaki and Hirokazu Tanaka

1A-2 C-14 Release Behavior and Thermal Decomposition Characteristics of Crud Particles Collected from the Coolant Filter of Commercial PWR
Shintaro Tsuji, Toshikazu Waki, Akira Sakashita and Kenichiro Kino

1A-3 Evaluation of Carbon-14 Release from Irradiated Zircaloy Fuel Cladding through a Long-term Static Leaching Test
Hiroyoshi Ueda, Tomofumi Sakuragi, Naoki Fujii and Hitoshi Owada

Technical Session 1B 14:00-16:05 [Hall B]

Decontamination & Decommissioning: Decontamination-1: Decontamination

Chair ; Shinichi Nakayama (JAEA)

1B-1 The Assessments and Comparisons of RASCAL and EPZDose on Atmospheric Dispersion and Dose Consequences in Radioactive Material Release Accidents
Shaohsuan Chen, Jongrong Wang, Chunkuan Shih, YuTing Ku, Yu Chiang, ShaoWen Chen and WenSheng Hsu

1B-2 Confirmation of Appropriate Operation Condition with Blasting Device
Yuuki Tsuhara, Hirotaka Izuka, Shinro Hirano, Yuji Matsunaga, Yasuhiro Sugahara and Yoji Kanamori

1B-3 Development of In-situ Radioactivity Inspection System for Radioactive Waste and Decontamination System Using Microalgae
Sujung Min, Dohyung Kim, Woyoung Kim, Sheunghyun Ha, San Chae, Jongman Lee and Unjang Lee

1B-4 Rapid Removal of Cesium-137 from Urban Area After the Fukushima Dai-ichi Nuclear Power Plant Accident
Kazuya Yoshimura

1B-5 A Study on the Performance of Flocculating Agent for Radioactively Contaminated Soil by Soil Washing Process
Jong Soon Song and Sun Il Kim

Technical Session 1C 14:00-16:05 [Hall C]

Radioactive Waste Policies, regulations and Programs-1
Chair : Motoi Kawanishi (ASANO TAISEIKISO ENGINEERING Co.)

1C-1 Spent Nuclear Fuel Final Disposal Management in Taiwan
Allan Lee

1C-2 Scientific Basis for Nationwide Screening of Geological Disposal Sites in Japan
Takehiro Matsumoto, Hiromitsu Saegusa, Hideaki Hyodo, Akira Deguchi and Hiroyuki Umeki

1C-3 Sensitivity of WIPP Performance Assessment Results to Regulator-prescribed Changes
Todd R. Zeitler and Brad A. Day

Technical Session 2A 16:20-18:00 [Hall A]

SNF/HLW Disposal-1: Modelling (THMC, etc.)
Chair : Shinzo Ueta (MITSUBISHI MATERIALS Co.)

2A-1 Geochemical Modeling of Water-rock Interactions in Granitic Rocks, Eastern Taiwan
Yu-Te Chang

2A-2 Centrifuge Model Test to Gain Reliability of the Future Prediction in Terms of Long Term THM Processes in Deep Geological Repository
Soshi Nishimoto

2A-3 Thermo-hydro-chemical Processes Influence on Buffer Material Degradation in High Level Radioactive Waste Disposal
Wen-Sheng Lin, Suu-Yan Liang and Chen-Wuing Liu

2A-4 Coupled THMC Processes in Radionuclide Waste Management
Gour-Tsyh (George) Yeh and Chia-Hsing (Peter) Tsai

Technical Session 2B 16:20-18:00 [Hall B]

Decontamination & Decommissioning: Decommissioning-2: Decommissioning
Chair : Satoshi Yanagihara (Univ. of Fukui)

2B-1 Efforts toward Safe, Steady and Efficient Decommissioning

Toyoaki Yamauchi, Satoshi Karigome and Hitoshi Ohata

2B-2 **Decommissioning Planning for Unit 1 and 2 at Mihama Nuclear Power Plant**
Shinya Kato, Koichi Kamahori, Hiromu Isaka and Shinro Hirano

2B-3 **Radiation Survey and Waste Inventory Estimation for Decommissioning of Taiwan NPP**
Chun-Cheng Lin, Wei-Sin Chen, Jyi-Lan Wuu and Shu-Jun Chang

Technical Session 2C 16:20-18:00 [Hall C]

Radioactive Waste Management Policies, Regulations and Programs-2:
Chair : Kenichi Kaku (NUMO)

2C-1 **Status of Radioactive Waste and Spent Nuclear Fuel Management in Finland**
Jari Tuunanen

2C-2 **Communication Activities through Dialogue in Japanese Geological Disposal Project of High-level Radioactive Waste**
Ayako Araki, Saki Ikeda, Kumiko Ezaki and Kenichi Kaku

2C-3 **Efforts in the Field of Education for Japanese Geological Disposal of High-level Radioactive Waste**
Kumiko Ezaki, Kenichi Kaku and Shunsuke Suzuki

■Day 2: Tuesday 28 November 2017

Technical Session 3A 08:30-10:10 [Hall A]

SNF/HLW Disposal-2 : Safety Case Development-1

Chair : Morimasa Naito (JAEA)

3A-1 Overview of the NUMO Safety Case at Pre-siting Stage
Tetsuo Fujiyama, Satoru Suzuki, Akira Deguchi and Hiroyuki Umeki

3A-2 Geosynthesis of a State-of-the-art Knowledge Base into SDMS in the NUMO Safety Case
Kunio Ota, Hiromitsu Saegusa, Takanori Kunimaru and Saori Yamada

3A-3 Layout Design of Underground Facilities Tailored to SDM in the NUMO Safety Case
Takahiro Goto, Yoichi Yamamoto, Satoru Suzuki and Shigeru Kubota

3A-4 Preliminary Study of Pre-closure Safety Assessment in the NUMO Safety Case
Kazuhisa Yamashina, Satoru Suzuki and Shigeru Kubota

Technical Session 3B 08:30-10:10 [Hall B]

LLW/ILW Disposal-1

Chair : Teruyuki Yamada (FEPC)

3B-1 Conceptual Study on Disposal Facility for Waste from Decommissioning of NPPs
Norie Kawahata, Ryoichi Hojo, Takayuki Hamanaka and Takashi Kozawa

3B-2 An Integrated Framework for Simulating Radionuclide Decay Transport of Low-level Radioactive Waste with Tunnel Disposal in Nearshore Environment
Chin-Chang Lu, Ming-Hsu Li and Yu-Ru Chen

3B-3 Sensitivity Analysis of Simulating Radionuclide Decay Transport of Low-level Radioactive Waste in Nearshore Environment
Yu-Ru Chen, Chin-Chang Lu and Ming-Hsu Li

Technical Session 3C 08:30-10:10 [Hall C]

SNF/HLW Disposal -3 : Barrier Technology (Overpack etc.)

Chair : Yoichi Yamamoto (NUMO)

3C-1 Seismic Response of Canister in Buffer Material Under Water Invasion Condition by Centrifuge Modeling
W.Y. Hung, J.J. Xu, Y.C. Wu and M.H. Hsieh

3C-2 Study on the Applicability of Cast Steel Overpack –Evaluation of Casting Defects and Corrosion Resistance Using Full-scale Prototype–
Yusuke Ogawa, Satoru Suzuki, Kazuhisa Yamashina and Shigeru Kubota

3C-3 Structural Integrity Assessment of Disposal Package for Radioactive Waste Failure Assessments for Overpack Using Finite Element Analysis
Masahiro Kawakubo and Masato Kobayashi

3C-4 Stress Analysis for the Canister Under Earthquake Induced Fracture Shear Displacement considering Long-term Creep Effect of Copper Shell
Yuan-Chieh Wu, Hsi-Ting Lo and Yi-Ren Wang

Technical Session 4A 10:30-11:45 [Hall A]

SNF/HLW Disposal -4 : Safety Case Development-2
Chair : Morimasa Naito (JAEA)

4A-1 Preliminary Study of Post-closure Safety Assessment in the NUMO Safety Case
Keisuke Ishida, Takafumi Hamamoto, Sanae Shibutani, Kiyoshi Fujisaki and Motoyuki Yamada

4A-2 Assessment of Sorption and Diffusion in the Rock Matrix in the NUMO Safety Case
Takafumi Hamamoto, Sanae Shibutani, Keisuke Ishida, Kiyoshi Fujisaki, Motoyuki Yamada and Yukio Tachi

4A-3 How Will New Knowledge Be Reflected to the Management of Geological Disposal? - Influence of an FEP Not Considered So Far to Some Sub-scenarios -
Koichi Shin

Technical Session 4B 10:30-11:45 [Hall B]

LLW/ILW Disposal-2
Chair: Minoru Emori (RWMC)

4B-1 Barrier of Near-surface LILW Disposal Facility in Korea: Hydraulic Model Development
Mi-Jin Kwon, Ki-Jung Kwon and Jin Beak Park

4B-2 Numerical Simulation of the Thermal Performance of a Dry Storage Cask for Spent Nuclear Fuel
Chi-Ming Lai, Ron-Horng Chen, Chu-Tsen Liao, Ting-Yi Wang and Heui-Yung Chang

Technical Session 4C 10:30-11:45 [Hall C]

SNF/HLW Disposal -5 : **Site Investigation Technology-1**
Chair : Hiromitsu Saegusa (NUMO)

4C-1 Influence of inherent and Stress-induced Anisotropy of Hydraulic Conductivity on the Groundwater Flow Around a Rock Tunnel
Huang-Kuei Chu, Po-Sung Lai and Jia-Jyun Dong

4C-2 Data Qualification Methodology in the Literature Survey Stage
Saori Yamada, Takanori Kunimaru, Kunio Ota, Stratis Vomvoris and Niels Giroud

Technical Session 5A 13:00-14:40 [Hall A]

SNF/HLW Disposal -6 : R&D by URL
Chair : Hiroyuki Tsuchi (SHIMIZU Co.)

5A-1 Mizunami Underground Research Laboratory Project - Achievement During Phase I/II and Important Issues for Phase III -
Katsuhiro Hama

5A-2 Virtual Reality Geological Modeling for the Horonobe Underground Research Project
Takayuki Motoshima, Makito Nago and Yuji Ijiri

5A-3 Latest Rock Grouting Technologies Under Sea Water in Nordic Countries and Japan
Masakuni Tsuji, Mitsunobu Okihara, Hitoshi Nakashima, Toshinori Sato and Kazuhei Aoyagi

5A-4 Strategic and Technical Aspects in RD&D Program Development for HLW Disposal System in Korea
JeongHyoun Yoon, JeongHwan Lee and SeungHyun Kim

Technical Session 5B 13:00-14:40 [Hall B]

SNF/HLW Disposal -7: Barrier Performance (Buffer-1)
Chair : Takamitsu Ishidera (JAEA)

5B-1 Study on Gas Migration Behavior through Bentonite Buffer Material
Tomoyuki Shimura, Shinichi Takahashi, Masanobu Nishimura, Kazumasa Koga and Hitoshi Owada

5B-2 Migration Experiment of Void Air in Buffer Material During Seepage
Naohiko Takamoto, Ichizo Kobayashi, Masahiro Kawakubo, Masataka Imai and Tomoko Ishii

5B-3 Study on Piping and Erosion of Buffer Material During the Re-saturation Period
Takayuki Abe, Ichizo Kobayashi, Masahiro Kawakubo, Masataka Imai and Tomoko Ishii

5B-4 Numerical Analysis of Inflow Control for Quality Management of Buffer Material Using Discrete Fracture Network Model
Kazuhiko Masumoto, Makoto Nakajima, Hayato Nonaka, Tomoko Ishii, Mayumi Jo, Masataka Imai and Hiroyuki Atsumi

Technical Session 5C 13:00-14:40 [Hall C]

SNF/HLW Disposal -8 : Nuclear & Disposal Related Technology
Chair : Tetsuo Fujiyama (NUMO)

5C-1 Development of Wireless Monitoring Systems for Geological Disposal
Kazuhiro Tsubono, Masato Kobayashi, Hiromitsu Yamakawa and Akinori Hasui, Kazuhiko Masumoto, Tomoaki Matsushita, Norihisa Sugahara,Tatsuya Tanaka and Chiaki Nagai

5C-2 Feasibility Study of Ventilation Design for Underground Facilities
Naoki Katsumata, Ryoji Yahagi, Hiromi Kurosaki and Shigeru Kubota

5C-3 Establishment and Application of Control Room Habitability Methodology for Maanshan Nuclear Power Plant
Kai-Chun Yang, Jong-Rong Wang, Hsiung-Chih Chen, Shao-Wen Chen, Chunkuan Shih and Wen-Sheng Hsu

Technical Session 6A 14:55-16:35 [Hall A]

Radioactive Waste Management Policies, Regulations and Programs-3: International Cooperation

Chair : Hiroyoshi Ueda (RWMC)

6A-1 International Cooperation Activities of KORAD Including Mid-term and Long-term Strategy of International Cooperation for Radioactive Waste Management
Ou Jeong Yoo and Gyeong Hwan Park

6A-2 Metadata in Geological Disposal of Radioactive Waste: The RepMet Libraries
Russell C. Camphouse. Massimo Ciambrella and Kevin McMahon

6A-3 Metadata in Geological Disposal of Radioactive Waste: The RepMet Initiative
Massimo Ciambrella, Kevin McMahon and József I. Fekete

6A-4 Spent Nuclear Fuel Final Disposal Knowhow, Methodology and Technology Transfer
Magnus Holmqvist

Technical Session 6B 14:55-16:35 [Hall B]

SNF/HLW Disposal -9 : Barrier Performance (Buffer-2)

Chair : Masamichi Obata (TOSHIBA Co.)

6B-1 Sulfide Corrosion by Sulphate-Reducing Bacteria in MX-80 Bentonites
Szu-wei Lee and Ching-Tu Chang

6B-2 Adsorption of Uranium(VI) on the MX-80 Bentonite
Ying-Chieh Lin

6B-3 Am(III)/Nd(III) Interactions with Borate: Experimental Investigations of $Nd(OH)_3$(micro cr) Solubility in NaCl Solutions in Equilibrium with BORAX
Yongliang Xiong, Leslie Kirkes, Cassie Marrs and Jandi Knox

Technical Session 6C 14:55-16:35 [Hall C]

SNF/HLW Disposal -10 : **Site Investigation Technology-2**

Chair : Soshi Nishimoto (CRIEPI)

6C-1 Microbial DNA; A Brand-new Tracer of Groundwater Flow
Ayumi Sugiyama, Kenji Kato, Kazuyo Nagaosa, Tetsuo Ibara, Kazuyoshi Takenobu and Atsunao Marui

6C-2 Seismic Analysis for the Deposition Tunnel in Fractured Rock by 3DEC
Meng-Hsiu Hsieh and Yuan-Chieh Wu

6C-3 Groundwater Flow Analysis for Evaluating Factors on Water Inflow to the Facility During the Operation Period
Masataka Imai, Minoru Emori, Tomoko Ishii, Masahiro Kawakubo, Kazuhiro Tsubono, Masayoshi Yamaura, Tsuneyuki Maemura and Eiko Sugimoto

Presentation materials for the Plenary Session (6 Materials)

METI

Nationwide Map of Scientific Features for Geological Disposal of High-Level Radioactive Waste in Japan

Agency for Natural Resources and Energy
Ministry of Economy, Trade and Industry

Katsumoto Yoshimura

History of Legislation on Geological Disposal of High-Level Radioactive Waste

1976: JAEC "Report on Radioactive Waste Management"

- PNC and JAERI (now JAEA) started R&D for HLW geological disposal

*JAEC: Japan Atomic Energy Commission, PNC: Power Reactor and Nuclear Fuel Development Corporation, JAERI: Japan Atomic Energy Research Institute, JAEA: Japan Atomic Energy Agency

1998: JAEC "Report on Basic Concept of HLW Geological Disposal"

- Basic concept about securing way of financing, foundation of implementer, site selection process, public communication and planning URL projects etc. was summarized.

1999: JNC (now JAEA) "H12 report"

- JNC summarized geological disposal concept, geological environment features, engineering technology and safety assessment etc. to evaluate technical feasibility of HLW geological disposal in Japan.

*JNC: Japan Nuclear Cycle Development Institute,
H12: Project to Establish the Scientific and Technical Basis for HLW Disposal in Japan

2000: "Final Disposal Act" Promulgated

- NUMO was established as an implementer of the HLW geological disposal in Japan

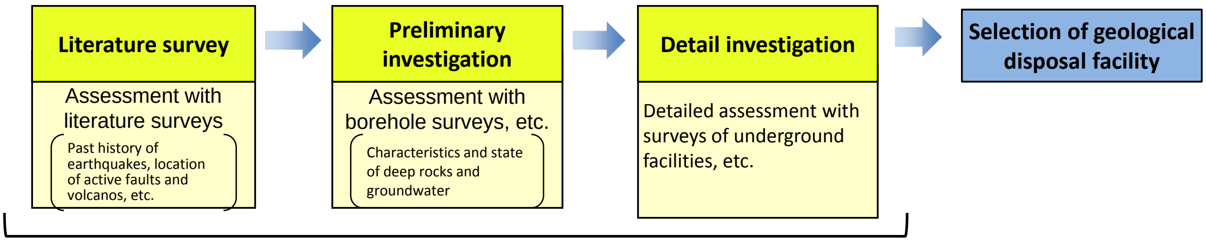
1

Overview of the "Final Disposal Act"

◆ **<u>The followings were included in the</u>** "Final Disposal Act" (enacted in 2000) in order to systematically and reliably conduct the final disposal (disposal in a stratum more than 300 m deep underground) of high-level radioactive waste generated after the reprocessing of spent fuel used in nuclear power generation.

- **Minister** of Economy, Trade and Industry **stated a basic policy** for final disposal of specified radioactive waste (Cabinet decision).
- Nuclear Waste Management Organization (NUMO) established as an implementer for geological disposal.
- Three-stage selection investigation process was set for selection of repository sites, etc.

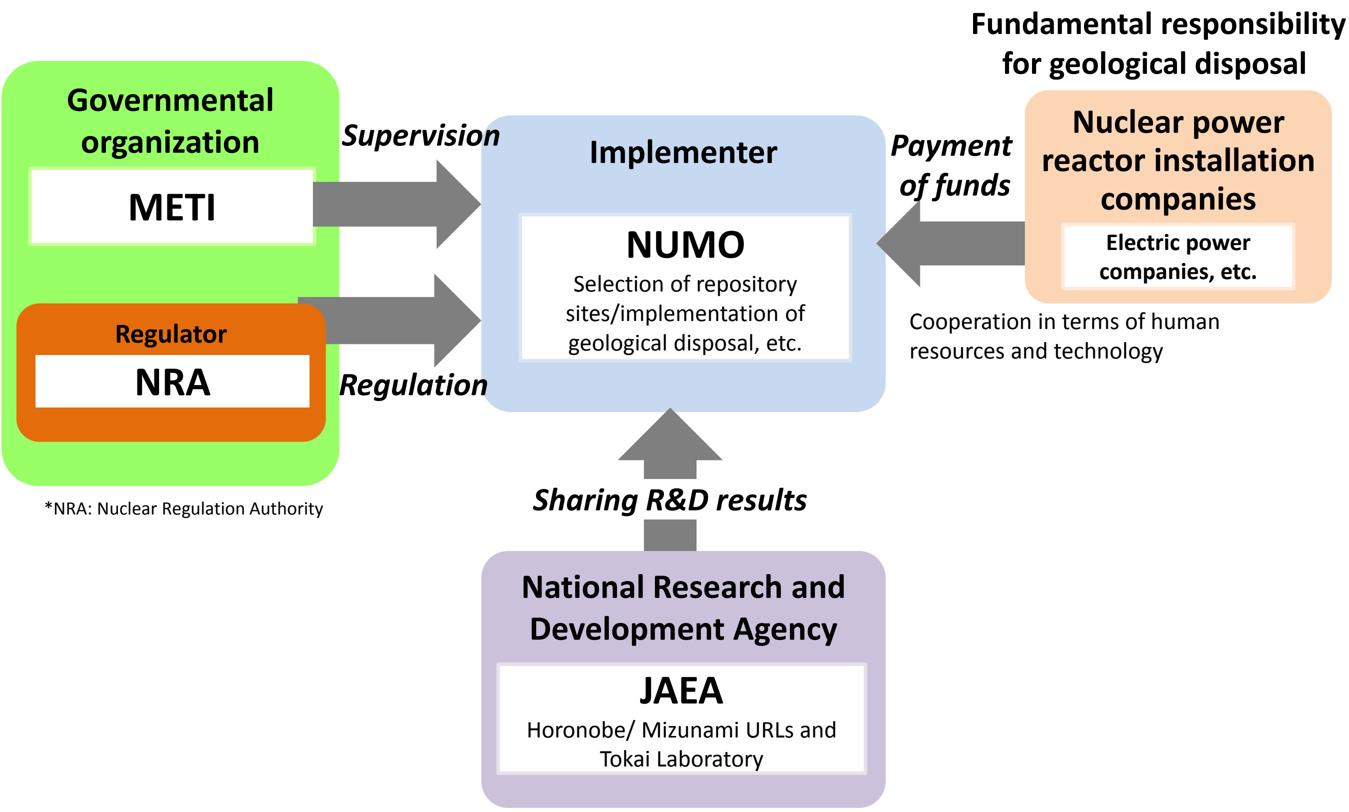
◆Selection process outlined in the "Final Disposal Act"



※The government will hear the opinions of local municipalities in each stage of the investigation process (not proceed to the next stage if local municipalities oppose).

2

Implementation System for Geological Disposal



*NRA: Nuclear Regulation Authority

3

Timeline of Review of Initiatives for Geological Disposal

- In December 2002, **NUMO started open solicitation** for all municipalities to apply for an investigation.
- In January 2007, **Toyo Town** in Kochi Prefecture **submitted a formal application.** Following this submission, a controversy erupted around the pros and cons of their participation in the survey, which divided the town politically. **The application was withdrawn** after the mayoral election in April of the same year.
- To date, **no formal investigation has been carried out**.

Review of initiatives

Est. of Ministerial Meeting on Final Disposal (Dec 2013)

Discussion on direction of review

Strategic Energy Plan (Apr. 2014)

Revision of the basic policy based on the Final Disposal Act (May 22, 2015)

4

Points on the Revision of the Basic Policy Based on the Final Disposal Act (May 22, 2015)

(1) Responsibility of current generations and potential for future generations to choose

- The responsibility of the current generation, which has generated the waste, is to successfully promote measures for geological disposal, in order not to pass the burdens on to future generations.
- Specifically, current generations must ensure the potential for **reversibility and retrievability** (R&R) to offer future generations the potential to change to more ideal disposal methods. R&D for the alternative disposal options will be conducted to ensure there is a broad range of options.

(2) Encourage national public understanding and regional understanding

- It is important to encourage the public to share respect and appreciation for areas that contribute to final disposal projects and to recognize the need to return profits to those areas.
- Seamless provision of information from the national government to local governments throughout Japan through numerous careful dialogues.

(3) Activities spearheaded by the national government

- Proposals made to related local governments to obtain their understanding and cooperation in nationwide scientific screening that is considered to be more scientifically suitable and the status of activities to promote understanding of geological disposal including geological feature in Japan.

(4) Support for the region to contribute to the project

- Support of activities and the establishment of a Forum for Dialogue in which a diverse set of residents can take part towards proactively building consensus in the area.
- Consider enacting comprehensive support measures to contribute to sustainable development of the regions.

(5) Improvements of the organizational structures

- Strengthen the organizational system of the project entity NUMO (Nuclear Waste Management Organization of Japan).
- Clarification of the involvement of the Japan Atomic Energy Commission and implementation of ongoing assessments in order to ensure reliability. The Nuclear Regulation Authority, Japan will successively present safety considerations related to safety regulations according to the progress of NUMO's surveys.
- Promote the expansion of storage capacity for spent fuel.

5

Discussion of requirement and criteria for nationwide screening

Nationwide Map –Making Process

- ◆ 2014: Geological Disposal Technology WG started
- ◆ 2015: Interim summary was published
- ◆ 2016: OECD/NEA International Peer Review

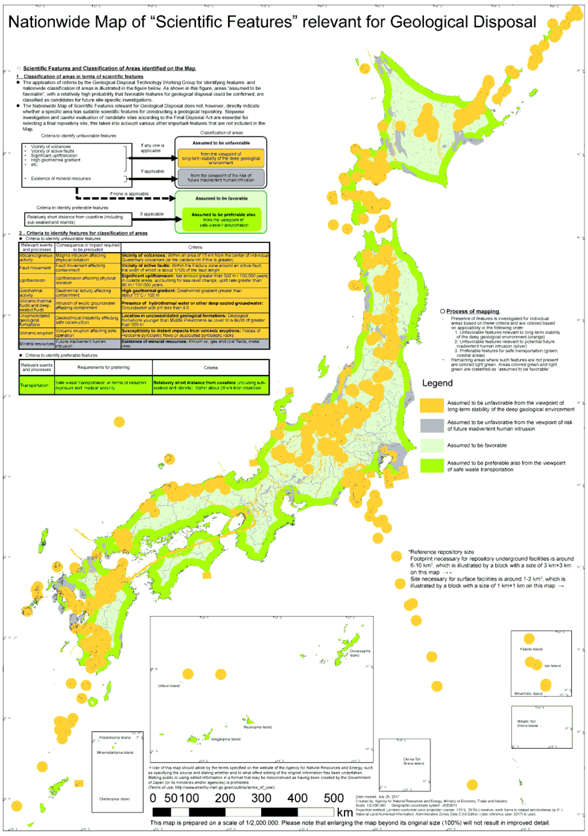
  (https://www.oecd-nea.org/rwm/pubs/2016/7331-japan-peer-review-gdrw.pdf)
- ◆ 2016: JAEC review
- ◆ 2017: Final Report was published : **Requirement and criteria were set up for making nationwide map**

- ◆ July 2017: Publication of **Nationwide Map of Scientific features**

  (http://www.enecho.meti.go.jp/category/electricity_and_gas/nuclear/rw/kagakutekitokuseimap/)

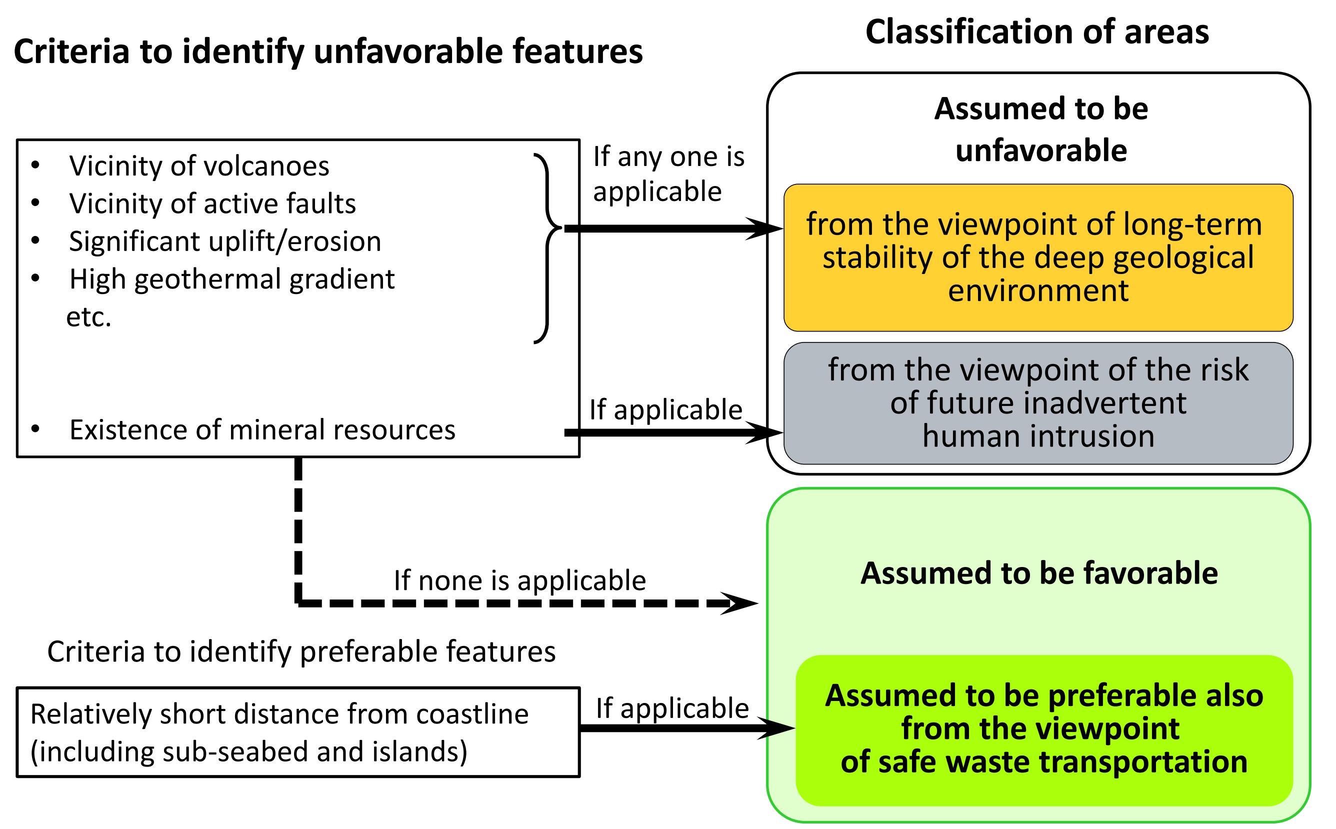
6

"Nationwide Map of Scientific Features"



7

Status of the "Nationwide Map of Scientific Features for Geological Disposal"



8

Requirement and Criteria

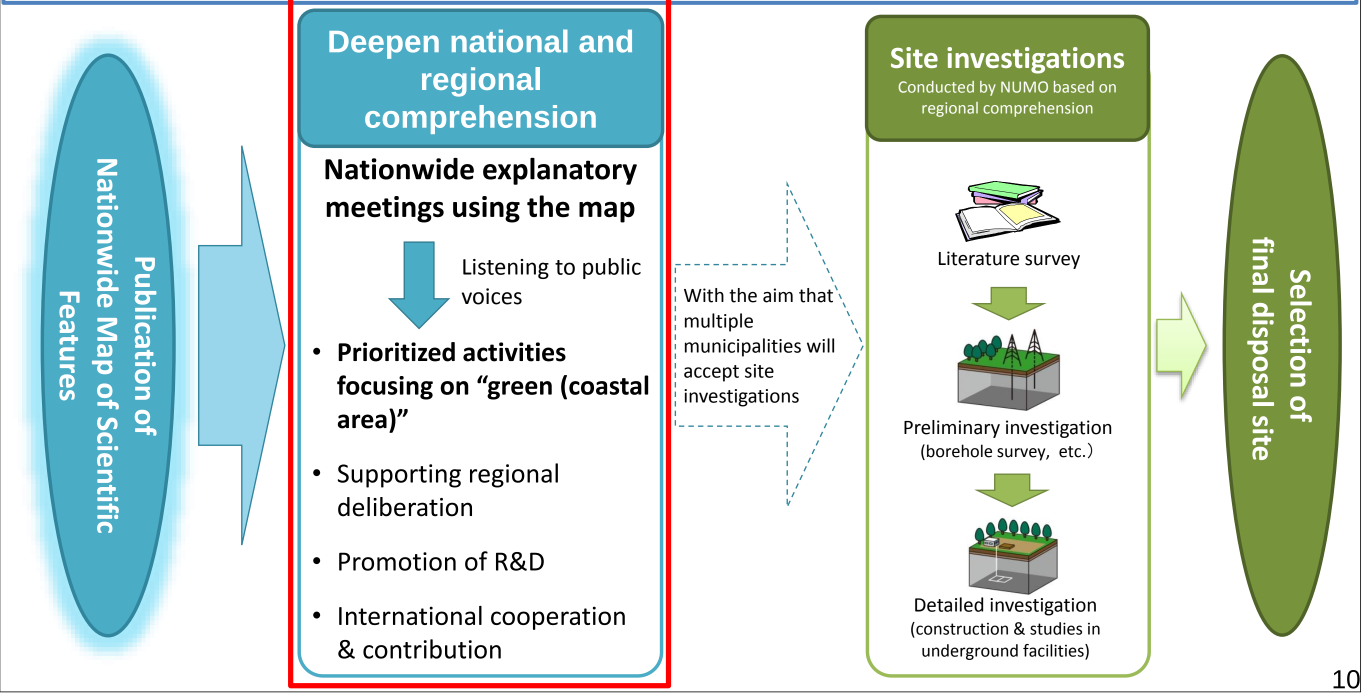
		Requirement	Criteria
Geological Environment Features and Long-Term Stability	**Volcanic/igneous activity**	• Magma intrusion affecting physical isolation	× Vicinity of volcanoes: Within an area of 15km from the center of individual Quaternary volcanoes (or the caldera rim if this is greater)
	Fault movement	• Fault movement affecting containment	× Vicinity of active faults: Within the fracture zone around an active fault, the width of which is about 1/100 of the fault length
	Uplift/erosion	• Uplift/erosion affecting physical isolation	× Significant uplift/erosion: Net erosion greater than 300m/100,000 years; in coastal areas, accounting for sea-level change, uplift rate greater than 90m/100,000 years
	Geothermal activity	• Geothermal activity affecting containment	× High geothermal gradient: Geothermal gradient greater than about 15^{o}C/100m
	Volcanic thermal fluids and deep-seated fluids	• Intrusion of exotic groundwater affecting containment	× Presence of hydrothermal water or other deep-seated groundwater: Groundwater with pH less than 4.8
	Mineral resources	• Future inadvertent human intrusion	× Existence of mineral resources: Known oil, gas and coal fields, metal ores
Construction and Operation of Facilities	**Volcanic eruption**	• Volcanic eruption affecting safe construction	× Susceptibility to distant impacts from volcanic eruptions: Traces of Holocene pyroclastic flows or associated pyroclastic rocks
	Unconsolidated geological formation	• Geotechnical instability affecting safe construction	× Location in unconsolidated geological formations: Geological formations younger than Middle Pleistocene as cover to a depth of greater than 300m
Transportation	**Transportation**	• Safe waste transportation in terms of radiation exposure and nuclear security	✓ Relatively short distance from coastline (including sub-seabed and islands): Within about 20km form coastline

✓ : preferable ✕ : unfavorable

9

Step-by-step approach toward site selection and geological disposal

- The publication of the map is **the first step on a long way toward completion of geological disposal.**
- With the aim that multiple municipalities will undertake site investigations**, we will continue to hold public dialogues to ensure a deeper public understanding of the issue**.



Concluding remarks

<Purpose of the Map>

- The Nationwide Map of Scientific features for Geological Disposal was published in order to deepen the public understanding, not for the site selection directly.

<First step by map>

- Publication of the map is the first step in a long way and a new challenge toward geological disposal completion. Government and NUMO will implement and hope multiple regions' acceptance of site investigation.

<International cooperation>

- Sharing learned knowledge with countries would be helpful for implement of geological disposal. Japan can share the reaction of the map publication.

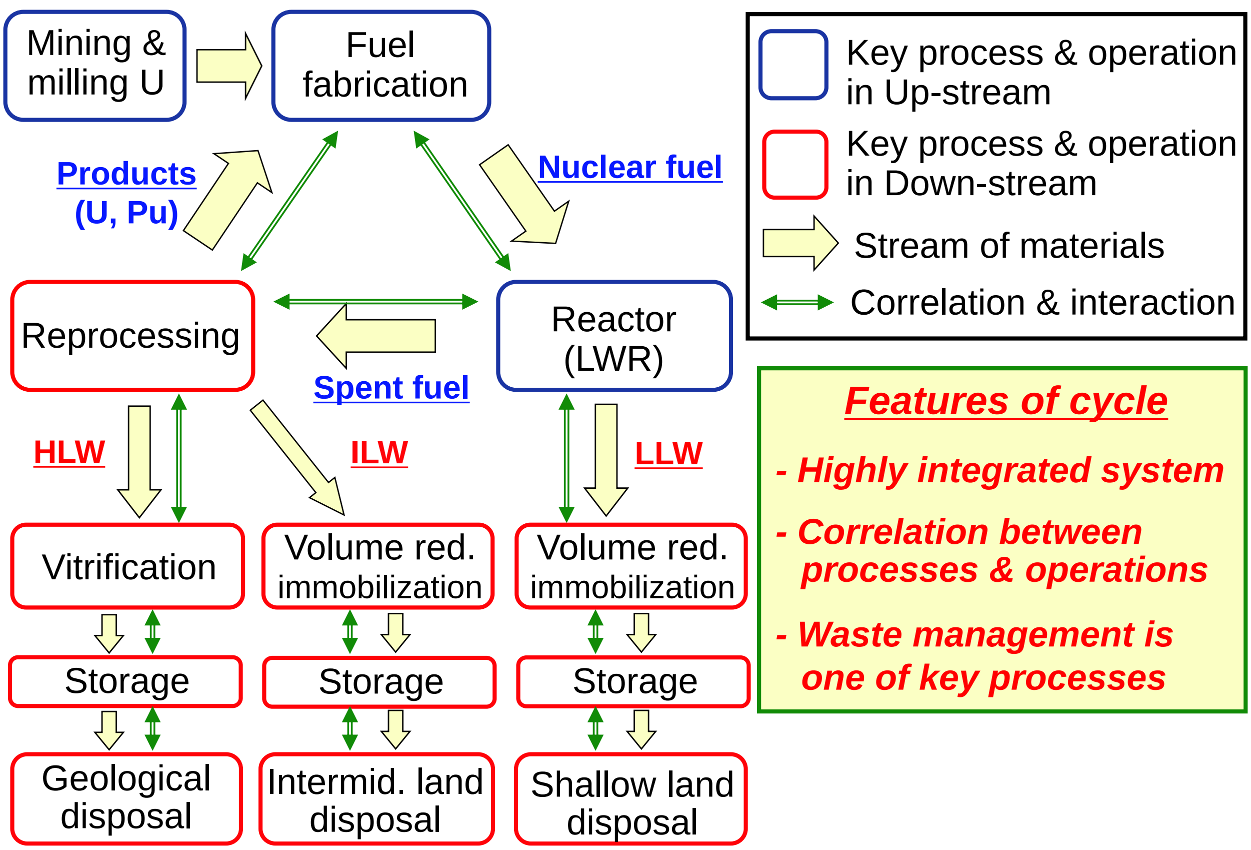
How to Integrate Various Research Fields for Reasonable and Reliable Radwaste Management

Yaohiro Inagaki

Kyushu University

Chair of the Division of Nuclear Fuel Cycle & Environment, AESJ

Waste management in the present nuclear fuel cycle



Waste management for progress in nuclear fuel cycle 3

Progress in nuclear fuel cycle

High burn-up LWR → MOX (U+Pu) -LWR → FBR → ?

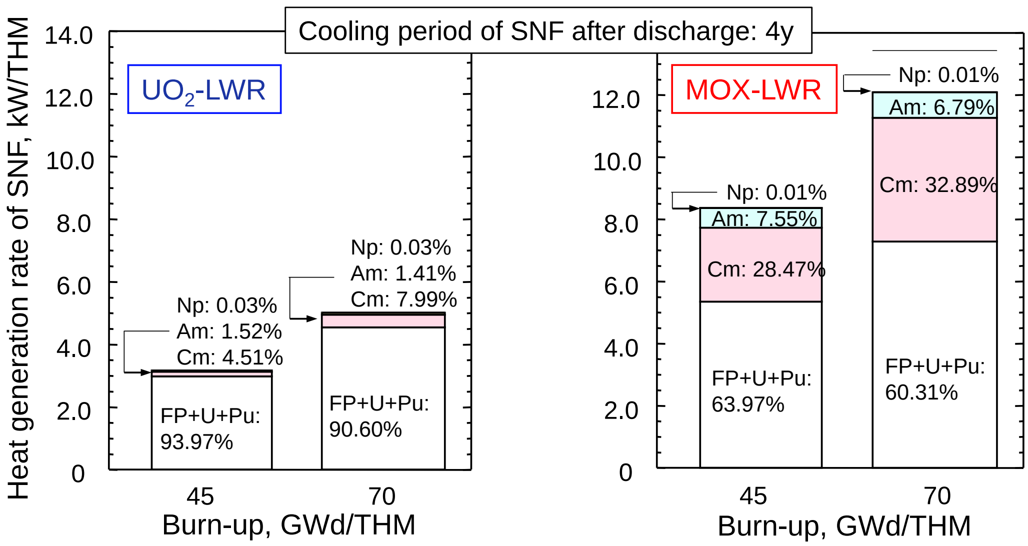
Changes in waste properties

Nuclide composition, Radioactivity, Heat generation

For progress in total performance of cycle

- ***Consistency between many processes & operations***
- ***Evaluation of the effects on waste management***
- ***Evaluation of total cycle performance from up-stream to down-stream with developing evaluation methods***

An example of the effects on waste management: Heat generation rate of spent nuclear fuel (SNF) 4

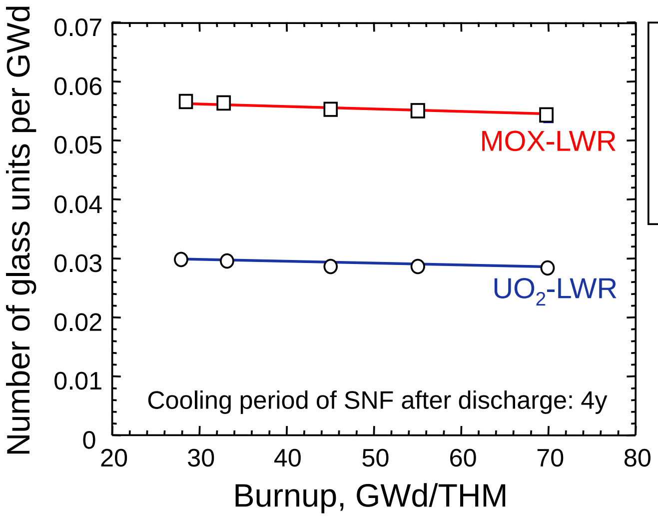


Heat generation rate of SNF after 4 year cooling calculated for high burn-up UO_2–LWR and MOX-LWR (Inagaki, et al., 2009).

- ***For MOX-LWR, the heat generation rate is larger than that of UO_2-LWR by a factor of 2 by an increase in contribution of MA(Am, Cm).***
- ***Contribution of MA increases with burn-up.***

5

An example of the effects on waste management: Number of HLW glass units generated per GWd



Restrictions for present vitrification

Heat generation rate < 2.3kW/glass unit
Content of MoO_3 < 1.50 wt%
Content of Noble metals < 1.25 wt%

Dominant restriction factor

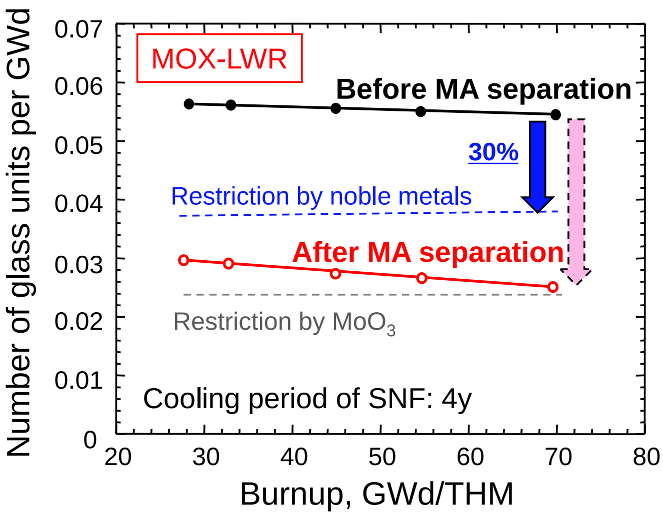
UO_2-LWR: Heat generation rate
MOX-LWR : Heat generation rate

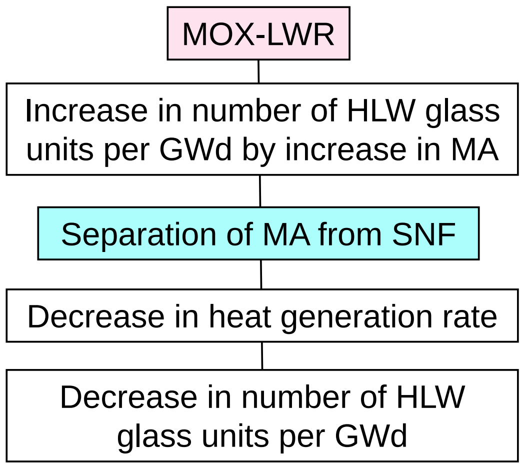
Number of glass units generated per GWd as a function of burn-up for UO_2-LWR and MOX-LWR assuming present vitrification. (Inagaki, 2009)

- Dominant restriction factor is "heat generation rate" for both cases.
- Number of glass units for MOX-LWR is larger than that of UO_2-LWR.
- Number of glass units per GWd is constant with burn-up for both cases.

6

An example of the effects on waste management: Reduction of HLW glass units for MOX-LWR

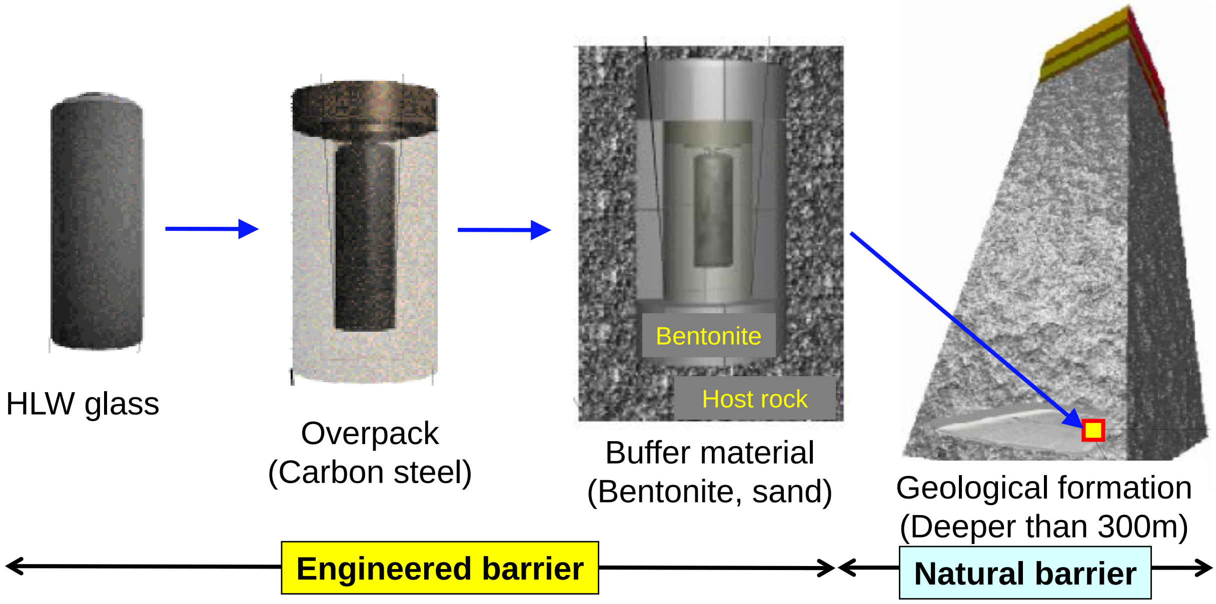




Effects of MA separation on number of glass units generated per GWd (Inagaki, 2009)

- MA separation from SNF is effective to reduce number of glass units.
- In this case, content of noble metals is dominant restriction factor.
- Separation of noble metals can provide much reduction of glass units.

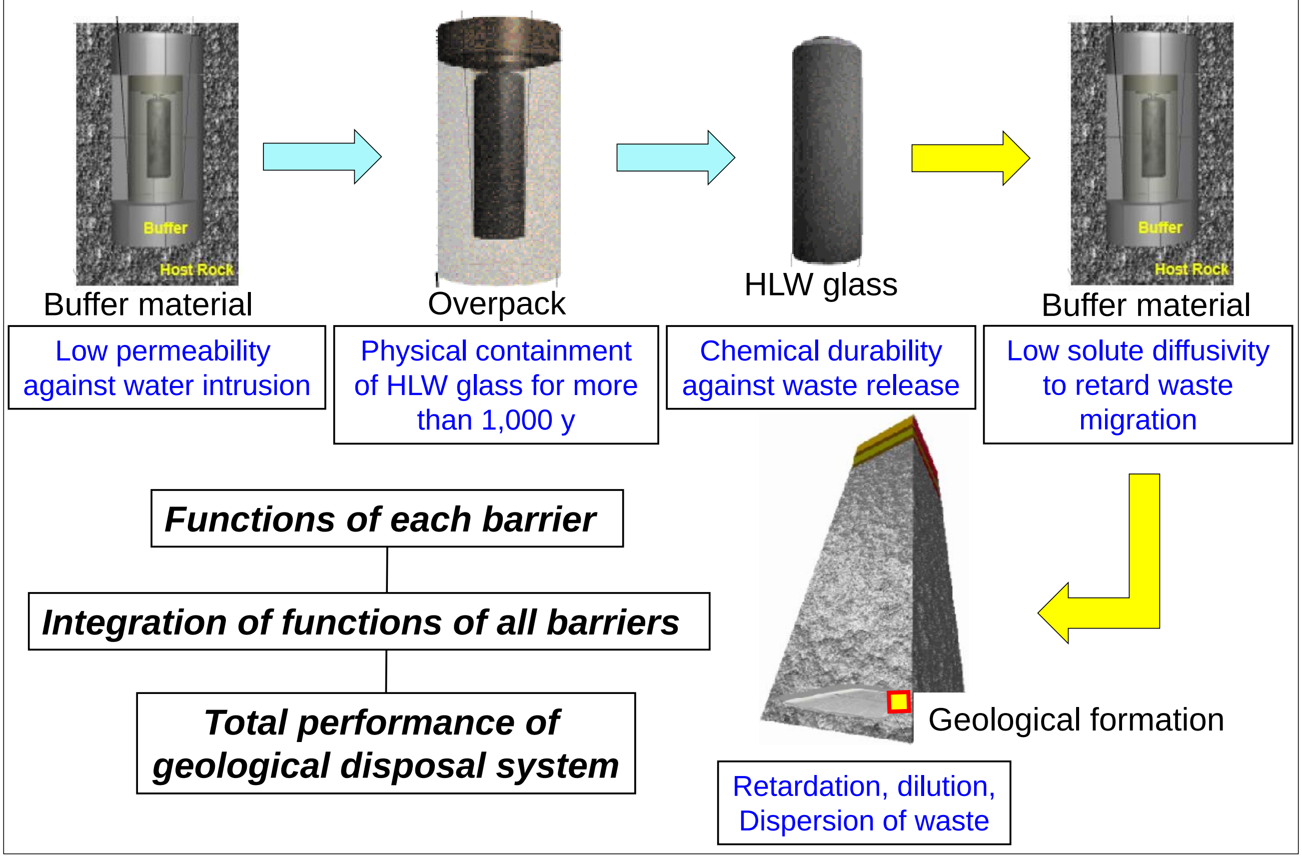
Basic concept of HLW geological disposal system

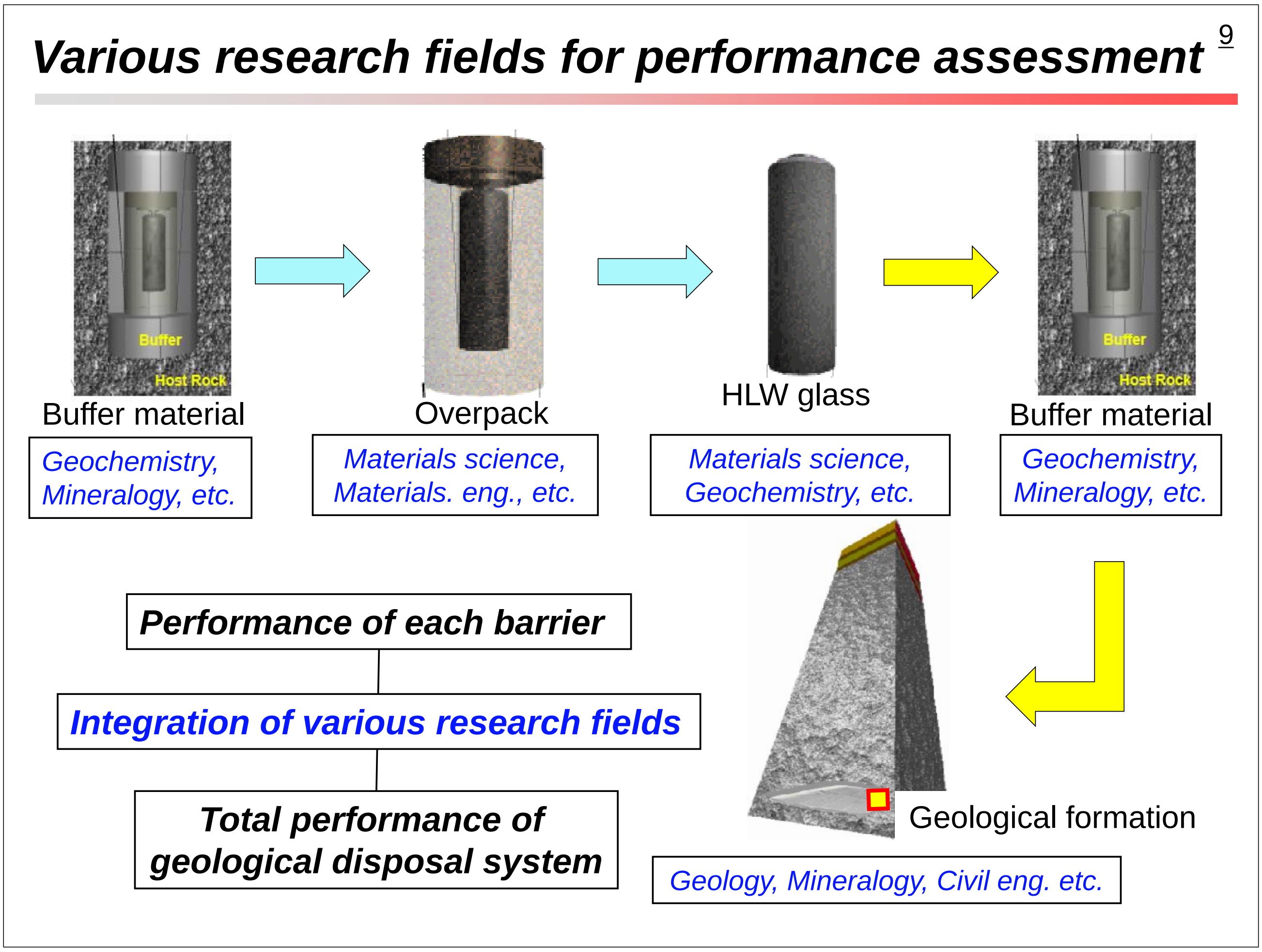


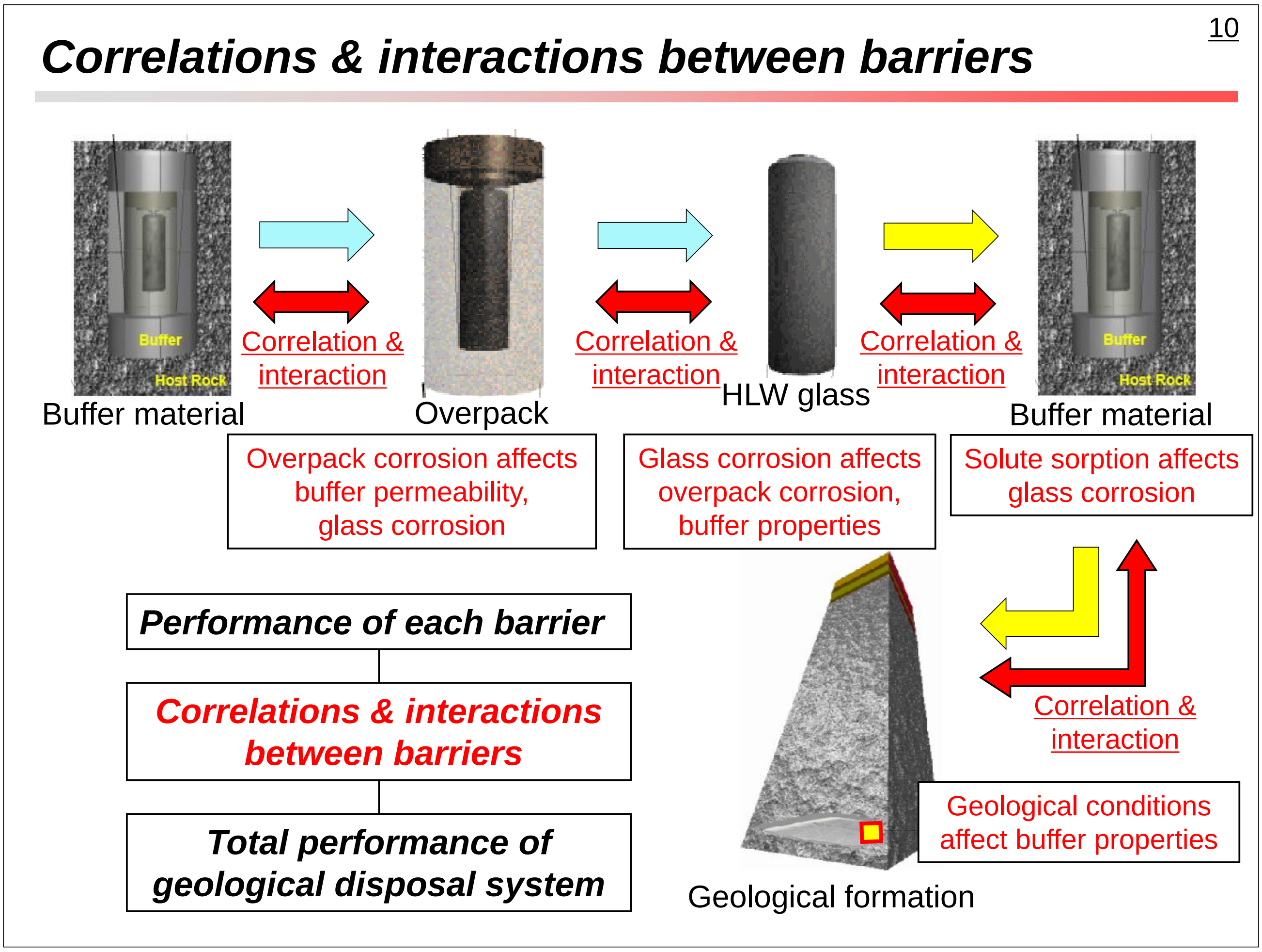
Basic concept of geological disposal system in Japan (JNC, 2000)

- Multi-barrier system consists of engineered and natural barriers.
- The system is expected to isolate waste for more than 100,000 years.

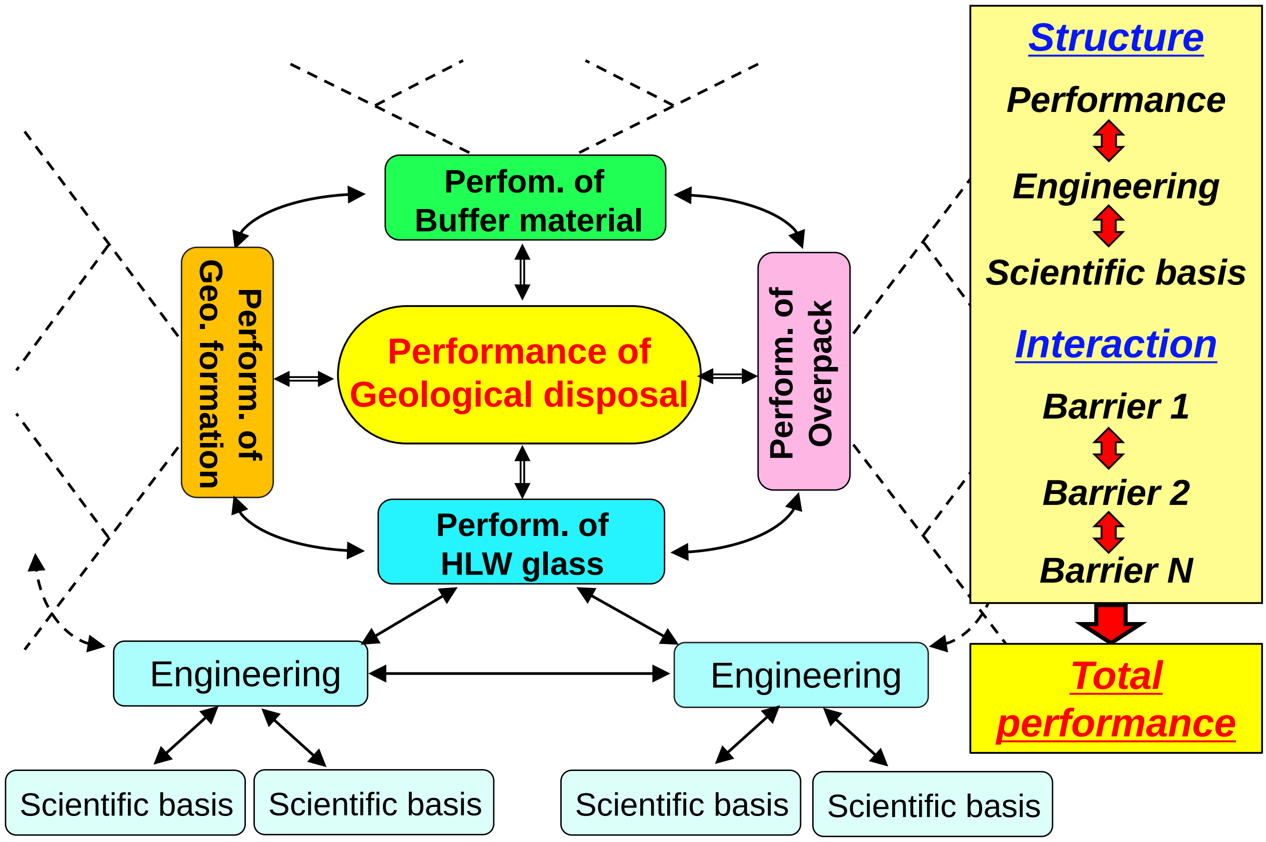
Barrier functions of geological disposal system



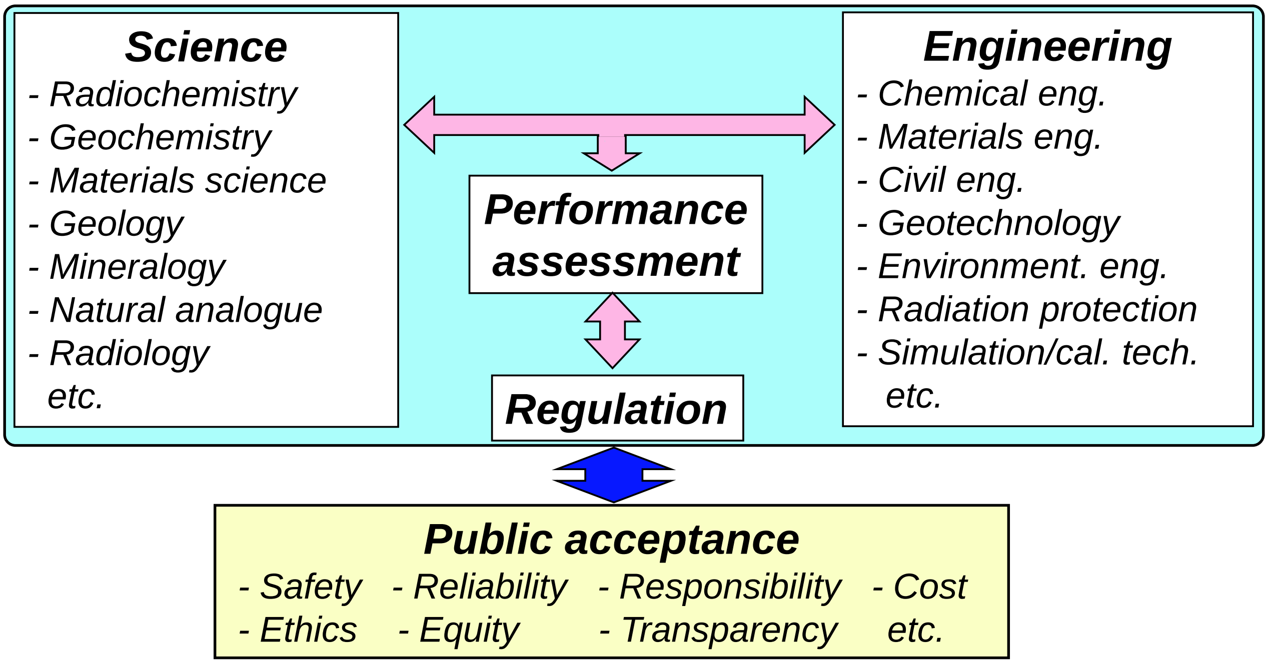

9
Various research fields for performance assessment
Buffer
Host Rock
Buffer material
Geochemistry, Mineralogy, etc.
Overpack
Materials science, Materials. eng., etc.
HLW glass
Materials science, Geochemistry, etc.
Buffer
Host Rock
Buffer material
Geochemistry, Mineralogy, etc.
Performance of each barrier
Integration of various research fields
Total performance of geological disposal system
Geological formation
Geology, Mineralogy, Civil eng. etc.


10
Correlations & interactions between barriers
Buffer
Host Rock
Buffer material
Correlation & interaction
Overpack
Correlation & interaction
HLW glass
Correlation & interaction
Buffer
Host Rock
Buffer material
Overpack corrosion affects buffer permeability, glass corrosion
Glass corrosion affects overpack corrosion, buffer properties
Solute sorption affects glass corrosion
Performance of each barrier
Correlations & interactions between barriers
Total performance of geological disposal system
Correlation & interaction
Geological conditions affect buffer properties
Geological formation

Method for reliable performance assessment



Integration of research fields for waste management



"How to integrate various research fields"

The most important subject to be considered for implementation of reasonable & reliable waste management

Summary

- *Nuclear fuel cycle is highly integrated system consisting of many processes with correlations & interactions between them.*
- *Waste management is one of key processes for progress in total cycle performance.*
- *Waste management is also highly integrated system consisting of several barriers & functions with correlations & interactions.*
- *Performance assessment should be based on integration of various research fields from scientific basis to engineering in consideration of correlations & interactions.*
- *"How to integrate various research fields including social issues" is one of the most important subjects to be developed for implementation of reasonable & reliable waste management.*

Thank you for your attention

&

I hope you will enjoy

active & successful discussions

at EAFORM 2017

Current Situation of Radioactive Waste Management in Taiwan

Ching-Tsuen Huang, Ph. D.

Chairman, Academic Committee on Radioactive Waste Management, Chung Hua Nuclear Society (CHNS)

Professor, Inst. of Nuclear Eng. & Sci., National Tsing Hua University

1

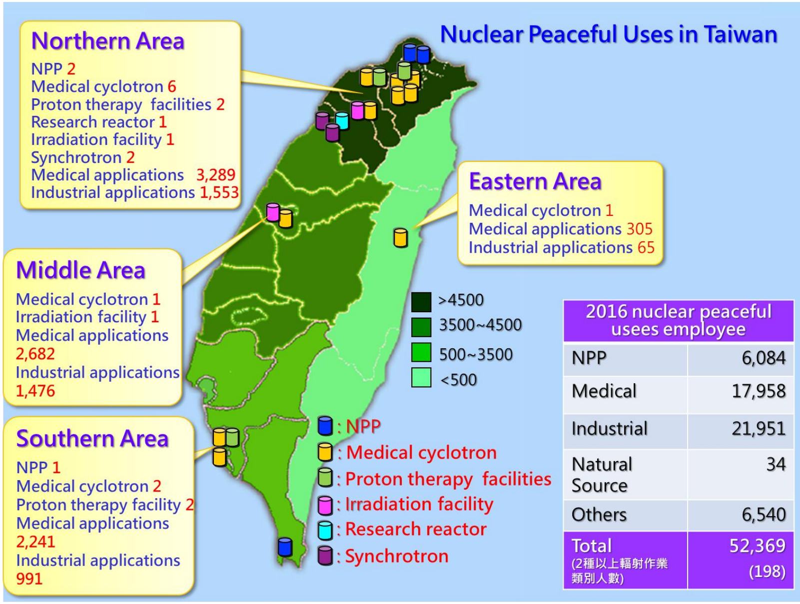
Outline

- Introduction
- Low Level Radwastes Management
- Spent Nuclear Fuels Management
- New Policy & Challenges
- Summary

2

Introduction

Peaceful Use of Nuclear Energy in Taiwan



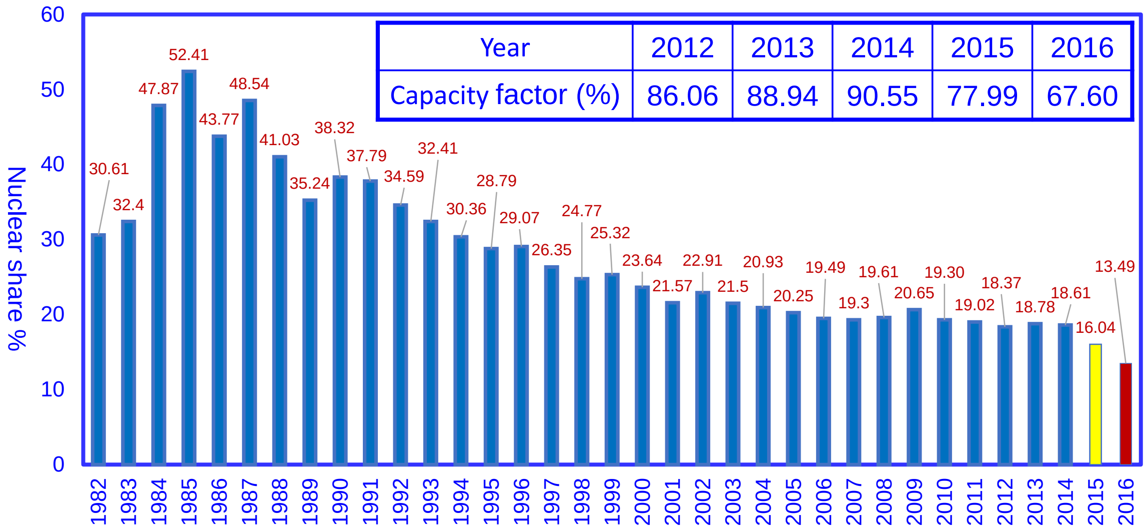
2016 nuclear peaceful usees employee	
NPP	6,084
Medical	17,958
Industrial	21,951
Natural Source	34
Others	6,540
Total (2種以上輻射作業類別人數)	52,369 (198)

3

Introduction

Peaceful Use of Nuclear Energy in Taiwan

- Supplies safe, clean, inexpensive electricity

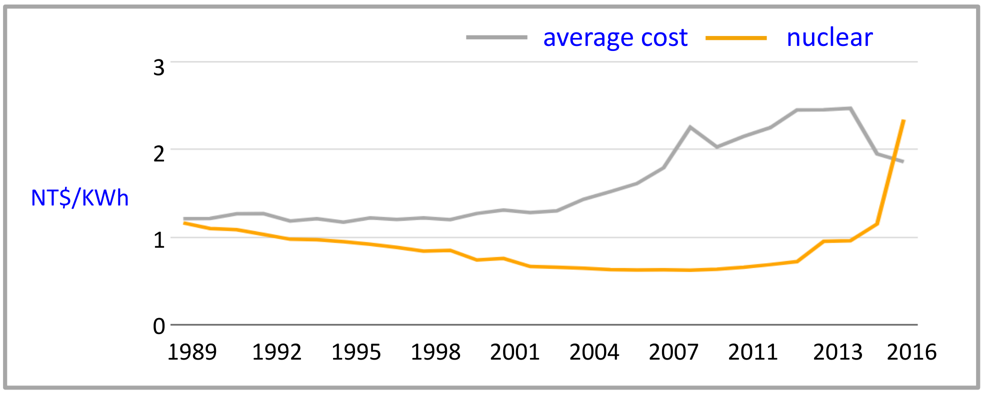


Year	2012	2013	2014	2015	2016
Capacity factor (%)	86.06	88.94	90.55	77.99	67.60

4

Introduction

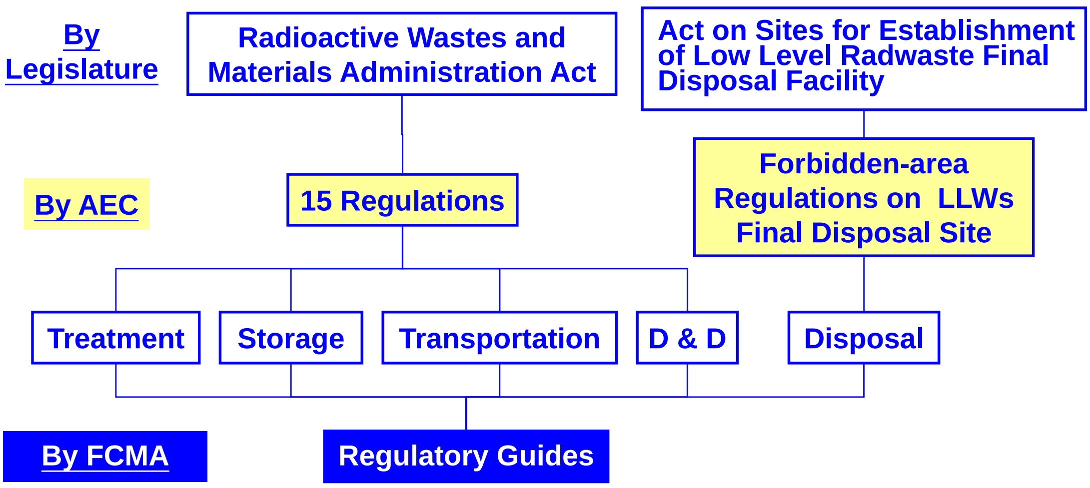
- Peaceful Use of Nuclear Energy in Taiwan
  - Supplies safe, clean, inexpensive electricity



5

Introduction

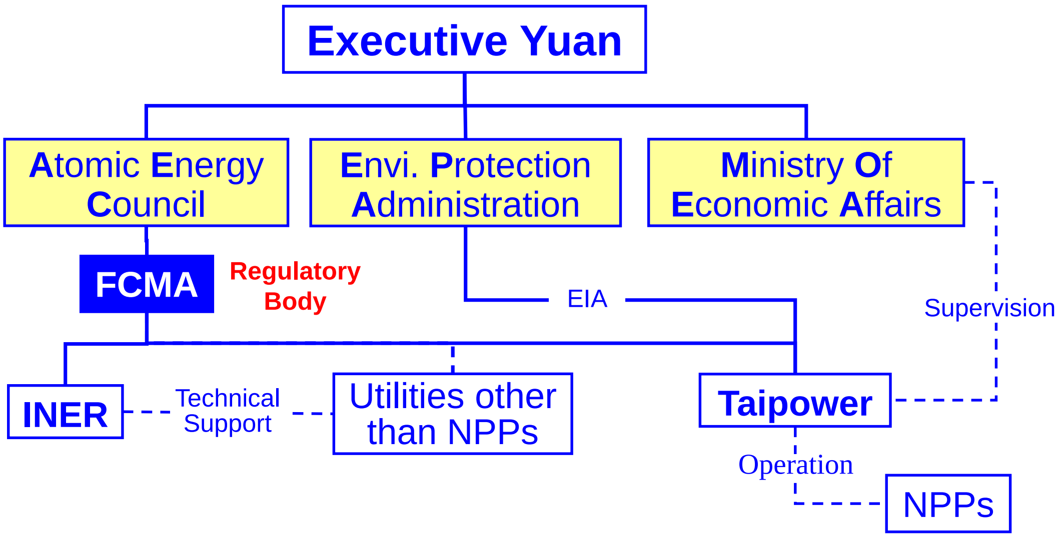
- Administration System
  - Legal Framework of RWs Management



6

Introduction

- Administration System
  - Organization of RWs Management



7

Introduction

- Congenital Deficiency of RWs Management
  - Small territory and dense population lead to serious NIMBY syndrome
    - Leading to the rapid growth of anti-nuclear force after the 311 nuclear accident
      - Causing the difficulty of radioactive waste final disposal

8

![CHNS logo]

LLWs Management

Generation of LLWs

- About 90% from NPP, 10% from others
  - All LLWs are safe in storage

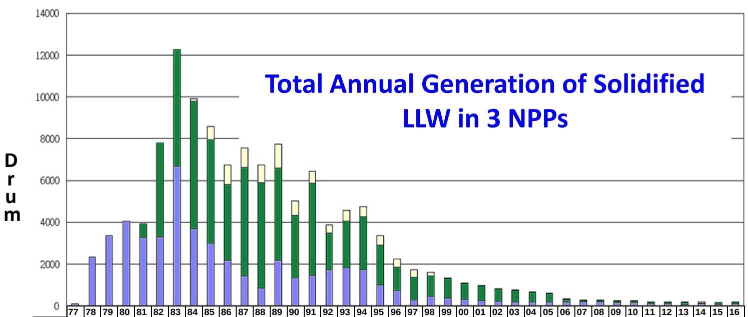
In NPPs (drum)		In INER (drum)		In Orchid Island (drum)	
Solidified Waste	38,282	Solidified Waste	3,904	Solidified Waste	100,277
Resin	17,302	Resin	165		
Compressible	13,895	Metal	10,430		
Miscelaneous	36,651	Spent source	11,458		
Subtotal	118,320	26,282		100,277	
Total	244,879				

9

LLWs Management

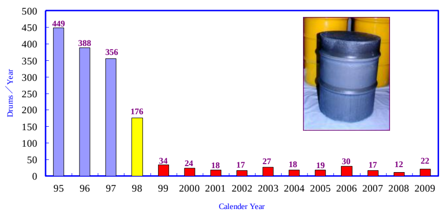
Minimization of LLWs

- Source reduction
- Application of High Efficiency Solidification Technologies



	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
NPP 3								138	607	935	919	842	1147	686	586	381	529	500	449	388
NPP 2					673	4494	5576	6107	4982	3625	5204	5054	4405	2983	4391	1757	2214	2525	1904	1114
NPP 1	83	2345	3365	4069	3258	3293	6682	3680	2984	2191	1425	838	2194	1349	1463	1736	1833	1731	1010	729

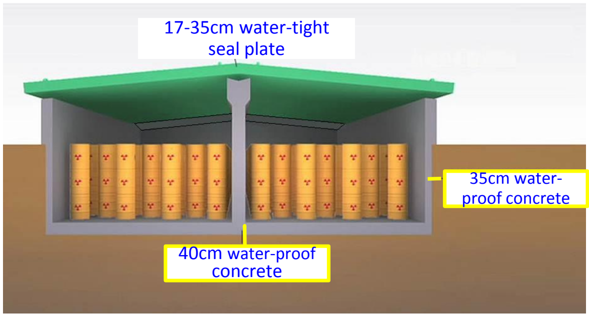
	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
NPP 3	356	176	34	24	18	17	27	18	19	30	17	12	22	18	15	30	35	35	42	32
NPP 2	1070	983	938	741	685	582	538	446	387	107	62	61	59	68	57	58	66	51	58	58
NPP 1	292	444	374	316	260	219	200	200	195	190	180	180	170	148	90	90	80	90	63	85

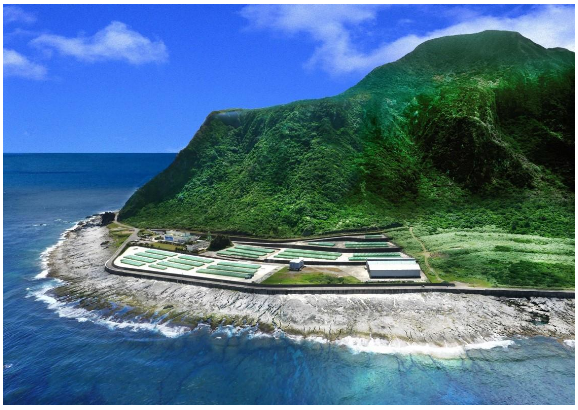


10

LLWs Management

- Storage of LLWs
  - Orchid Island storage site
    - 100,277drums in 23 trenches





11

LLWs Management

- Storage of LLWs
  - NPPs & INER warehouse storage
    - 118,320 drums in 3 NPPs
    - 26,282 drums in INER

12

SNFs Management

- Storage Capacity and Inventory of Spent Fuel
  - Full loading of fuel pools

Status of Spent Fuel Storage (July 2017)					
Unit		Date Of License Expires	Capacity (Assembly)	Storage Inventory (Assembly)	Full discharge per cycle
Chinshan	#1	Dec. 5, 2018	3,083	3,074	~110
	#2	July 15, 2019	3,083	3,076	~110
Kuosheng	#1	Dec. 27, 2021	4,838	4,548	~180
	#2	Mar. 14, 2023	4,398	4,388	~180
Maanshan	#1	July 26, 2024	2,160	1,452	~70
	#2	May 17, 2025	2,160	1,468	~70
Total			19,722	18,006	

13

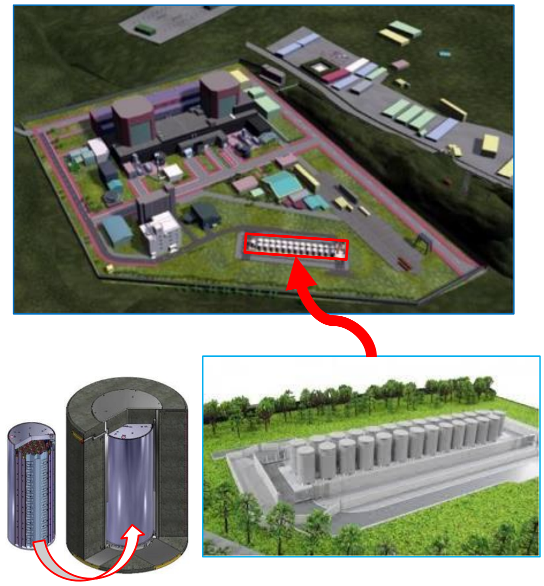
SNFs Management

- On-Site Dry Storage
  - Chinshan NPP
    - AEC granted the Construction License in Dec, 2008.
    - Completed pre-operational tests in Jan., 2013
    - Hot test approved in Sept., 2013 by AEC
      - 2 casks of spent fuel
    - Current status
      - Local government refused to issue 〈Certificate of Completion of Soil and Water Conservation〉

14

SNFs Management

- On-Site Dry Storage
  - Kuosheng NPP
    - MAGNASTOR concrete casks will be used
    - Licensing applicationin March, 2012
    - Construction License granted by AEC in Aug., 2015
    - Current status
      - Waiting for the local government to approve the 〈Runoff Waste Water Pollution Reduction Plan〉



15

SNFs Management

- Small-scale abroad reprocessing plan in 2015
  - 1,200 bundles of used BWR fuel to be reprocessed abroad
    - To relieve fuel pool volume for 3-year operation of Chinshan and Kuosheng NPPs
  - As a plan B of interim storage project
  - The budget was rejected by the legislature

16

SNFs Management

□ Promotion of Public Acceptance

- Public Hearings on SNF Dry Storage Facility
- Public Observation on SNF Dry Storage Facility
- Public Participation in Environmental Radiation Monitoring

SNFs Management

□ Promotion of Public Acceptance

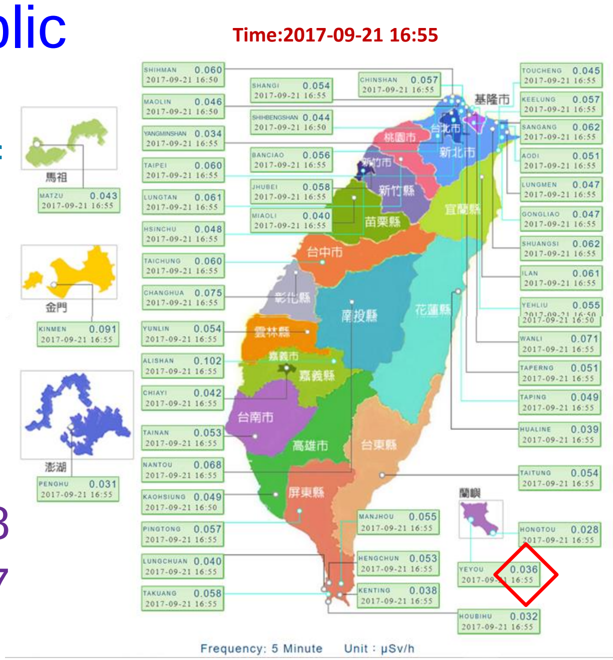
- Summary of Public Hearing & Observation
  - The pre-operation of SNF dry storage facility (ISFSI) must include a mockup simulation of the retrieval operation of SNFs
  - The operator must make sure a facility available for retrieving SNFs in the NPP's decommissioning plan.
  - The maintenance and surveillance plan of the ISFSI shall include the monitoring of SCC of the storage facility.
  - The operator must re-evaluate the seismic design of the ISFSI.
  - The storage facility should be decommissioned when the 40-years license expires

Public Hearing

Public Participation

SNFs Management

- Promotion of Public Acceptance
  - Establishment of Real-time Environmental Radiation Monitoring System
    - 28 stations, 2008
    - 46 stations, 2017



19

SNFs Management

- Promotion of Public Acceptance
  - Public Participation in Environmental Monitoring in Orchid Island
    - Observational check by third party (2008 to 2017)
      - Invite scholars, experts, NGO and congress man to participate in environmental monitoring and sampling
    - Parallel Environmental monitoring and sampling (Nov., 2012)
      - All results were far below regulatory concern and at the level of environmental radiation background


Introduction before sampling


Detection record


Environmental detection


Water sampling


Soil & grass sampling

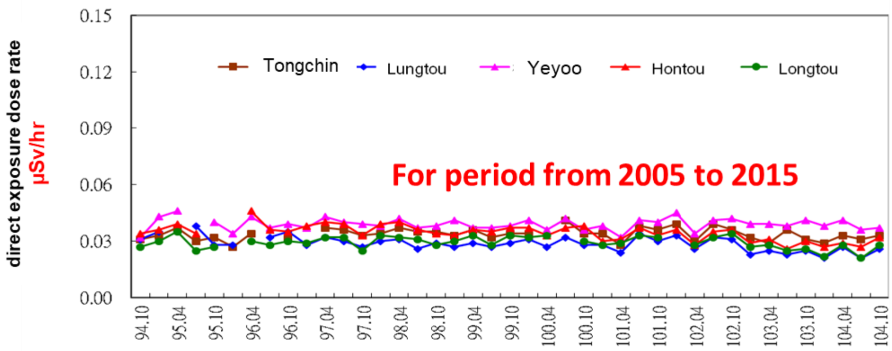
20

SNFs Management

□ Promotion of Public Acceptance

■ Environmental Monitoring in Orchid Island

- Monitoring data showed that Orchid Island has much lower environmental radiation than other area in Taiwan.



21

New Policy & Challenges

□ 「Nuclear-free Homeland」 Policy

Unit		License Expires	Status
Chinshan	#1*	Dec. 5, 2018	Restart denied after outage in Dec., 2014, due to fuel assembly handle loose during fuel transfer
	#2*	July 15, 2019	Shutdown in June, 2017 due to full load of fuel pool
Kuosheng	#1	Dec. 27, 2021	Fuel pool re-racking in June, 2017 allowing 2 more refueling cycle
	#2*	Mar. 14, 2023	Shutdown in May, 2016 Due to lightning arrester failure
Maanshan	#1	July 26, 2024	Operating
	#2	May 17, 2025	Operating

22

New Policy & Challenges

- 「Nuclear-free Homeland」 Policy
  - New 《Electricity Act》- January 26, 2017
    - Article 95：Nuclear power generation facilities shall be shut down before 2025
  - Tough target of renewable energy share
    - 20% share of electricity in 2025, totally 27.4GW
      - Solar 20GW
      - Wind 4.2GW
    - Advices from international independent scientists, conservationists, and energy experts
      - Michael Shellenberger：Taiwan is uniquely unsuited for renewables like solar and wind

23

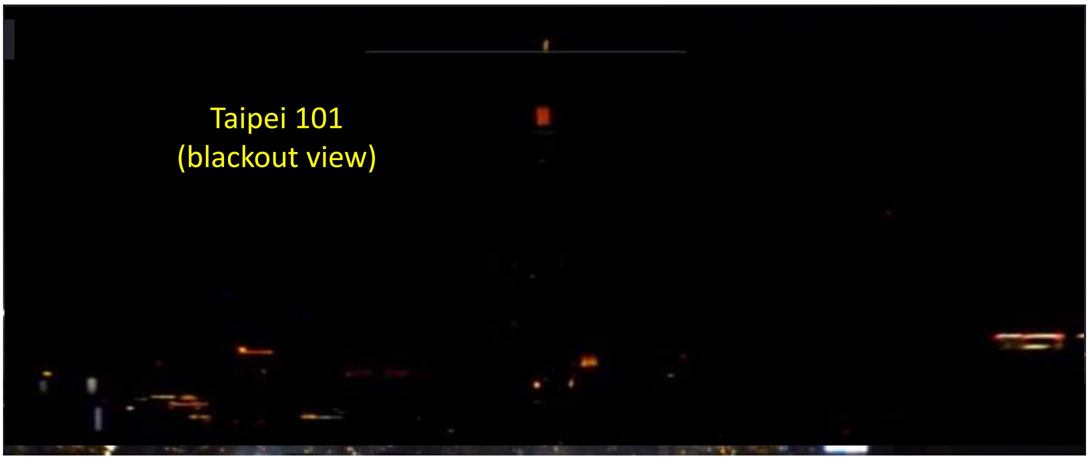
New Policy & Challenges

- 「Nuclear-free Homeland」 Policy
  - Dramatic warning of consequences of nuclear phase-out
    - Electricity blackout on Aug. 15th, 2017
      - Lost 4,384 MWe due to gas supply interrupted
        - Half of Taiwanese households lost power, as did a large number of companies.
      - Too low POR (Percent Operating Reserve)

24

New Policy & Challenges

- 「Nuclear-free Homeland」Policy
  - Electricity blackout – A dramatic warning



25

New Policy & Challenges

- 「Nuclear-free Homeland」Policy
  - Be beset with difficulties
    - Local government boycotts the on-site SNF interim storage facilities
      - Obstruct the decommissioning of NPPs
    - Local government refuses to conduct the referendum for LLW final repository siting
      - LLWs in Orchid Island storage site can not be removed out as the governing party promised

26

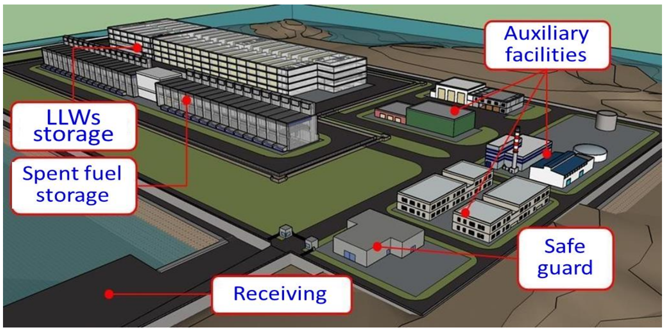
New Policy & Challenges

- 「Nuclear-Free Homeland 」Policy
  - Promotion Project
    - Purpose
      - Strategic planning
      - Promote public acceptance
      - Reforming of RWM laws and regulations
    - Advisory Committee
      - Organized by government representatives and 14 civil members

27

New Policy & Challenges

- The「Nuclear-free Homeland」Policy
  - Contingency Plan of RWM
    - Centralized storage facility
      - An off-site in-door storage facility
      - To store SNFs and LLWs for 40 years
        - $2.635bn investment as estimated
        - Needs an area at least 26 hectares



28

New Policy & Challenges

- The「Nuclear-free Homeland」Policy
  - Contingency Plan of RWM
    - Challenge
      - Anti-nuclear attitude of local government has no change
      - Facility site selection is a mission almost impossible
        - » More difficult than the site selection of LLWs final repository

29

New Policy & Challenges

- Changes Anticipated
  - Legal Framework Reform

Laws and Competent Authority			
Current Status		**After Reform**	
Atomic Energy Act	**AEC**	**Atomic Energy Act (amend/abolish？)**	**AEC ?**
Nuclear Materials and Radioactive Waste Management Act	AEC	Nuclear Materials and Radioactive Wastes Regulatory Act	AEC
		Radioactive Wastes Management Act	MOEA
Act on Sites for Establishment of Low Level Radwaste Final Disposal Facility	AEC	Act on Sites for Establishment of Low Level Radwaste Final Disposal Facility	MOEA
		Act on Sites for Establishment of Spent Nuclear Fuel Final Disposal Facility	MOEA
-		Act on the Establishment of Independent Administrative Inst. of Radwaste Management Center (RWMC)	MOEA

30

New Policy & Challenges

- Changes Anticipated
  - Organization & Duty
    - AEC：Authority of Nuclear Safety
      - FCMA：Safety Regulation of Nuclear Materials and RWs
    - MOEA：Authority of RWs Administration
      - Taipower：RWs Treatment and storage
      - Nuclear Power Backend Fund Management Committee：Backend fund management
      - Radioactive waste Management Center：RWs Final Disposal

31

Summary

- The routine operation of RWM in Taiwan is as good and safe as it was, and made the best record of LLW minimization.
- People's fear of nuclear energy burst out after Fukushima nuclear accident, causing local governments to oppose all nuclear facilities.
- The legislature has amended the “Electricity Act” claiming to shut down all NPPs before 2025.
- Local government's attitude towards nuclear facilities has not changed. Decommissioning of nuclear power units is beset with difficulties.

32

The 6th East Asia Forum on Radwaste Management

Status of High-level Radioactive Waste Management Program in Korea

November 27, 2017

Joowan PARK

KORAD
KOREA RADIOACTIVE WASTE AGENCY

KORAD
한국원자력환경공단

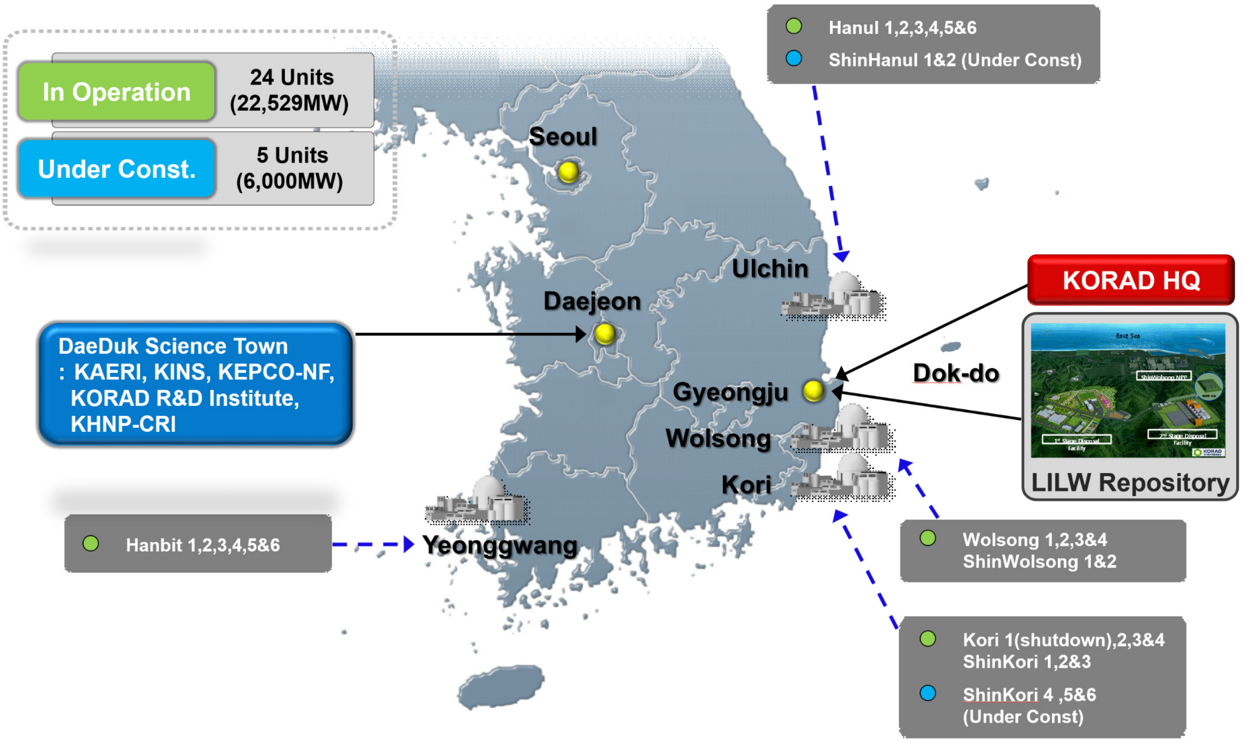
Contents

KORAD
한국원자력환경공단

I Overview

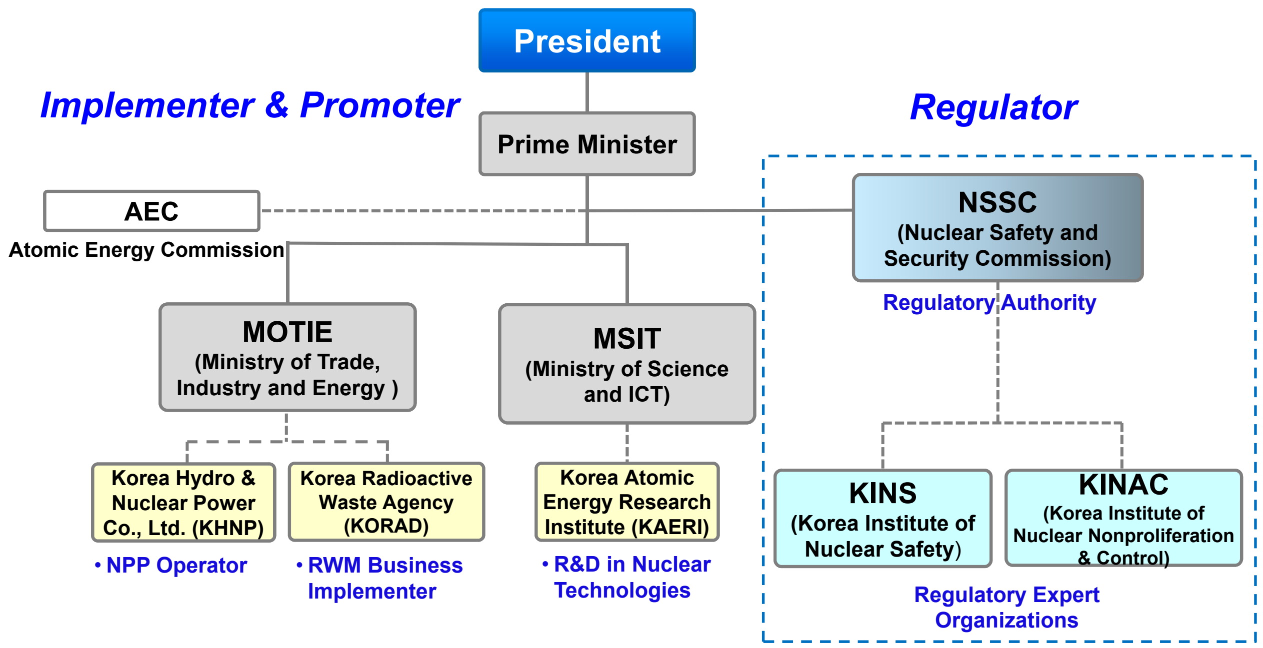
Nuclear Fuel Cycle Facilities in Korea

KORAD



4

National Framework of RWM



5

Radioactive Waste Management Act

☐ Independent organization for radioactive waste management (article 10)

- "Korea Radioactive Waste Agency(KORAD) is designated as the dedicated organization for RWM business"

☐ Scope of radioactive waste management business (article 9)

- Transportation, storage, treatment and disposal of radioactive waste
- Siting, construction, operation and post-closure management of radioactive waste management facilities
- Collection, investigation, and analysis of data on radioactive waste
- Public relations
- Other activities such as R&D, international cooperation and training

☐ Radioactive waste management fund (article 28-33)

- Establishing the Government Fund to improve the transparency and stability of financial resources for RWM
- Administration of RWM fund is committed to the KORAD

6

Current SNF Management Practice in NPPs

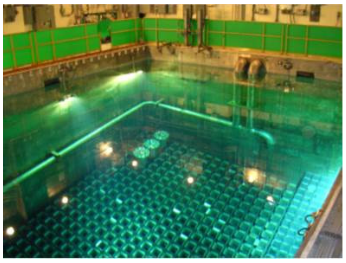
KORAD

☐ **PWR Spent Nuclear Fuel**

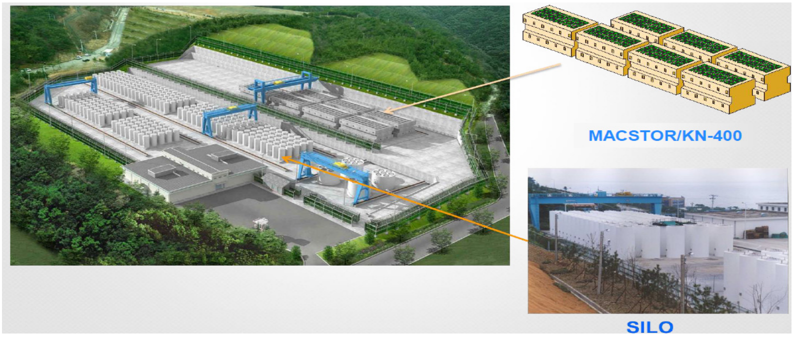
- Stored in on-site SNF pool (Wet storage)
- Re-racking, Trans-shipment to neighboring NPP

☐ **PHWR(CANDU) Spent Nuclear Fuel**

- Stored in both on-site SNF pool and dry storage facilities



On-site SNF pool (Wet storage)



Wolsong On-site Dry Storage Facilities

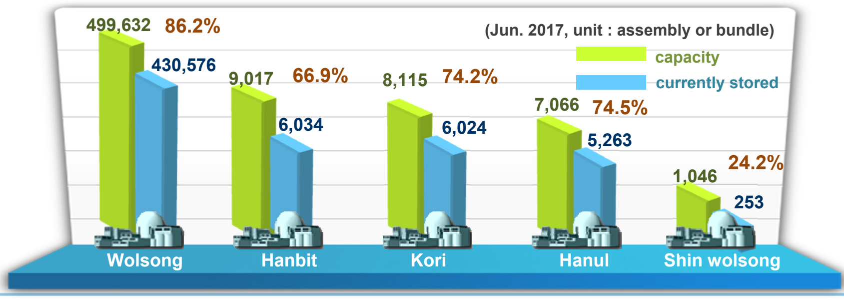
7

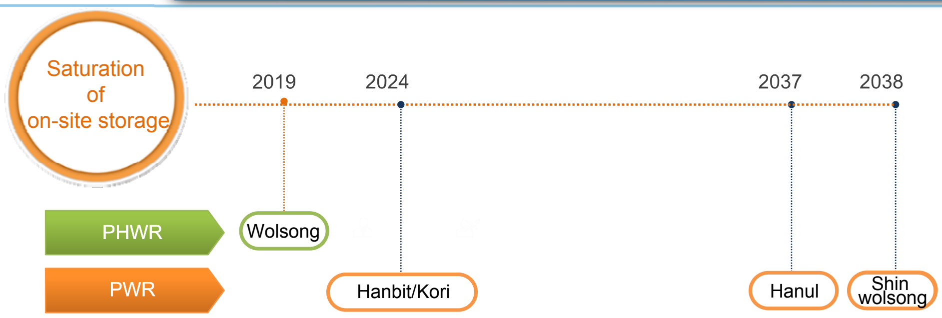
SNF Generation in NPP sites & Saturation of storage

KORAD

SNF Generation & Future Estimate

- **SNF generated 15,401 tons as of end of Jun. 2017**
  17,574 assemblies(7,256 tons) from PWR, 430,576 bundles(8,145 tons) from PHWR
- **Expected : 38,941 tons (presumed 30 reactors to be operated)**
  63,146 assemblies(26,521 tons)from PWR, 657,148 bundles(12,420 tons) from PHWR





8

II National Plan for HLW Management

Efforts made in HLW Management Policy-making (1/3)

1 Dec. 2004 : The 253rd Atomic Energy Commission(AEC)

- decided that the project of HLW management should be carried out separately from that of LILW management
- Consent-based national policy for SNF management should be made with consideration of related R&D, international trend, etc.

2 Dec. 2009 : Legal ground for the public engagement

- established the public engagement process and function of the public engagement commission in the Article 6.2 of RWMA

3 Nov. 2011~Aug. 2012 : SNF Policy Forum

- consisted of 23 forum members (including the chair)
- shared opinions and discussed on SNF management options and the public engagement process among experts and stakeholders
- operated 2 working groups for review of SNF management options and review of public engagement process

10

Efforts made in HLW Management Policy-making (2/3)

4 Oct. 2013~Jun. 2015 : Public Engagement Commission on SNF(PECOS)

- collected opinions of the public, local residents of NPP areas and stakeholders through town hall meetings, deliberative poll, etc.
  (about 370,000 people participated)
- submitted the recommendation report to the government (Jun. 2015)


Town hall meeting


Discussion at the National Assembly

Deliberative Poll

5 Jul. 2015~Apr. 2016 : TFT for national plan for HLW management

- was organized consisting of 50 people(including experts of academic field, related organizations, and government agencies and lawyers) for have in-depth review of the draft national plan

11

Efforts made in HLW Management Policy-making (3/3)

6 Jun. 2016 : Public Hearing for National Plan on HLW management

7 Jul. 2016 : Public Announcement of National Plan for HLW management

- 6th Atomic Energy Commission deliberated and decided the National Plan in the Article 3 of Nuclear Promotion Act(NPA)

8 Nov. 2016 : Legislative Bill [The Site Selection Process and Host Community Support for HLW Management Facilities]

- The Legislative Bill submitted to the National Assembly

9 Jul. 2017 : Announcement for 5-year Government Operation Plan

- Review of National Plan on HLW Management by the 2nd PECOS

12

Outline of National Plan on HLW Management

KORAD

Legal basis	• Article 6 of the Radioactive Waste Management Act(RWMA) • Presenting the principles and directions for radioactive waste management(RWM) as the highest level of plan • KORAD should establish the implementation plan based on the national plan annually according to the Article 7 of RWMA
Process	• The Atomic Energy Commission(AEC) approves the national plan for RWM prepared by MOTIE, according to the Nuclear Energy Promotion Act
Contents	• ①Principles of HLW management, ②Current situation & estimate of HLW generation, ③Facilities development plan including siting process ④Investment plan, ⑤Plan for social trust & confidence, ⑥R&D plan

13

Principles of HLW Management

KORAD

1 Governmental responsibility

- As HLW needs to be safely managed for long-term period, HLW should be managed under control of government, conforming to domestic and overseas safety standards.

2 Top priority on safety

- The public health and the environment should be protected by eco/environmental friendly management of HLW.

3 Trust & confidence

- All the relevant information should be open to the public.
- HLW management project should be under the public consensus.

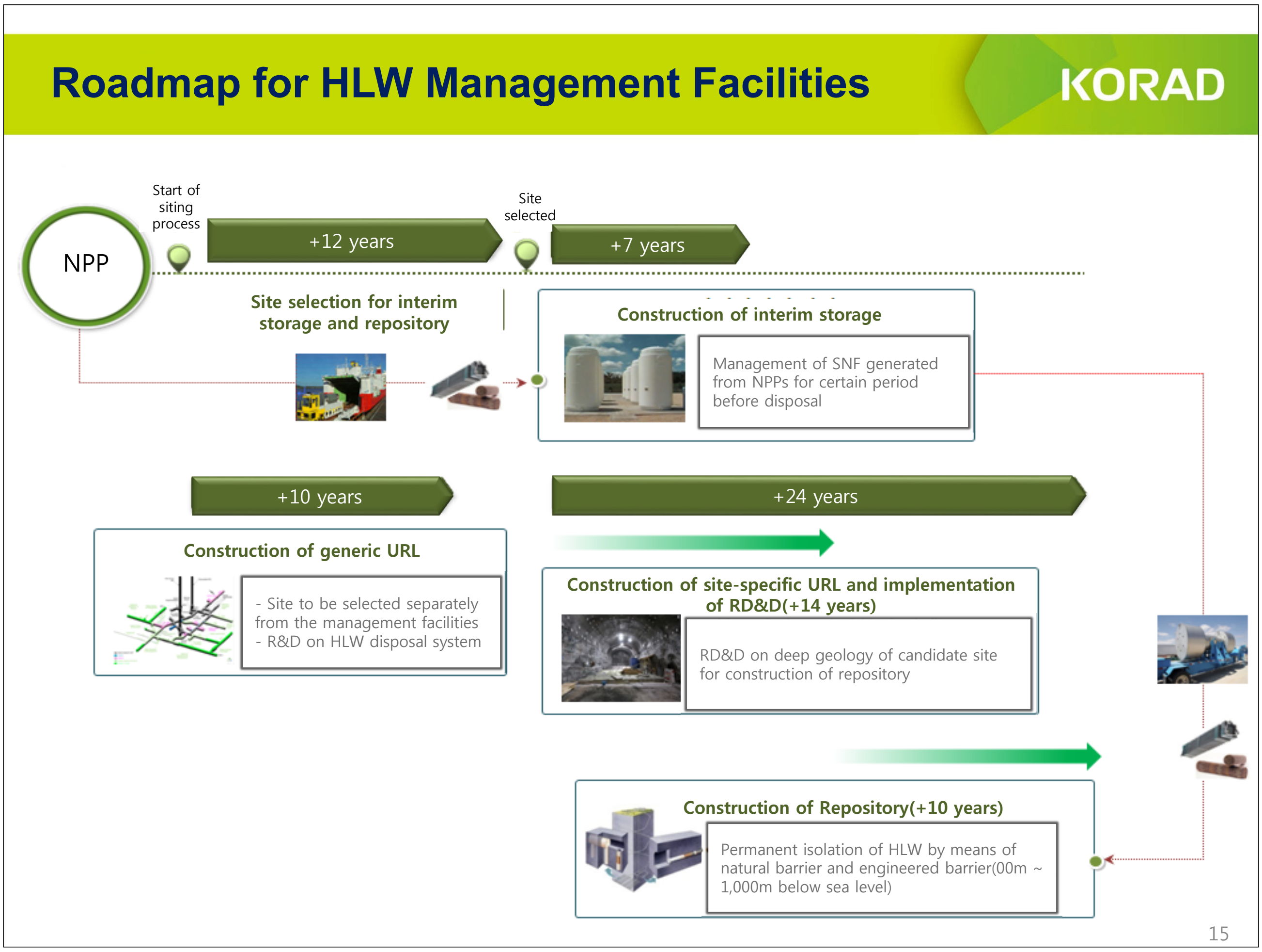
4 Due burden on present generation

- Present generation should be responsible for HLW
- 'Polluter Pays' principle should be applied

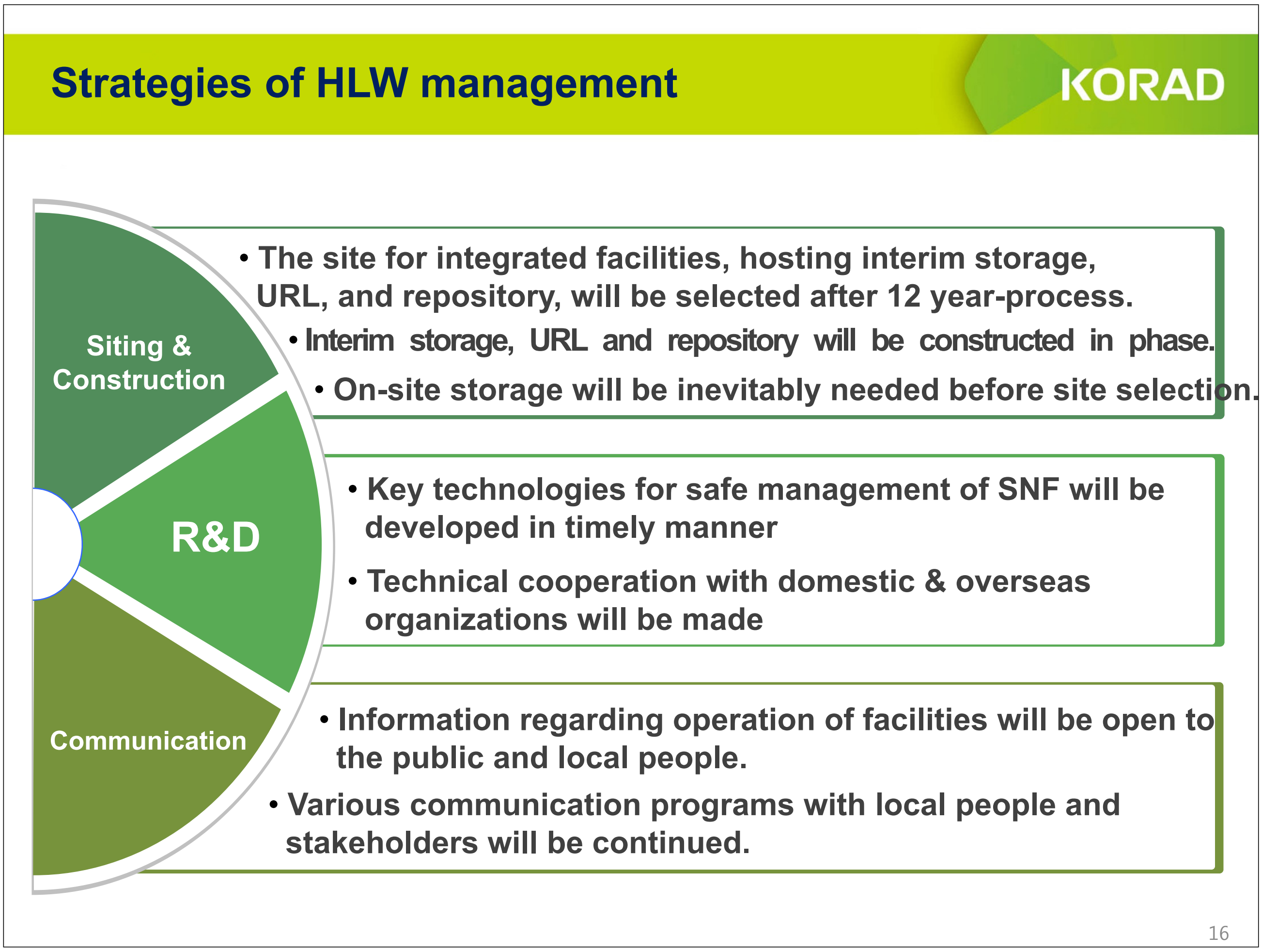
5 Effectiveness of HLW management

- Technologies on transportation, storage, disposal and reduction of toxicity & volume should be developed for effective management of HLW

14



Roadmap for HLW Management Facilities
KORAD
NPP
Start of siting process
+12 years
Site selected
+7 years
Site selection for interim storage and repository
Construction of interim storage
Management of SNF generated from NPPs for certain period before disposal
+10 years
+24 years
Construction of generic URL
- Site to be selected separately from the management facilities
- R&D on HLW disposal system
Construction of site-specific URL and implementation of RD&D(+14 years)
RD&D on deep geology of candidate site for construction of repository
Construction of Repository(+10 years)
Permanent isolation of HLW by means of natural barrier and engineered barrier(00m ~ 1,000m below sea level)
15

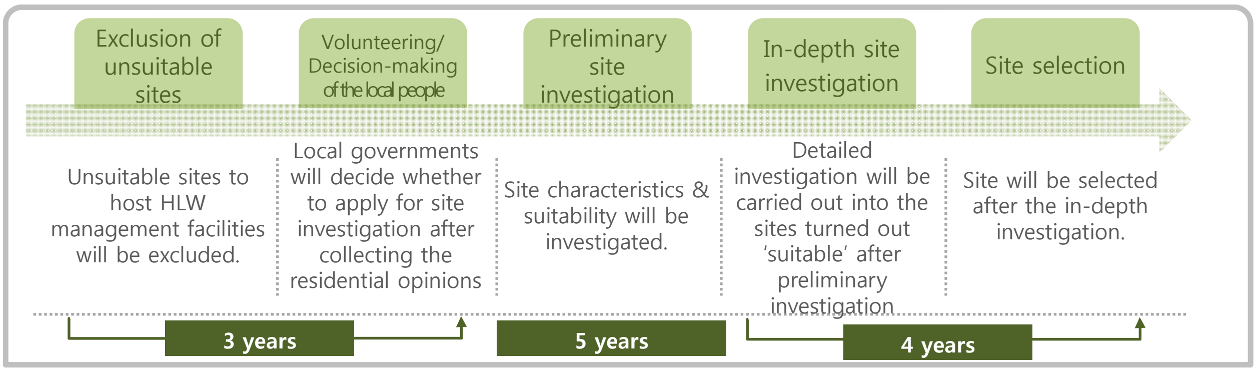


Strategies of HLW management
KORAD
Siting & Construction
• The site for integrated facilities, hosting interim storage, URL, and repository, will be selected after 12 year-process.
• Interim storage, URL and repository will be constructed in phase.
• On-site storage will be inevitably needed before site selection.
R&D
• Key technologies for safe management of SNF will be developed in timely manner
• Technical cooperation with domestic & overseas organizations will be made
Communication
• Information regarding operation of facilities will be open to the public and local people.
• Various communication programs with local people and stakeholders will be continued.
16

Contents of Legislative Bill

KORAD

☐ Siting process



☐ The Third party (the Committee on Site Selection) for transparent siting process to be organized under the MOTIE

☐ The Committee on Host Community Support to be organized under the Prime Minister

17

KORAD
한국원자력환경공단

III Future Plan

The 2nd Public Engagement

KORAD

Why?

- In accordance with change of governmental roadmap on long-term energy transition
- Improvement of social acceptance

How?

- Organization of the 2nd Public Engagement Commission on SNF(PECOS)

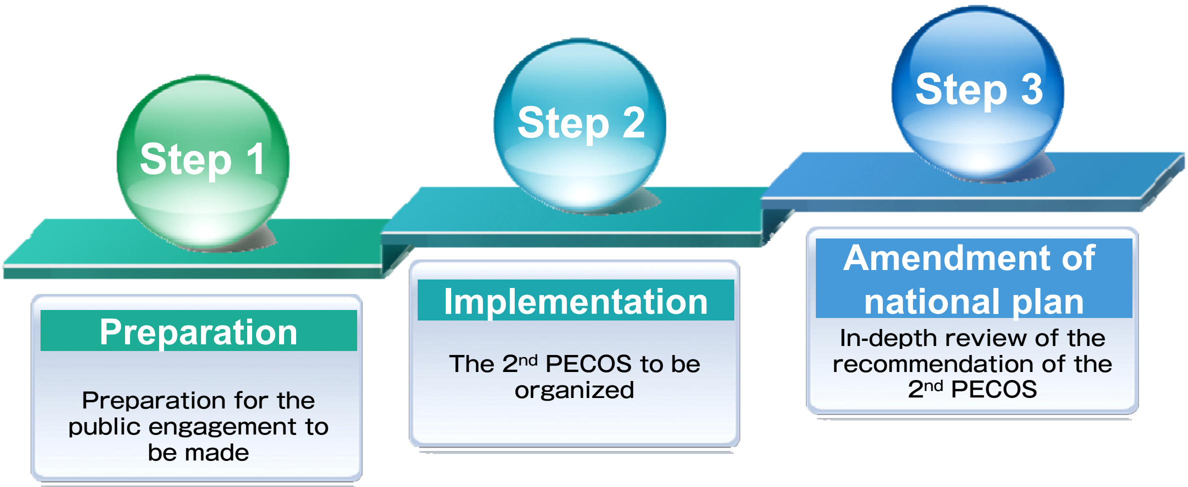
What?

- Focused on the controversial issues included in the national basic plan
- Detailed agendas to be decided by the 2nd PECOS

19

The 2nd Public Engagement

KORAD



20

IV Summary

Summary

KORAD

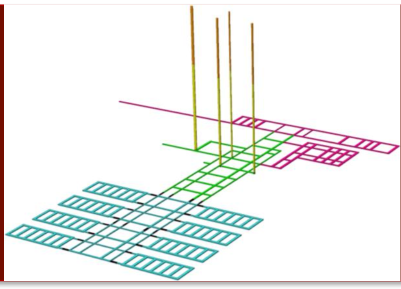
- ☐ Safety is the most important fundamental objective of the national HLW management program in Korea.
- ☐ RWM, including HLW management, could be more effectively and transparently proceeded by establishment of the KORAD in 2009, separated from the RW generators.
- ☐ Based on the recommendations by Public Engagement Commission on Spent Nuclear Fuel(PECOS), a national basic plan for HLW management was set up in July 2016.
- ☐ New government is to make in-depth review of the National Plan on HLW Management by the 2nd PECOS to raise the public acceptance
- ☐ KORAD is continuing the efforts, including RD&D activities, toward successful implementation of the national HLW management program.

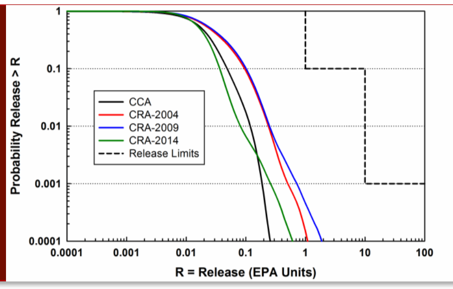
22


Thank you for
your attention !!
KORAD
KOREA RADIOACTIVE
WASTE AGENCY

Exceptional service in the national interest

Sandia National Laboratories





Recertification of WIPP: From Submittal of the CRA-2014 to an EPA Recertification Decision

EAFORM2017: 6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017

Todd R. Zeitler

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

Sandia National Laboratories is a multimission 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.
SAND2017-12125C

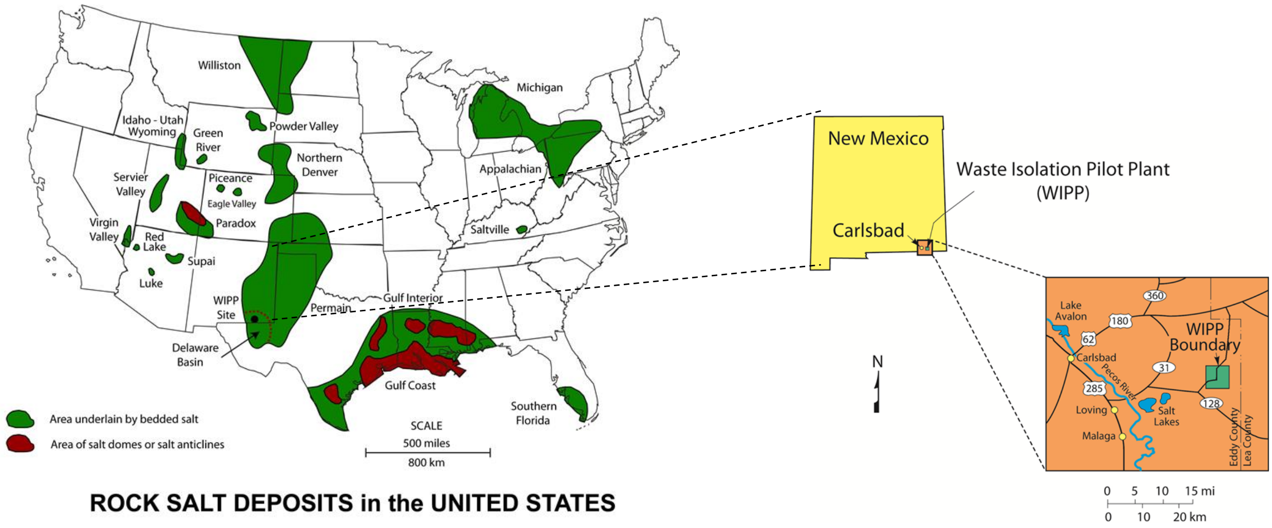
Outline

Sandia National Laboratories

- WIPP Background and Performance Assessment
  - Regulatory requirements
  - Performance Assessment
  - Release Mechanisms and Compliance Metric
- 2014 WIPP Compliance Recertification Application
  - Submittal in March, 2014
  - Completion of three EPA-mandated sensitivity studies
  - Recertification in July, 2017
- Summary

2

Waste Isolation Pilot Plant Location

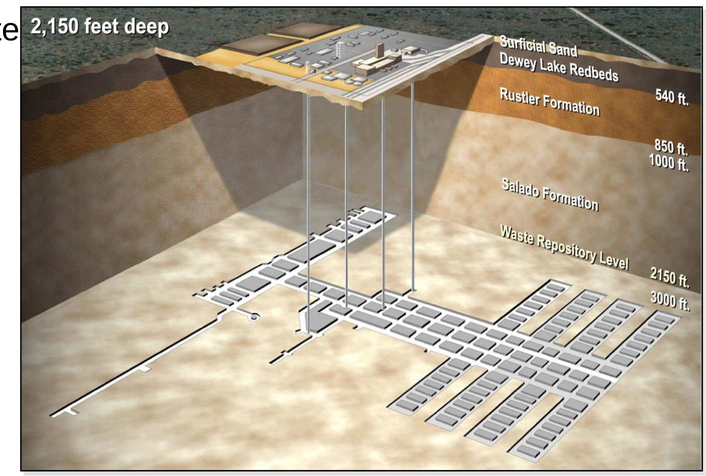


3

About The WIPP

The WIPP is a permanent disposal facility for transuranic waste

- The nation's only licensed deep geologic repository for nuclear waste
- Operated by U.S. Department of Energy (DOE)
- Long-term performance regulated by U.S. Environmental Protection Agency (EPA)
- Waste is emplaced in a **salt formation** deep underground
- Long-term regulatory compliance is demonstrated via Performance Assessment (PA) undertaken by Sandia National Laboratories (SNL) Carlsbad



4

Long-Term Regulatory Requirements

- Regulatory requirements guide the WIPP PA framework.
  - The WIPP must be designed to provide *reasonable expectation* that *cumulative releases* of radionuclides to the accessible environment for *10,000 years* after closure from all *significant processes and events* shall be less than specified *release limits*

Regulatory Requirements

- Reasonable expectation: regulations acknowledge substantial uncertainties
- 10,000 years: PA must predict behavior for entire regulatory time period
- Significant processes and events: PA must include all of these, including the possibility of human intrusion

TABLE 1—RELEASE LIMITS FOR CONTAINMENT REQUIREMENTS

[Cumulative releases to the accessible environment for 10,000 years after disposal]

Radionuclide	Release limit per 1,000 MTHM or other unit of waste (see notes) (curies)
Americium-241 or -243	100
Carbon-14	100
Cesium-135 or -137	1,000
Iodine-129	100
Neptunium-237	100
Plutonium-238, -239, -240, or -242	100
Radium-226	100
Strontium-90	1,000
Technetium-99	10,000
Thorium-230 or -232	10
Tin-126	1,000
Uranium-233, -234, -235, -236, or -238	100
Any other alpha-emitting radionuclide with a half-life greater than 20 years	100
Any other radionuclide with a half-life greater than 20 years that does not emit alpha particles	1,000

From 40 CFR 191

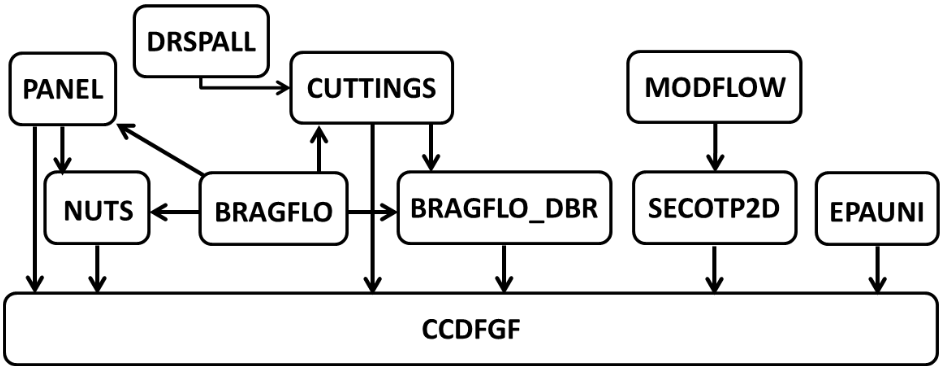
$$R = \sum \frac{Q_i}{L_i} \left(\frac{1 \times 10^6 \, curies}{C} \right)$$

***R* = Normalized release in "EPA units"**
Q_i* = 10,000-year cumulative release (in curies) of radionuclide *i
L_i* = Release Limit for radionuclide *i
***C* = the total transuranic inventory (in curies of α emitters w/halflives > 20 years)**

WIPP Performance Assessment

Sandia National Laboratories

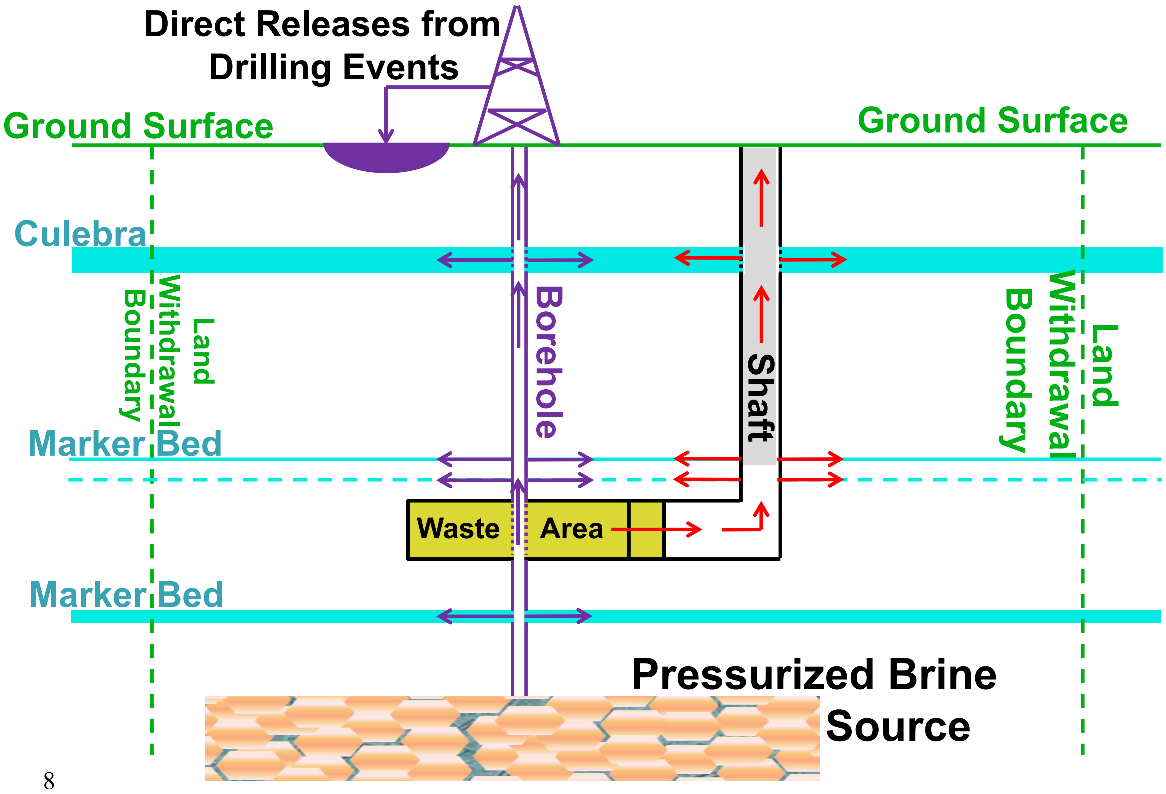
- PA calculations cover 24 peer-reviewed conceptual models
- PA codes include 10 principal codes and many utility codes



7

Release Pathways in WIPP PA

Sandia National Laboratories

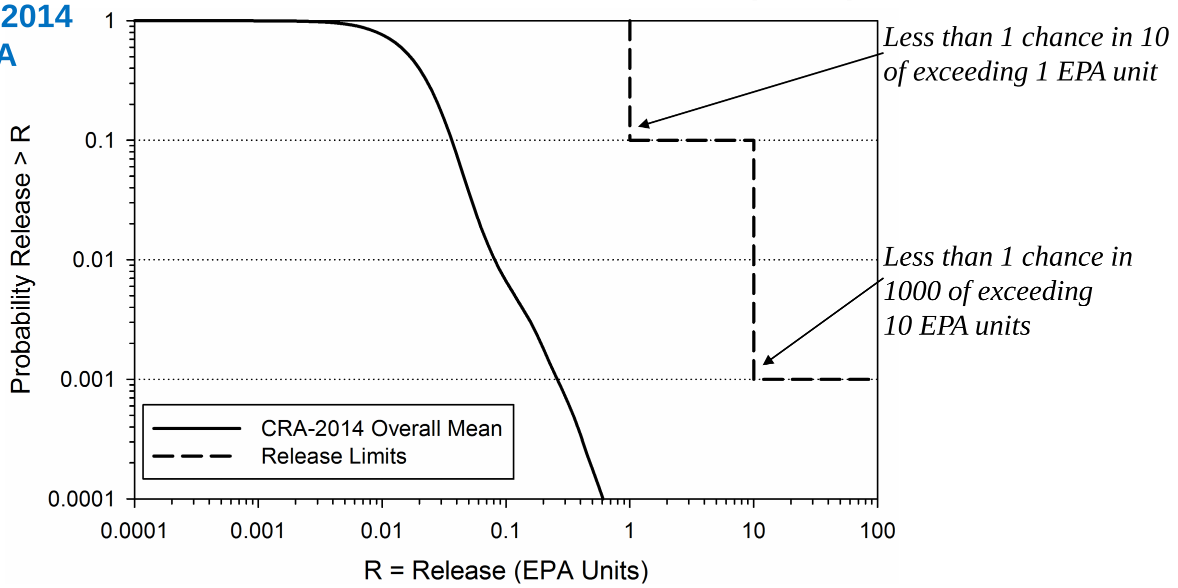


8

Total Release CCDF is the Measure of Compliance

Total releases from the repository are compared to regulatory release limits to determine compliance via a Complementary Cumulative Distribution Function (CCDF).

CRA-2014 PA



9

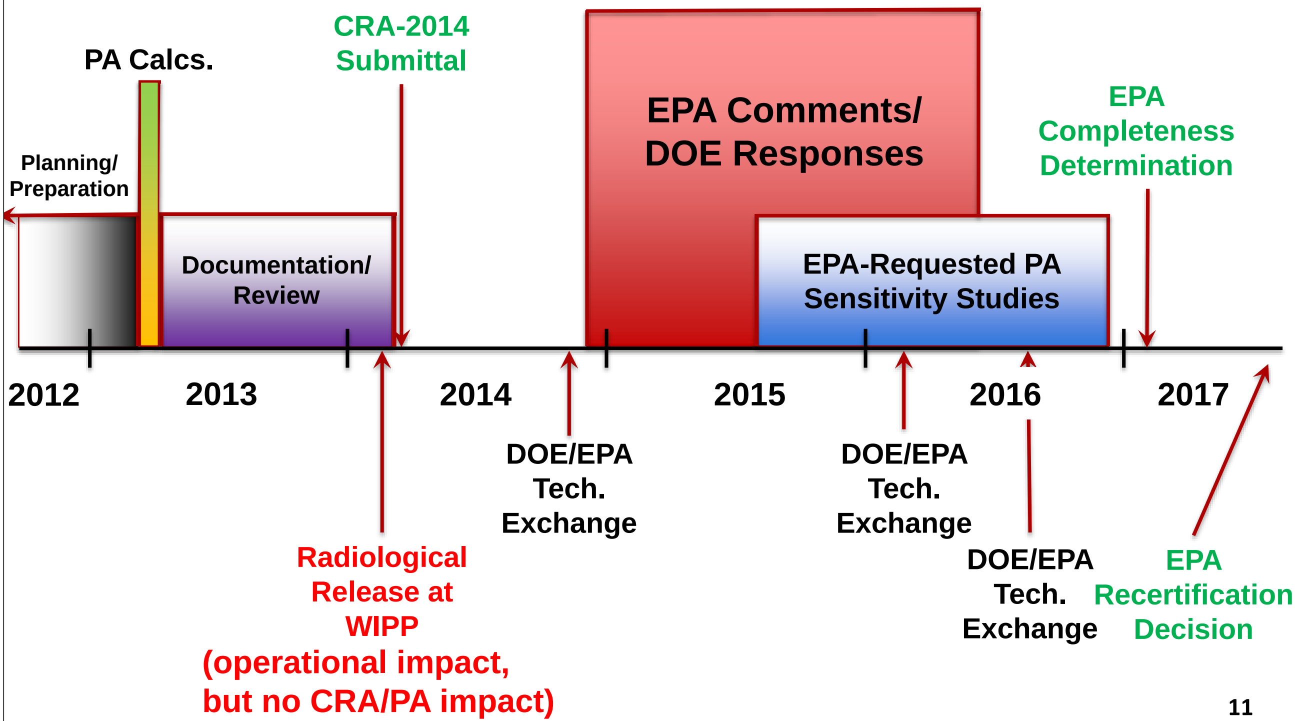
WIPP Recertification

Federal regulations require that the WIPP be recertified every five years following the first waste shipment in 1999.

- The prior regulatory baseline was established by the 2009 Performance Assessment Baseline Calculation (PABC-2009).
- The 2014 Compliance Recertification Performance Assessment (CRA-2014 PA) demonstrates continued compliance of the WIPP with federal containment requirements.
- The CRA-2014 was submitted to the EPA in March, 2014.
- A number of changes/refinements were included in the CRA-2014 PA (e.g. incorporate new data and experimental results).
- Following its review of DOE's application, the EPA recertified WIPP facility in July, 2017.

10

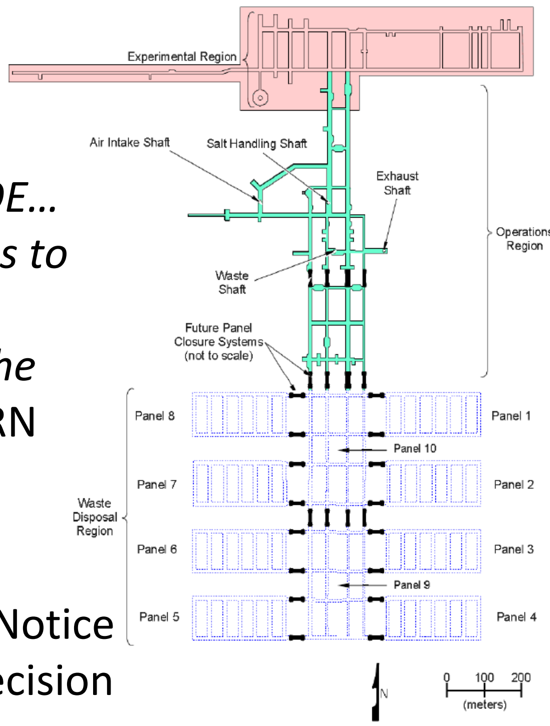
CRA-2014 Timeline



11

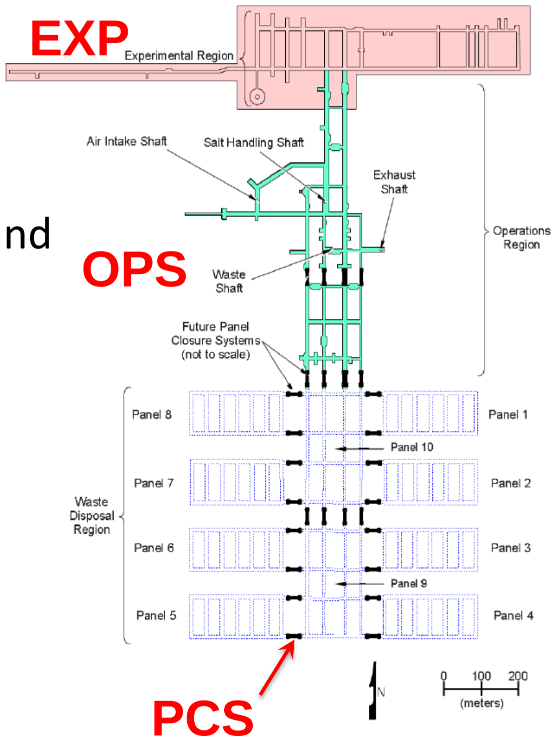
Three Sensitivity Studies

- EPA-directed (EPA-mandated parameters)
- *"…the EPA requested that the DOE… conduct a set of sensitivity studies to address some of the significant technical concerns arising from the EPA's CRA-2014 review."* –EPA FRN
- Not compliance calculations
- Formally analyzed by SNL
- Codified in EPA Federal Register Notice regarding WIPP recertification decision



12

Three Sensitivity Studies



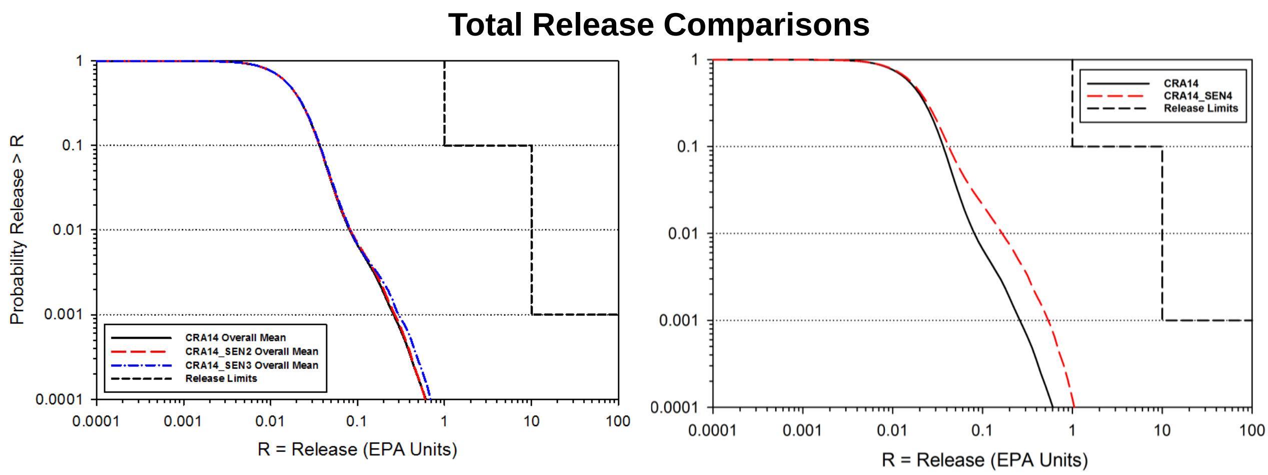
- **CRA14_SEN2**: Operations (OPS) and Experimental (EXP) Areas
- **CRA14_SEN3**: OPS/EXP + Panel Closures (PCS)
- **CRA14_SEN4**: Chemistry, brine intersection probability, etc.

Three Sensitivity Studies

Name	Changes to Baseline	Results Summary
CRA14_SEN2	Faster creep closure of OPS/EXP areas	Insignificant increase in releases
CRA14_SEN3	Faster creep closure of OPS/EXP areas and PCS	Minor increase in releases
CRA14_SEN4	Actinide solubility uncertainties Prob. intersecting brine Error corrections	Significant increase in releases

Three Sensitivity Studies

Sandia National Laboratories



CRA-2014
vs.
CRA14_SEN2
CRA14_SEN3

CRA-2014
vs.
CRA14_SEN4

Summary of Sensitivity Studies

Sandia National Laboratories

- *"The inputs to these sensitivity studies broadly address many of the EPA's technical concerns that could potentially impact long-term repository performance."* –EPA TSD
- *"The Agency has reviewed the results of these studies and determined that there exists an adequate level of confidence—that is, a reasonable expectation—that the repository will continue to comply with EPA regulations."* –EPA TSD
- *"The Agency does not consider these studies as being inclusive in addressing all the technical issues identified in our CRA-2014 review."* –EPA TSD

EPA Recertification Decision

- EPA Federal Register Notice issued July 2017
- "With this notice, the Environmental Protection Agency (EPA or the Agency) recertifies that the U.S. Department of Energy's (DOE) Waste Isolation Pilot Plant (WIPP) continues to comply with the ''Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic (TRU) Radioactive Waste.''
- "The Agency has determined that the DOE continues to meet all applicable requirements of the WIPP Compliance Criteria, and with this action, recertifies the WIPP facility."

17

EPA Recertification Decision (continued)

- "The EPA has also identified areas in which the DOE's technical analyses and justifications could be improved for the next recertification application."
- "The EPA recommends that the performance assessment technical basis be evaluated for improvement in these areas: (1) Calculations of actinide solubility, (2) modeling the chemical conditions in the repository, and (3) modeling direct brine releases."

18

Summary

- WIPP PA calculations are performed by SNL and used by DOE to demonstrate long-term repository performance

- The CRA-2014 PA was submitted to the EPA as part of compliance recertification application
  - EPA-requested sensitivity studies aided recertification decision

- The EPA recertified WIPP in July 2017
  - The WIPP remains in compliance with long-term federal containment requirements
  - The EPA has made recommendations for changes to PA for later CRA submittals

- Thanks to WIPP PA Team for support in all PA calculations performed for CRA-2014 activities

(in preparation from China)

Presentation materials for the Special Session (4 Materials)

Technical Strategy for Decommissioning of the Fukushima Daiichi NPS

27 November 2017

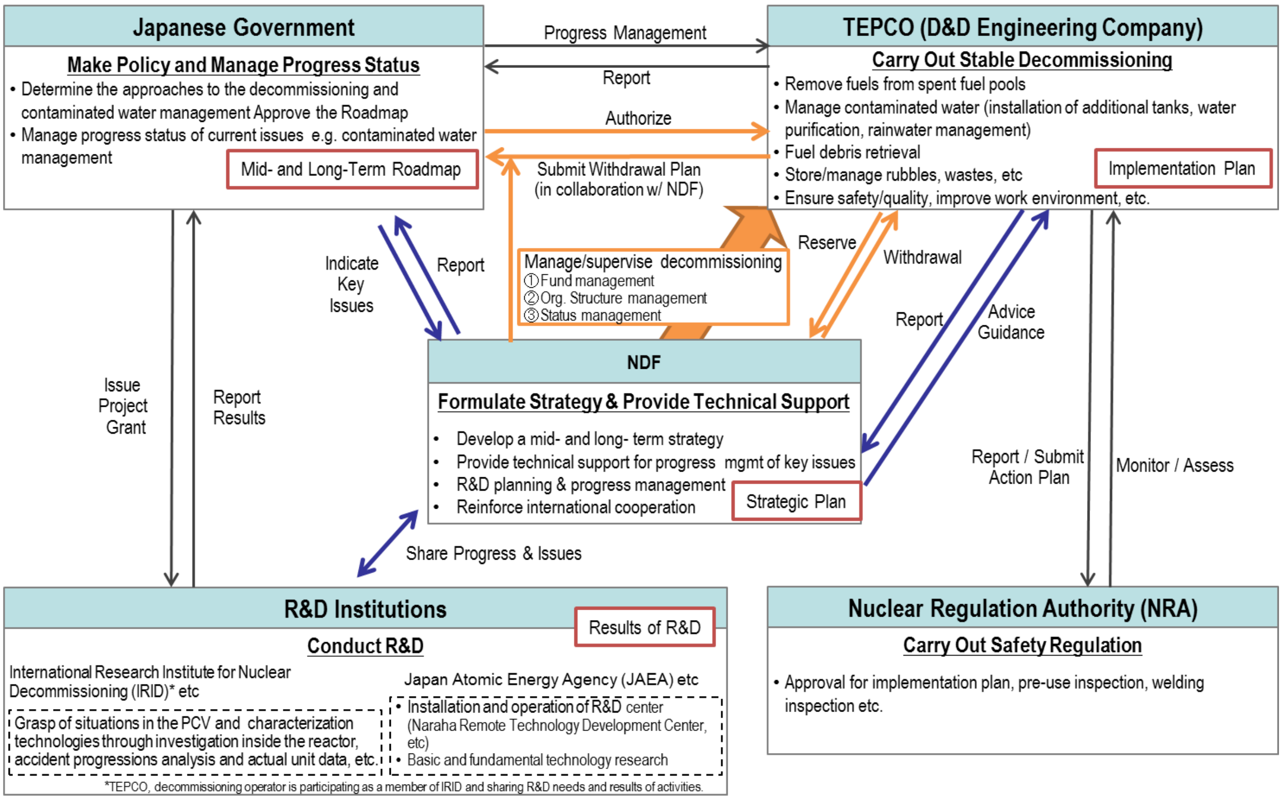
Nuclear Damage Compensation and Decommissioning Facilitation Corporation

NDF

Kazuyuki KATO

Contents

1. Roles & Responsibilities of Organizations Relevant to Fukushima Daiichi NPS Decommissioning



2－1. Purpose and Positioning of the Strategic Plan

FY 2015 | FY 2016 | FY 2017

The purpose of the Strategic Plan is to provide a firm technical basis for contributing to the steady implementation of the Government-developed Medium- to Long-Term Roadmap.

Providing strategic proposals for "determination of fuel debris retrieval policies for each unit" and "compilation of the basic concept of processing and disposal for solid waste"

Published on Apr 30th, 2015

Strategic Plan 2015

- Concepts and Direction of Initiatives

Published on July 13th, 2016

Strategic Plan 2016

Strategic Plan 2017

- Strategic Plan 2017 provides strategic proposals for the milestones of Mid-and Long-Term Roadmap based on discussions so far.

Basic Attitude

✓ The decommissioning of Fukushima Daiichi NPS is a project in which considerable uncertainty inheres.

✓ To realize prompt decommissioning, it is necessary to assume the attitude of taking flexible and prompt approach, based on the directions determined with previously obtained experience and knowledge, placing safety at the top priority, even though a certain extent of uncertainty remains.

→ The attitude of optimizing the entire project from the long-term and comprehensive viewpoint, and the attitude of making preparations for unexpected cases, are also important.

 5

2－2. Basic Concept of the Strategic Plan

Fundamental Policy

To continuously and promptly reduce the risks associated with the radioactive materials generated by the accidents

Five Guiding Principles

◆ Principle 1 : **Safety**

→ Reduction of risks * posed by radioactive materials and ensuring work safety (*) Environmental impacts and exposure to the workers

◆ Principle 2 : **Proven**

→ Highly reliable and flexible technologies

◆ Principle 3 : **Efficient**

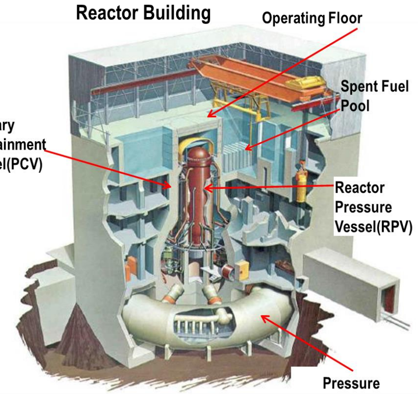
→ Effective utilization of resources (e.g. human, physical, financial and space)

◆ Principle 4 : **Timely**

→ Awareness of time axis

◆ Principle 5 : **Field Oriented**

→ Thorough application of Three Actuals (actual field, actual things and actual situation)



 6

3－1． Progress in Decommissioning of Fukushima Daiichi NPS①

- Over the last year, progress has been made in the following areas.

Contaminated Water Management

【Removal】Removal of contamination resources is underway using advanced multi-nuclide removal system.

【Keeping Away】Freezing operation of the land-side impermeable walls has bee extended; The operation on the mountain side is yet to be completed only at one location. After the operation on the sea side was completed in October 2016, the amount of groundwater pumped up from the area of 4.0m above sea level was reduced to one-third (an average of about 118 m^3/day in March 2017). As a result of implementing preventive/multi-layered measures such as subdrain, the amount of groundwater flowing into the buildings decreased to an average of about 120 m^3/day in March 2017.

【Preventing Leakage】The concentration of radioactive materials in the surrounding sea area is constantly low.

【R/B Stagnant Water Management】The stagnant water level in the Unit 1 Turbine Building was reduced to the lowest floor level in March 2017.

Removal of Spent Fuel from Spent Fuel Pool

•Unit 1: The removal of the cover wall panels for the reactor Building was completed. Information gathering for developing a rubble removal plan is in progress.

•Unit 2: A yard around the Reactor Building was prepared and a working platform for access to the operating floor was constructed.

•Unit 3: Measures to reduce the dose rates on the operating floor were completed. Installation of a cover for fuel removal is underway.

3－2. Progress in Decommissioning of Fukushima Daiichi NPS②

- Over the last year, progress has been made in the following areas.

Fuel Debris Retrieval

•Unit 1: An investigation using a robot in the basement outside the pedestal and in the vicinity of the access in PCV was conducted.

•Unit 2: A survey inside the pedestal in PCV using a robot and other devices was conducted.

•Unit 3: An investigation using muon detection system and an investigation in PCV using a robot were performed.

Waste Management

•The waste reduction measures are continued to be in place. An operation to reduce waste protective clothing with an incinerator was started.

•The solid waste storage management plan was updated.

•Sampling and analysis is underway in order to characterize the solid waste.

Other Specific Measures

•Since the rubble removal and facing in the area 4m above sea intended for improving site environment have resulted in the reduced risks of contamination, the classification for the protective equipment has been changed to “ordinary clothing area”.

3－3. Risk Estimation and Evaluation

- Risk level defined by the combination of the level of the impact in case of the release of radioactive materials and the likelihood of impact
- Risk estimation and evaluation is performed based on the SED score* developed by the U.K. Nuclear Decommissioning Authority (NDA)

*Safety and Environmental Detriment Score

(1) Hazard Potential (Index of the level of impact)

- ➢ Use SED score as it is.
- ➢ Consider the amount of all radioactive materials, the form of risk sources (e.g. gas, liquid and solid) and the available time for recovery in the event of a loss of safety function.

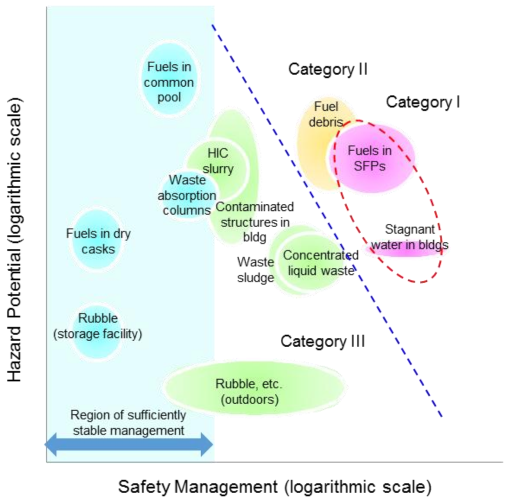
(2) Safety Management (Index of the likelihood of impact)

- ➢ Partially revised to flexibly cope with the situation of the Fukushima Daiichi NPS referencing the SED score.
- ➢ Graded and quantified the risk sources by the factors of integrity of the facility, containment function and a possibility of change in the state of the risk sources.

It will be appropriate to develop risk reduction measures based on the classification such as Category Ⅰ ～ Ⅲ.

【the interim goal】 To bring their risk levels to the “region of sufficiently stable management ”

Sample of risk analysis of the Fukushima Daiichi



1. Introduction
2. Strategic Plan
3. Strategy for Reducing Risks Posed by Radioactive Materials
4. Fuel Debris Retrieval
5. Waste Management
6. R&D Initiatives
7. Enhancement of International Cooperation
8. Future Actions

4－1. Basic Concept for Ensuring Safety in the Fuel Debris Retrieval Operation

- "Concept of safety function" and "principles for realizing safety functions" have been developed
- Taking into account factors, such as the international safety fundamentals, the safety-related characteristics of the Fukushima Daiichi NPS and the risk associated with the fuel debris retrieval operation.

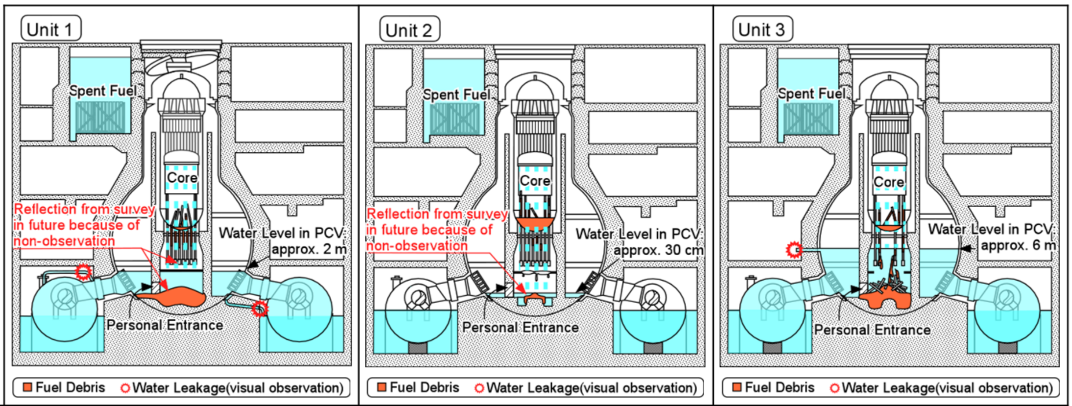
Concept of safety function

- ✓ Features to ensure the containment function (release prevention and management) and measures to prevent loss of the features are necessary
- ✓ Decay heat removal and criticality control, as well as prevention of pulverization and spread of fuel debris to the extent possible should be considered
- ✓ Preparedness for normal operations as well as for anticipated external events, such as earthquakes and tsunamis, and internal events, such as failures and operator errors, is required
- ✓ It is necessary to observe the dose limits for workers under normal operating conditions to reduce the exposure of workers to the extent possible, and to observe the emergency dose limits for workers engaged in emergency response activities

Principles for realizing safety functions

- ✓ Considering that the reactors after the accident are decommissioned, it is important to effectively use existing equipment, to provide the necessary equipment and to consider the combination of equipment and work management
- ✓ In order to reduce the exposure of workers engaged in preparatory work and maintenance work, it is important to ensure the containment function by maintaining the PCV at a negative pressure and to consider agile action using both permanent and mobile equipment
- ✓ In applying defense-in-depth, it is necessary to carefully consider the hierarchy of defense levels and the need for the independence of each level
- ✓ It is important to recognize the presence of uncertainty in the conditions in the PCV and to be able to change plans in a flexible manner
- ✓ In safety assessment, it is important to set a realistic management goal and assessment conditions. For example, actual lifestyles should be considered.

4 – 2. Current Status of Each Unit

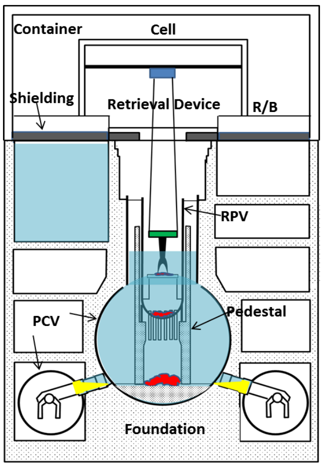


	Unit 1	Unit 2	Unit 3
Core Region	• Little fuel remains.	• Little fuel remains. • (Stub-shaped fuels might exist in peripheral region.)	• Little fuel remains.
RPV Lower Head	• A small amount of fuel debris is present. • A small amount of fuel debris is present in the inside and on the outer surface of the CRD housing.	• Large amount of fuel debris is present. • A small amount of fuel debris is present in the inside and on the outer surface of the CRD housing.	• Fuel debris remains on the RPV lower head partly. • A small amount of fuel debris is present in the inside and on the outer surface of the CRD housing.
Pedestal Inside	• Most of fuel debris is present.	• A small amount of fuel debris is present.	• Amount of fuel debris in Unit 3 is more than that in Unit 2.
Pedestal Outside	• Fuel debris may have spread on the pedestal outside through the personal entrance.	• The possibility of fuel debris spreading on the pedestal outside through the personal entrance is low.	• Fuel debris may have spread on the pedestal outside through the personal entrance.

* Based on the document provided by IRID and internal survey performed in 2017.

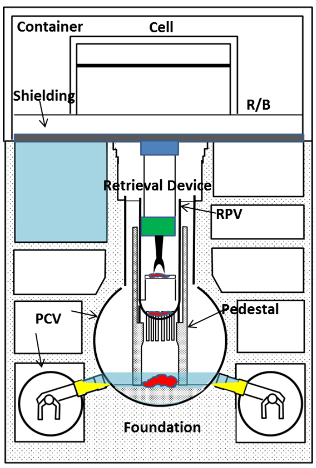
4 – 3. Feasibility of the Fuel Debris Retrieval Method

- In order to evaluate the feasibility of the fuel debris retrieval method, which are based on combination of water level and access routes, three priority method have been selected.



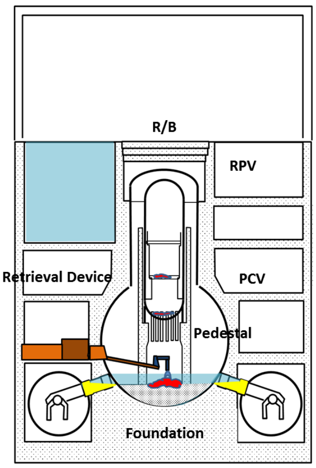
a. Submersion-Top Access method

Fuel debris is accessed from the top. PCV will be completely filled with water or filled with water to a level at which the fuel debris is present.



b. Partial Submersion - Top Access method

Fuel debris is accessed from the top. Part of fuel debris will be dealt with in the air without water covering.



c. Partial Submersion - Side Access method

Fuel debris is accessed from the side of the PCV. Part of fuel debris will be dealt with in the air without water covering.

4－4. Evaluation of Feasibility of the Methods ①

● Evaluate the feasibility based on the status of R&D, occupational radiation exposure and so on.

		Submersion-Top Access	Partial Submersion - Top Access	Partial Submersion - Side Access
Ensuring Containment Capability	Liquid Phase	･Hard to ensure water seal capability of resisting hydrostatic pressure when being submerged ･Hard to ensure capability to remotely fix penetration holes for upper PCV with lots of holes ･Emergency water leak prevention measure is required as a large amount of water is supposed to be kept	･Technical difficulty is slightly lower as hydrostatic pressure is lower than that of submersion case. ･Penetration holes on upper PCV to be fixed are limited. ･It is possible to prevent water leakage even on emergencies depending on water level settings.	･Technical difficulty is slightly lower as hydrostatic pressure is lower than that of submersion case. ･Penetration holes on upper PCV to be fixed are limited. ･It is possible to prevent water leakage even on emergencies depending on water level settings.
	Gas Phase	･Although air conditioning system with capability of maintaining negative pressure is required, small scale equipment may be good enough.	･Air conditioning system with capability of maintaining negative pressure for containing alpha-emitting nuclides is necessary. The scale of the equipment will be large, but it can be feasible.	･Air conditioning system with capability of maintaining negative pressure for containing alpha-emitting nuclides is necessary. The scale of the equipment will be large, but it can be feasible.
Criticality Management		･Preventing criticality when reactor core is covered with water is an issue.	･There is a low probability of re-criticality as reactor core will not be covered with water.	･There is a low probability of re-criticality as reactor core will not be covered with water.
Structural Soundness / Seismic Resistant Features of PCV and R/B		･Although the total weight of coolant in PCV and fuel debris retrieval equipment to be installed at upper R/B increases, seismic margin will be ensured for major components.	･Although the total weight of fuel debris retrieval equipment to be installed at upper R/B increases, seismic margin will be ensured for major components.	･Better seismic margin will be ensured as fuel debris retrieval equipment will be installed on the first floor.
Reducing Occupational Radiation Exposure		･Occupational radiation exposure would be of several times of the past annual total exposure when sealing upper PCV as there are lots of penetration holes on the upper PCV.	･Occupational radiation exposure would be less than the past annual total exposure when sealing lower PCV.	･Occupational radiation exposure would be less than the past annual total exposure when sealing lower PCV.

4－5. Evaluation of Feasibility of the Methods ②

		Submersion-Top Access	Partial Submersion - Top Access	Partial Submersion - Side Access
Establishing Access Route	Inner RPV	･Scale of work concerning retrieval of fuel debris located in RPV could be significant as inner structures of reactor must be removed.	･Scale of work concerning retrieval of fuel debris located in RPV could be significant as inner structures of reactor must be removed.	･Building an access route to fuel debris located in RPV is difficult at present.
	PCV Bottom	･Scale of work concerning retrieval of fuel debris located at the bottom of PCV could be more significant than that of side-access method as it is required to bore the bottom of RPV.	･Scale of work concerning retrieval of fuel debris located at the bottom of PCV could be more significant than that of side-access method as it is required to bore the bottom of RPV.	･Scale of work concerning retrieval of fuel debris located at the bottom of PCV could be less significant than that of top-access method.

Evaluation of feasibility

Submersion-Top Access	Partial Submersion - Top Access	Partial Submersion - Side Access
･Development of technologies for remotely fixing penetration holes for water sealing is difficult. ･Total occupational exposure concerning repair work could be enormous.	**･It is necessary to continue development of technology for maintaining negative pressure in order to contain alpha-emitting nuclides. ･Both top-access and side-access would be required.**	**･It is necessary to continue development of technology for maintaining negative pressure in order to contain alpha-emitting nuclides. ･Both side-access and top-access would be required.**

4 – 6． Comprehensive Evaluation

Evaluation of the water level during the fuel debris retrieval operation

- ✓ In the partially submersion method, though it is necessary to develop a gas-control system and contain radioactive materials in the gas-phase portion, we should further accelerate the R&D process and evaluate the applicability of the method to work in the field toward materialization of the partially submersion method in all Units 1 to 3.
- ✓ With discussing the feasibility of the submersion method in the future scope, we should also store the knowledge obtained in the R&D process and remaining issues in an appropriate manner to prepare for the possible use of them.

Access routes

- ✓ At the moment, it is considered difficult to access the fuel debris inside the RPV from the side for retrieval. It is necessary to access it from the operating floor (from the top).
- ✓ It is more realistic to access the fuel debris at the bottom of the PCV and retrieve it from the side of the PCV (on the first floor level of reactor building). In terms of reducing the exposure of workers and performing maintenance work, it is reasonable to access it from the side of the PCV.

Locations in the reactor from which fuel debris should be retrieved first

- ✓ It is realistic to retrieve the fuel debris from the bottom of the PCV first by accessing from the side.
  The reasons are:
  1. The bottom of the PCV in Units 1 to 3 has been investigated and, as a result, a certain amount of knowledge on the routes for accessing the bottom from the side has been accumulated, which can be used for realistic engineering.
  2. The actual time to reach the fuel debris will be longer when accessing the inside of the RPV from the top than when accessing the bottom of the PCV from the side.
  3. In order to streamline the decommissioning process as a whole, preparations for side access to the bottom of the PCV can be made concurrently with the removal of the fuel from the pool.

4 – 7． Proposal for Deciding Fuel Debris Retrieval Policies and Approach after Decision (Strategic Proposal) ①

Proposal for Drafting Fuel Debris Retrieval Policies

(1)Develop a comprehensive fuel debris retrieval plan aimed to optimize the entire retrieval process, from preparation work and transfer from the site to treatment, storage and cleanup, including coordination with other works in the field.

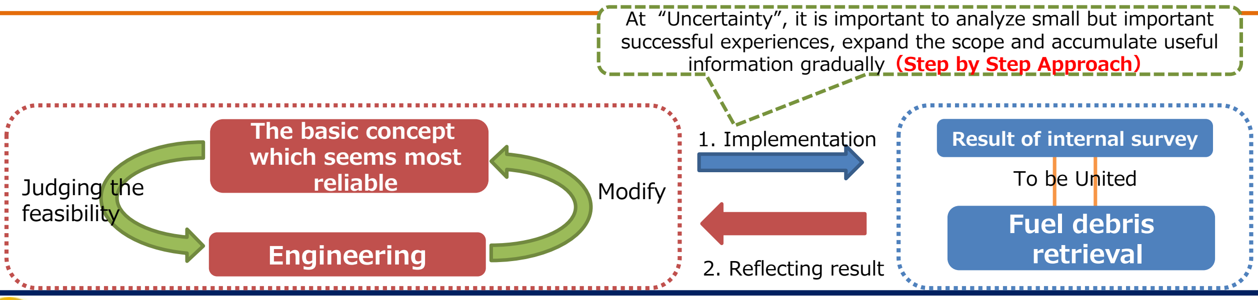
(2)Move forward in a flexible manner according to the information gained little by little via a step by step approach after deciding the retrieval method to be focused on.

(3)Assume that combination of a variety of methods will be required to complete the fuel debris retrieval.

(4)Promote preliminary engineering and R&D focusing on the partial submersion methods.

(5)Firstly, focus on retrieving the fuel debris located at the bottom of the PCV and keep reviewing the methods based on the newly gained expertise/experience through the retrieval.

(6)At first, focus on the route from the side of the PCV (the side-access method) for the first access to the fuel debris located at the bottom of the PCV. The following are the points to be stressed about the method.



4 – 8. Proposal for Deciding Fuel Debris Retrieval Policies and Approach after Decision (Strategic Proposal) ②

- Once the fuel debris retrieval policies have been defined, the following priority issues should be dealt with towards "determination of fuel debris retrieval method for the first implementing unit" and accelerating the development of the actual construction plan

Preliminary engineering

- ✓ The applicability of the results of research and development and system concept to the actual field will be evaluated and the processes involved in the retrieval will be specified.
- ✓ As needed, the fuel debris retrieval methods may be revised based on the results of the preliminary engineering.

Acceleration of technology development based on the selection and prioritization of research and development projects and practical application of technology

- ✓ Extra investigations into internal PCV
- ✓ Investigations into internal RPV
- ✓ Judging feasibility of alpha emitting radionuclides management system required for partial submersion methods
- ✓ Promoting the necessary research and development projects to materialize the side-access method into practical use and discussing the significance of mockup facility
- ✓ Conducting research and development on a system for containing, transferring and storing fuel debris, on the preparation of a storage facility, and on the waste to be generated by fuel debris retrieval

Path to Commencement of Fuel Debris Retrieval

- ✓ It is important to remember the following when promoting the fuel debris project.
  "Considerations to the continuity of the project", "Optimization of the entire retrieval process" and "Close communication with the local government and community"

NDF

NDF

5－1． Study Policy on the Strategic Plan for Waste Management

- It is considered that the solid waste generated due to the accident has different characteristics. Hence, characterization of solid waste has been conducted, on the basis of which the study towards processing and disposal has progressed. The management such as storage of solid waste also has been implemented in accordance with risk reduction approach.
- The international safety principles on radioactive waste management are compiled and the policies on solid waste management to be applied are shown, in light of the current state that solid waste characteristics data has been accumulated.

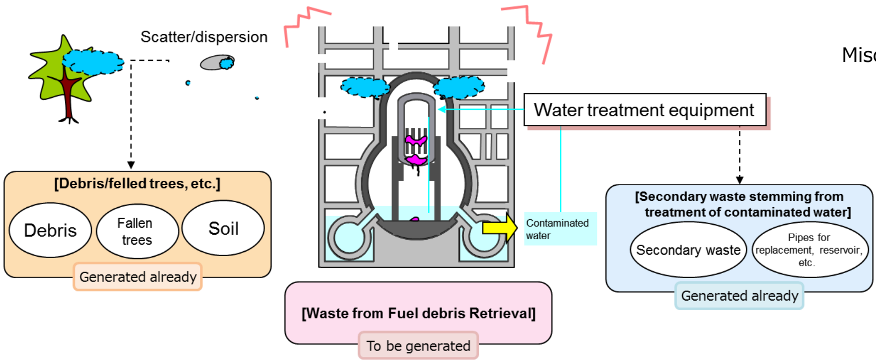
International Safety Principles on Radioactive Waste Management

✓ Described below are some principles in the safety principles on radioactive waste management compiled by ICRP and IAEA for all radioactive waste

- ➢ To contain all radioactive waste and isolate it from the accessible biosphere
- ➢ To be processed to have stable solid form, and reduced volume to the extent possible and immobilized during the management activity of radioactive waste
- ➢ At various steps in the predisposal management of radioactive waste, the radioactive waste shall be characterized and classified.
- ➢ During the predisposal management, storage is important as a measure to give the management with flexibility.
- ➢ To be stored in such a manner that it can be inspected, monitored, retrieved and preserved in a condition suitable for its subsequent management.
- ➢ The anticipated needs for any future steps in radioactive waste management have to be taken into account as far as possible in making decisions on the processing of the waste

5－2． Current State of Solid Waste Management

Effort	Current State
1． Storage	◆ Solid waste is safely stored continuously according to its type and surface dose rate. Volume reduction of solid waste such as used protective clothing is being carried out by operation of miscellaneous solid waste incineration facility. ◆ In the solid waste storage management plan, the amount of solid waste generated in the next ten years is estimated, and a plan is shown to reduce volume of waste stored outdoors as much as possible and transfer to indoor storage in order to achieve further reduction of the risk on storing solid waste.

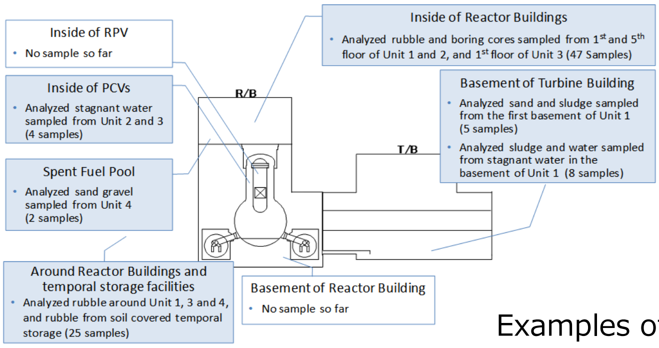


Miscellaneous solid waste incineration facility

Outline of solid waste contamination source and nuclide migration pathway

5－3． Current State of Solid Waste Management

Effort	Current State
2． Waste Characterization	◆ Sampling and analysis were carried out mainly on “rubble, etc.” and secondary waste from water treatment generated after the accident. Analysis results of about 300 samples have been accumulated over the past 6 years. ◆ Although some contamination characteristics of solid waste are being estimated based on accumulation of analysis results, further analysis is still required. In addition, in order to promote characterization, a method of understanding the characteristics by using analysis data and nuclide migration model evaluation data is being developed.
3． Processing and disposal	◆ For secondary waste from water treatment system, the technologies for stabilization and immobilization have been developed with priority. In order to narrow down the applicable candidates of conditioning technology, fundamental tests for solidification have been conducted with simulated non-radioactive waste using proven technologies. Through these tests, data was obtained on the possibility of solidification and the soundness of the solidified products. ◆ As for disposal, waste classification methodology has been studied on a trial basis for existing disposal concepts as an example. ◆ The case-based study of overseas disposal facilities has been conducted in order to contribute to the study on disposal concepts which is based on the characteristics of solid waste



Sampling（JAEA）

Examples of sampling location

5－4． Proposal for Compilation of the Basic Concept of Processing and Disposal for Solid Waste (Strategic Proposal) ①

Characteristics of Solid Waste

Described below are the characteristics of solid waste that have been presumed.

- ✓ The amount of solid waste is greater than that of radioactive solid waste generated by normal operation of nuclear power stations, and a lot of solid waste have relatively high dose rate.
- ✓ As the major source of contamination is fuel debris, radioactive concentration of nuclides in solid waste does not exceed that of spent fuel.
- ✓ Composition and radioactive concentration of nuclides in solid waste have a lot more varieties compared with those of radioactive solid waste generated by normal operation of nuclear power stations.
- ✓ Secondary waste generated from water treatment has high fluidity, high dose rate that can causes the generation of hydrogen, and the materials/substances which have never been dealt with in Japan.
- ✓ Solid waste generated immediately after the accident include materials/substances whose chemical characteristics might impact on the safety of the predisposal and disposal and/or whose chemical hazard might affect the environment.
- ✓ Information about the total amount of solid waste and their characteristics, which are essential for discussions on disposal, will be revealed sequentially as decommissioning activities proceeds.

Solid Waste Management Policies

Characterization, storage and preceding processes in predisposal management are mainly focused on until a prospect of disposal is obtained.

◇Thorough containment and isolation ◇Reduction of the amount of solid waste

◇Promotion of characterization

⇒ Increasing analytical capability systematically by constructing required facilities/equipment, keeping on analytical talented staff and bringing up analytical staff, and improving characterization by R&D from the perspective of efficiency.

◇Thorough storage ◇Establishment of a selection system of preceding processing methods in consideration of disposal

⇒ Establishment of a selection system of preceding processing methods for stabilization and immobilization of solid waste before technical requirements are set.

5－5. Proposal for Compilation of the Basic Concept of Processing and Disposal for Solid Waste (Strategic Proposal) ②

● Present Efforts/R&D Based on Solid Waste Management Policies

Thorough containment and isolation

- The measure such as store in containers or immobilization is performed as needed. Solid waste is isolated by storing in the storage place which is set up appropriately.

Reduction of the amount of solid waste

- Continue such efforts as carry-in control, re-use/recycling and volume reduction.

Promotion of characterization

【Increasing analytical capability】Construct new facilities/equipment and use existing ones systematically from a mid-to-long term perspective, and establish a system for human resource development (HRD) and technology transfer.

【R&D for improving characterization from the perspective of efficiency】Develop a characterization method with complimentarily combining analytical data and evaluation data based on nuclide migration models, and facilitate R&D for optimizing the number of analytical samples and for simplifying analytical methods to speed up analysis.

Thorough storage

- Reduce the amount of solid waste that have been stored temporarily outside of storage facilities by moving them to storage facilities after volume reduction as much as possible.
- Discuss the methods of evaluating the amount of hydrogen gas generated from the secondary waste from water treatment during the period of storage, estimate the timing of implementing additional safety measures and consider what kind of the measures will be required.
- Study storage method for solid waste to be generated by fuel debris retrieval.

Establishment of a selection system of preceding processing methods in consideration of disposal

- Establish a selection system of preceding processing methods. In this system, safety assessment of specifications of a provisional waste package is performed relatively in each developed disposal concept. The selection of preceding processing method depends on the result of safety assessment.

Efficient implementation of R&D projects from the perspective of overall solid waste management

Development of a system for continuous operations

Measures to reduce the exposure of workers to radiation

8． Future Actions

8． Future Actions

- The importance of project management will increase as the decommissioning activities at the Fukushima Daiichi NPS progress to an advanced phase and technically difficult activities, such as fuel debris retrieval, are fully performed

Enhancing Project Management Capabilities

- ✓ The fuel debris retrieval operation, which is technically difficult and needs to be performed, taking into account the relationship with and the continuity of the activities that have been performed, will be fully performed.
- ✓ Project risk management that identifies the risks which may impact on the implementation of the project, analyzes the significance of the risks and take required actions is essential.
- ✓ TEPCO, as the organization responsible for the implementation of decommission, and NDF, as the organization responsible for the management and supervision of decommission, need to clearly define their roles and accountability, and strengthen project governance in order to facilitate sound progress of the project, respectively.

Engagement with Stakeholders

- ✓ Based on providing plain and accurate information, it is necessary to have good conversation, make continuous effort mutually in order to reduce the gap between the providers and receivers, and repeat these processes.
- ✓ Just anxiety about potential risks may cause serious harm to the reputation. To avoid further reputational damages, it is more significant, than anything else, to manage radioactive materials in an appropriate manner in order not to let them leak and reduce the existing risks promptly.

Consideration for the Project Sustainability

- ✓ It is necessary to ensure the mechanism that enables continuous project management, etc. and to secure a large variety of human resources taking the roles in these works

NDF

Thank you for your attention!

Technical strategic plan 2017 is available

URL:http://www.dd.ndf.go.jp/jp/strategic-plan/index2017.html

NDF

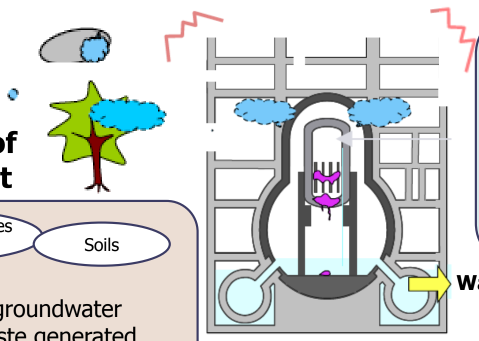
The 6th Conference of East Asia Forum on Radwaste Management,
27 November 2017 Osaka, Japan

Study on Post-accident Waste Management Scenarios for Fukushima Daiichi Nuclear Power Station

Satoshi Yanagihara

Subcommittee on Radioactive Waste Management
Study Committee on Decommissioning of the Fukushima Daiichi NPP
Atomic Energy Society of Japan

Consequences of the Fukushima Daiichi NPS Accident



Contamination of the Environment

Rubbles | Trimmed branches cut-down trees | Soils

- Wide area contaminated
- Contamination of soil and groundwater
- A significant amount of waste generated from clean up and remediation activities

Contamination of the Cooling/ground water

Secondary waste | Pipes and tanks, etc. | Contaminated water

- Approx. 120-130 t/d of contaminated water collected (as of Oct., 2017)
- Generation of secondary waste from water treatment
- Accumulation of Tritium containing water
- A need for disposal of tanks storing HTO in the future

Water treatment

Severe Contamination inside the Reactor Facilities

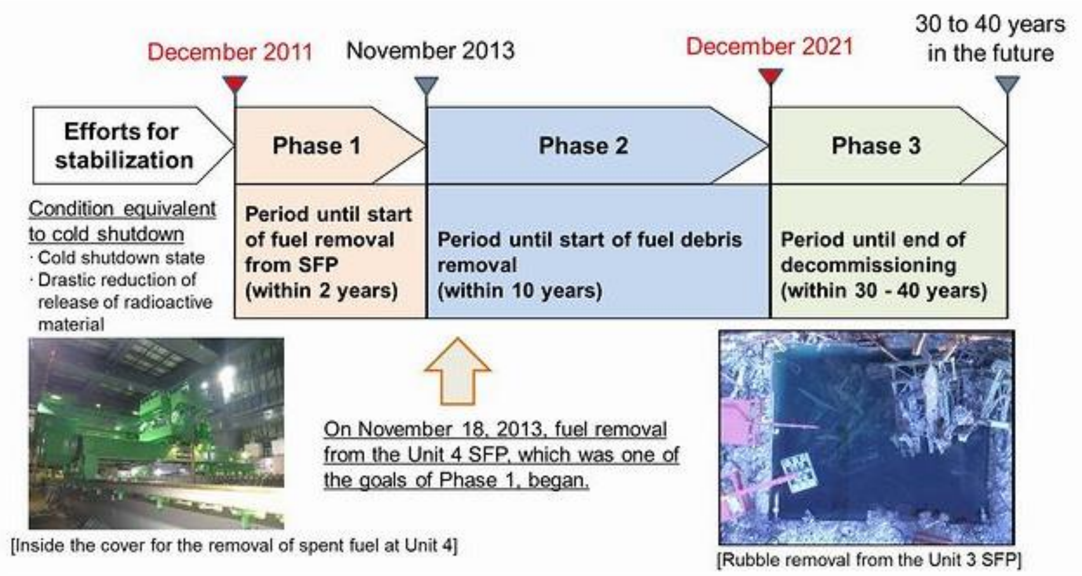
Fuel Debris | Reactor components | Facilities and buildings

- High dose rate inside the facilities
- Difficulty in radiological characterization
- Measures to ensure nuclear safeguards and security

Radioactive Inventory before the Accident
-> around 6 × 10^{19} Bq (in the Unit-1)
The amount released into the environment
-> around 7 × 10^{17} Bq (Total)

Sources: Special committee of Atomic Energy Society of Japan, Treatment and disposal of radioactive waste arising from Fukushima Daiichi NPS accident, 2015
Shunsuke Uchida, et. al, NUCLEAR TECHNOLOGY VOL.188 DEC. 2014, JAEA-Data/Code201-018

Mid-and-long-Term Roadmap towards Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4



http://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html

Organization of the Review Committee of Atomic Energy Society of Japan

Review committee

- **Risk Assessment and Management**
- **Robotics**
- **Radioactive Waste Management**
- **Structural Performance of Reactor Building**
- **Follow-up the Proposal for Lessons Learned**

Outline of the Activities by Subcommittee of Radioactive Waste Management

Literature review on past accidents and lessons learned

(Examples)

- As taken into account in the Fukushima Daiichi Decommissioning Roadmap, a strategy must be developed to identify the steps of post-accident clean out, including key milestones, hold points and end points. -----IAEA
- The development of a long-term strategic approach to the lifecycle design and operation of nuclear facilities, which takes into account waste management, decommissioning and site remediation, as well as the reuse of sites. ----OECD/NEA

Study on Radioactive Waste Management Scenarios

- Survey of the radioactive waste arising from the post-accident clean-up phase
- Discussion on the interim and final end points for decommissioning and remediation
- Estimation of the radioactive waste arising from all phases until site release

Radioactive Waste Storage Facilities at Fukushima Daiichi NPS

Temporary storage of radioactive waste

7

Radioactive Waste Arising from the Post-Accident Cleanup Phase

- Secondary waste by treatment of contaminated water：
  9,972 m^3 + 1,216 Bessels+2,580 Containers+9 Columns
- (Building) Debris ：216,200 m^3
- Trimmed Trees ：133,700 m^3
- Contaminated water（886 Tanks）*：1,041,878 m^3

Description of the 1000 m^3 Tank
- Diameter：12 m
- Hight：10 m
- Capacity：1000m^3

Water Stagnanted in Reactor Facility

Facility	Volume（m^3）
Unit-1	6000
Unit-2	12990
Unit-3	12770
Unit-4	13640
Total	45400

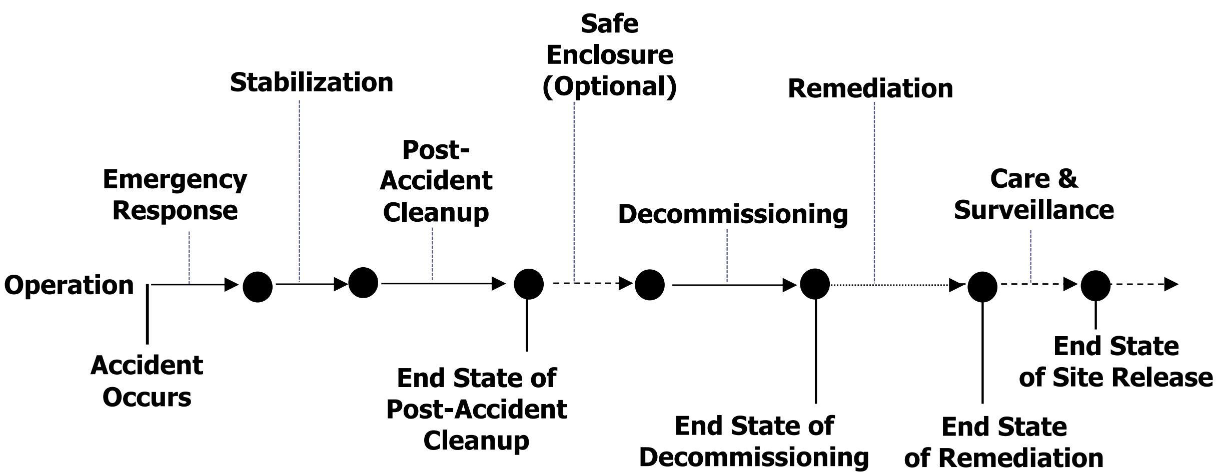
Water Stagnanted in Storage Building

Facility	Volume（m^3）
Process Main Bld.	4,060
High Temperature Incineration Bld.	3840
Total	7900

Source: TEPCO, October, 2017

8

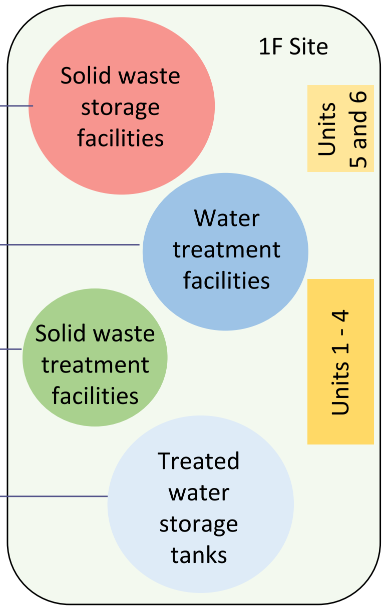
Timeline from Accident to the End State for Site Release



IAEA, Experiences and Lessons Learned Worldwide in the Cleanup and Decommissioning of Nuclear Facilities in the Aftermath of Accidents, Nuclear Energy series, No.NW-T-2.7, 2014

Present Status of the Radioactive Waste at Fukushima Daiichi NPS

- Approximately 350 thousand m^3 of solid waste, as of October 2017, was generated from the post-accident cleanup and stabilization activities, and is stored on-site. They are sorted by the types as well as the dose rate.
- Water treatment produces the secondary waste, such as adsorption towers, treatment columns, and filters.
- Solid waste treatment will be effective in volume reduction and stabilization. These facilities need to be dismantled and disposed of, once all of the solid waste is treated.
- Treated water containing tritiated water is stored in tanks. About 900 tanks are in use as of October 2017, which amounts to about one million tons of waste tanks after disposition of tritiated water.



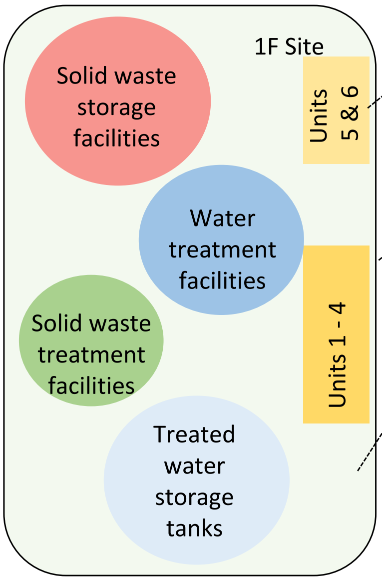
Radioactive Waste Management Scenarios ~ End State Options ~

End State Condition	Facilities on Site	Site Remediation	Radioactive Waste Management
OP-1 Green Field	Completely dismantled and demolished.	Decontaminated and remediated to a level that allows an uncontrolled access.	Radioactive waste is transported out to an interim storage or a disposal facility.*
OP-2 Brown Field	Partially dismantled. Remaining facilities enclosed for a long-term storage.	Decontamination and remediation for long-term care and maintenance. Restricted access.	Radioactive waste is conditioned, packaged, and stored on site until a final disposal site becomes available.

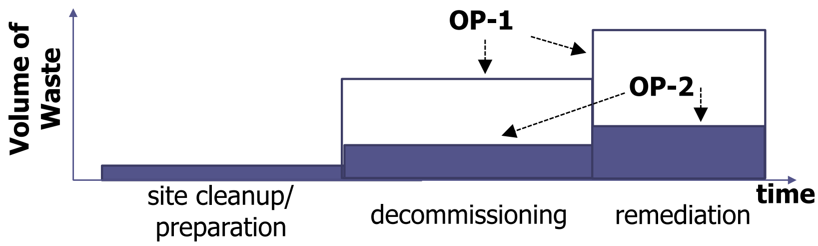
*: There is an agreement between national government and Fukushima prefectural government that the final disposal facilities for Fukushima accident waste will be constructed outside Fukushima prefecture.

11

Estimation of Waste Arising from Decommissioning

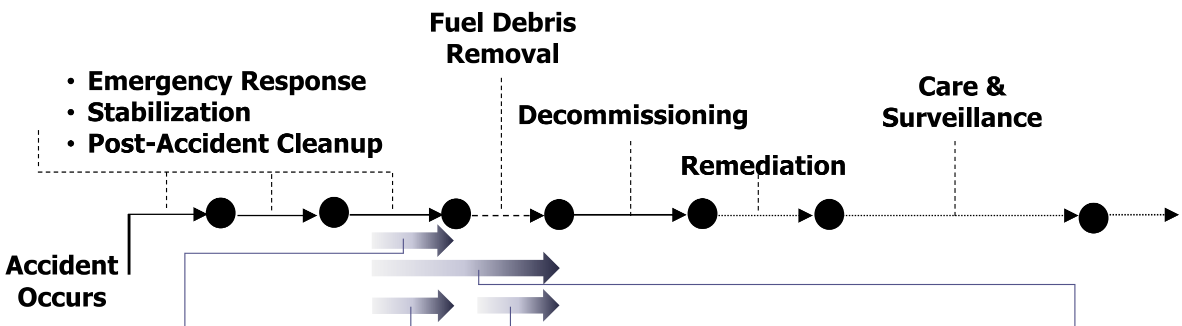


- Dismantling of the Units 5 and 6 will generate 700 to 800 thousand tons* of waste. Most the waste is expected to be non-radioactive, similar to the facilities that have not experienced accidents.
- Dismantling of the Units 1-4 is expected produce 800 to 900 thousand tons* of waste. Most or all of these waste may be radioactively contaminated from the explosions.
- Demolition of service buildings and site remediation will generate more waste.



12

Major Waste Management Decisions to make for Fukushima Daiichi NPS Decommissioning



Action Plan for Tritiated Water
- Release to the environment, or
- Continued storage
  → Work space for fuel debris removal, and/or fuel debris storage area

Waste Management Systems
- Interim storage on or off site, or
- Final disposal
  → Waste segregation and characterization system

Decommissioning End State Option
- Complete dismantling/ demolition, or
- Partial dismantling/enclosure and care/maintenance

Radioactive waste management decisions

Considerations for the Analysis of Radioactive Waste Management Scenarios

Safety of the public, the work force, and the environment

Proper Waste Management

- Physical, chemical, and radiological characterization
- Waste minimization
- Handling / conditioning / treatment / storage / disposal

Minimization of the Overall Environmental Impact

- Reduction/mitigation of the environmental impact not only via physical measures, but economical and administrative actions combined
- Balancing between the benefit of decommissioning /remediation and the impact of waste management

Effective Project Management

- Balancing the competing project constraints
  Scope/Quality/Schedule/Budget/Resources/Risks
- Integrated risk management
  Cost overrun/Schedule delay/Technical feasibility

Concluding Remarks

- The subcommittee is developing potential radioactive waste management scenarios for the waste arising from Fukushima Daiichi NPS decommissioning and site remediation.
- In the process, we have come to realize that defining the final end point and determining the long-term strategy toward the goal is essential in considering waste management options.
- The end point options for decommissioning and site remediation will be discussed on the technical point of view, including both the green field and the brown field options.
- The waste management scenarios leading to the end point will be discussed and evaluated thoroughly and carefully in terms of feasibility, radiation safety, technology availability, and consistency with the national framework.
- The subcommittee will discuss and identify the requirements on waste management imposed by the constraints of space and time for decommissioning/remediation activities (i.e. securing the space for handling/storage for fuel debris, interim storage facility and treatment /conditioning facilities).

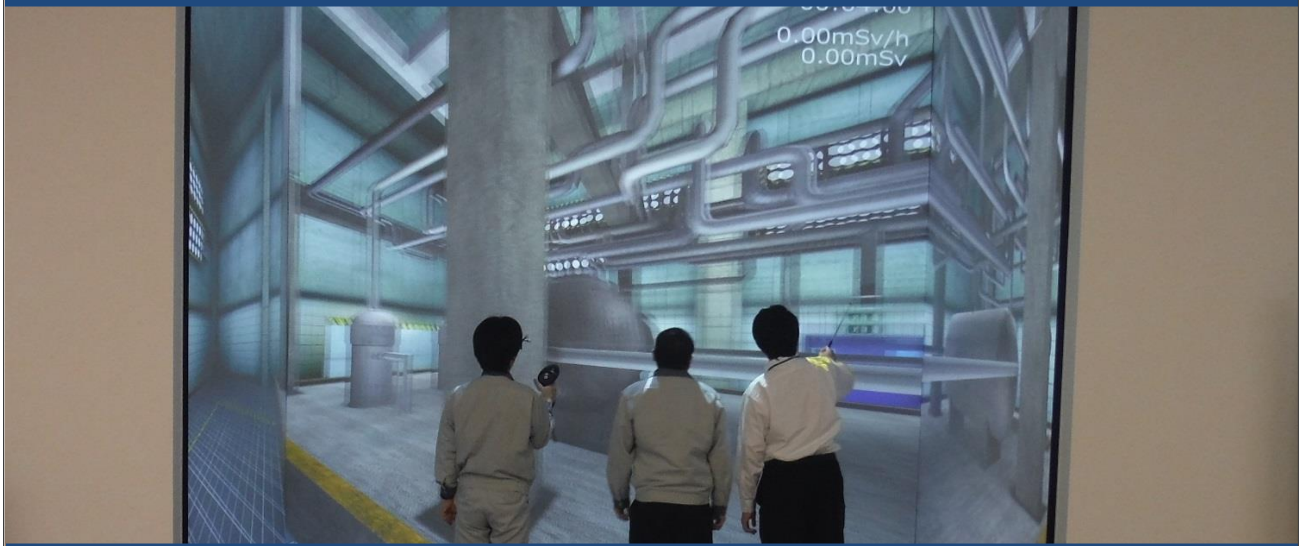
Subcommittee Members of Radioactive Waste Management

Satoshi Yanagihara (Univ. of Fukui)
Yuichi Niibori (Tohoku Univ.)
Naoko Watanabe (Hokkaido Univ.)
Daisuke Kawasaki (Univ. of Fukui)
Masahisa Watanabe (JAEA*)
Katsumi Kishimoto (JAEA*)
Noriko Asanuma (Tokai Univ.)
Kazuya Idemitsu (Kyushu Univ.)
Shunichi Suzuki (Univ. of Tokyo)
Takao Ohi (JAEA*)
Masaaki Kaneko (Toshiba Corp.)
Osamu Kontani (Kajima Corp.)
Kenji Noshita (Hitachi-GE Nuclear Energy)
Shigenobu Hirusawa (NSRA*)
Kazuto Maeda (MHI*)
Yasuaki Miyamoto (JAEA*)
Toyoaki Yamauchi (JAPC*)
Toshiyuki Nakazawa (MITSUBISHI MATERIAL)

JAEA: Japan Atomic Energy Agency
JAPC: The Japan Atomic Power Company
NSRA: Nuclear Safety Research Association
MHI: Mitsubishi Heavy Industrie

EAFORM 2017 Osaka, November 2017

JAEA's R&D for Decommissioning of Fukushima Daiichi Nuclear Power Station

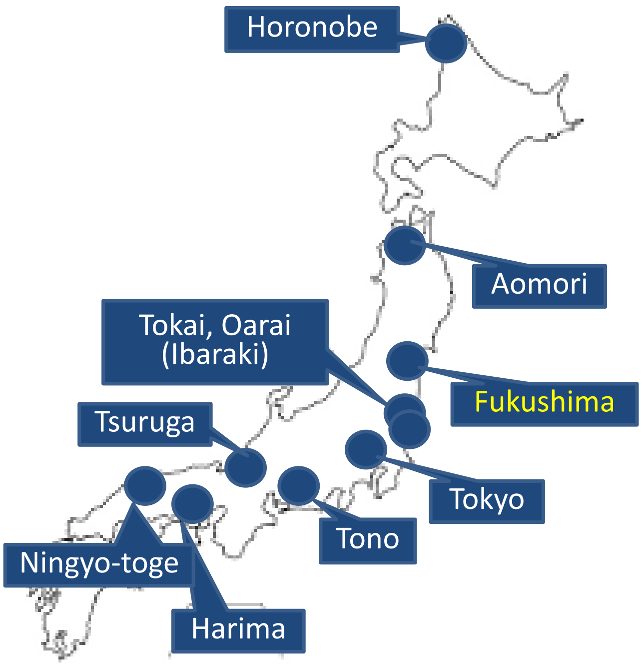


Shinichi NAKAYAMA
Fukushima Research Institute
Japan Atomic Energy Agency (JAEA)

1

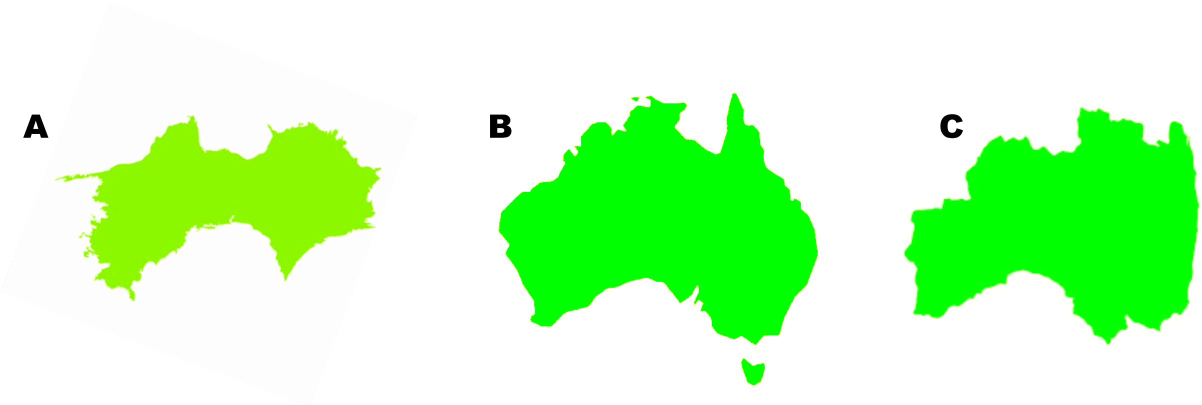
Japan Atomic Energy Agency

- Government-funded nuclear research and development institute
- Established in 2005
  (JNC and JAERI merged)
- 3,100 personnel
- 5 R&D sectors
  - ✓ Fukushima
  - ✓ Nuclear Safety Research and Emergency Preparedness
  - ✓ Decommissioning and Radioactive Waste Management
  - ✓ Fast Reactor
  - ✓ Nuclear Science Research

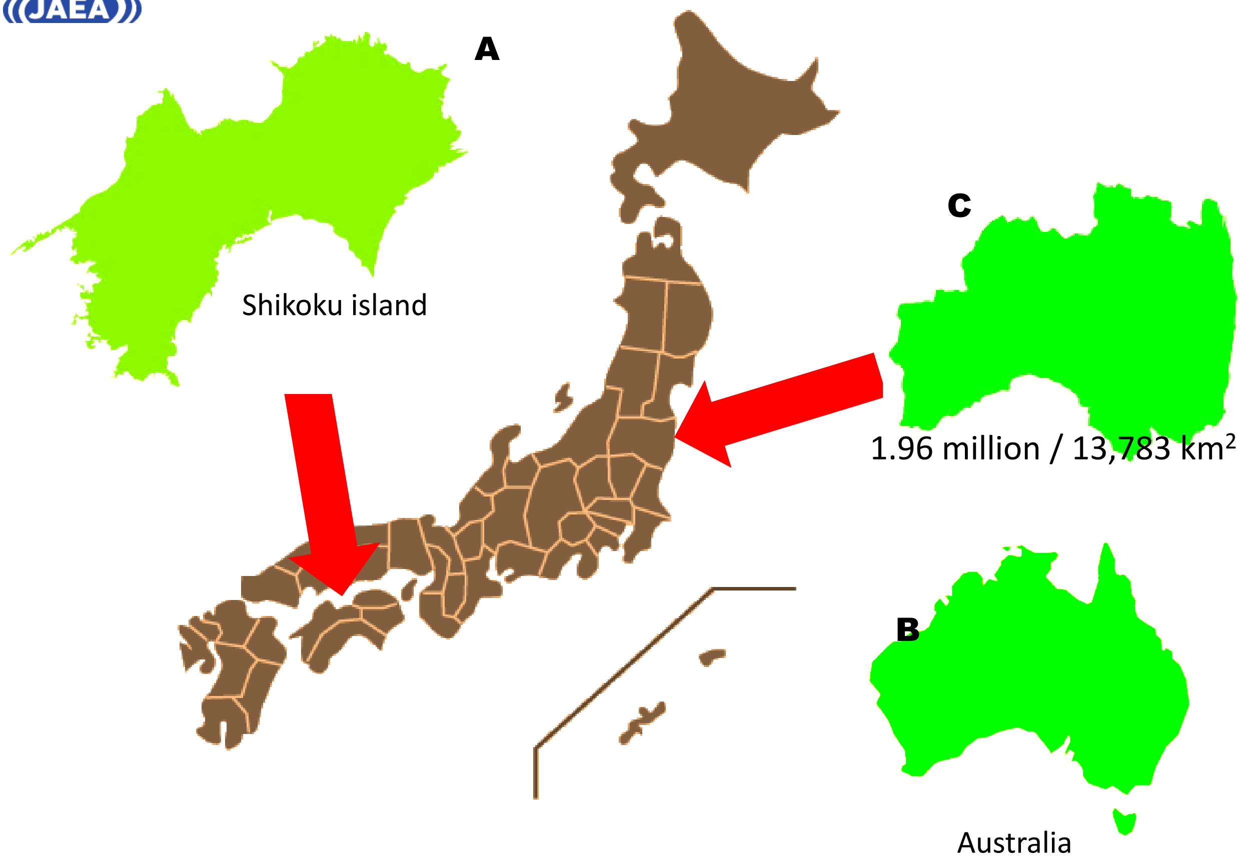


2

Which is Fukushima?



3



4

March 11th, 2011

Hydrogen explosions TEPCO HP

Evacuation

- ✓ Acute external exposure was nil
- ✓ Acute internal exposure was minimal
- ✓ Remained were regional scale of contaminated area and >160 thousand of evacuees
  → required minimization of long-term low-level radiation exposure from $^{134,137}Cs$

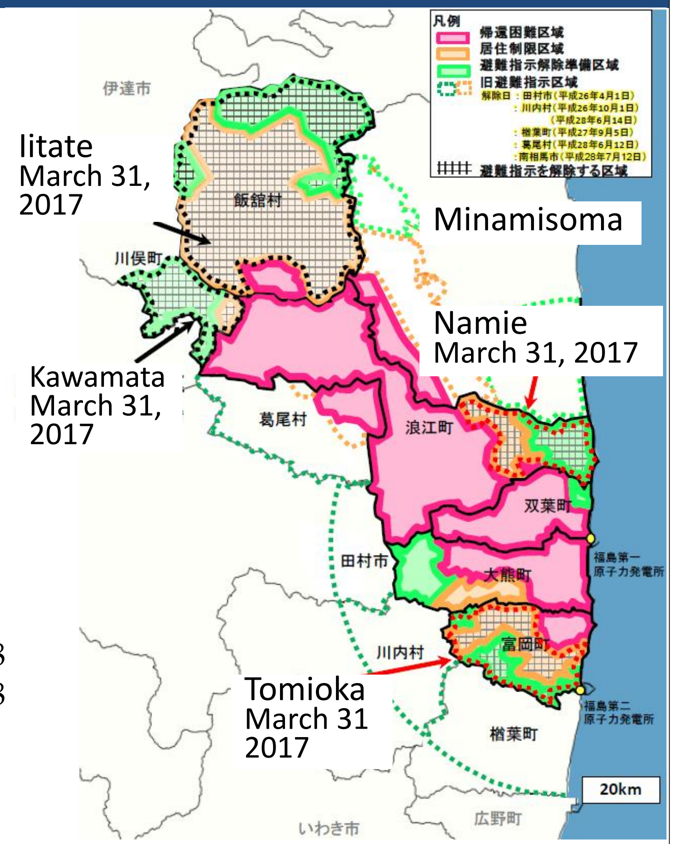
Remediation and living back in order needed

- ✓ Environmental decontamination(Clean-up)
- ✓ Infrastructure rebuilding

5

Evacuation Order

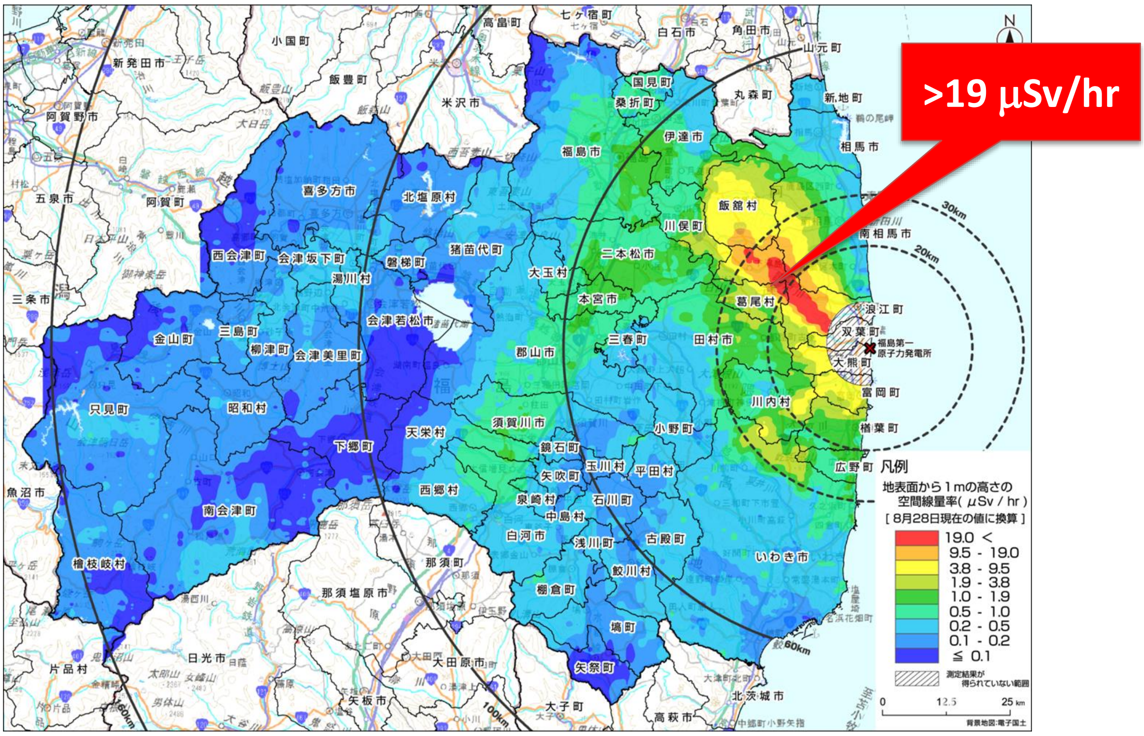
(pink)	Difficult to return
(yellow)	Not permitted to live
(green)	Ready to be lifted



Fukushima evacuees

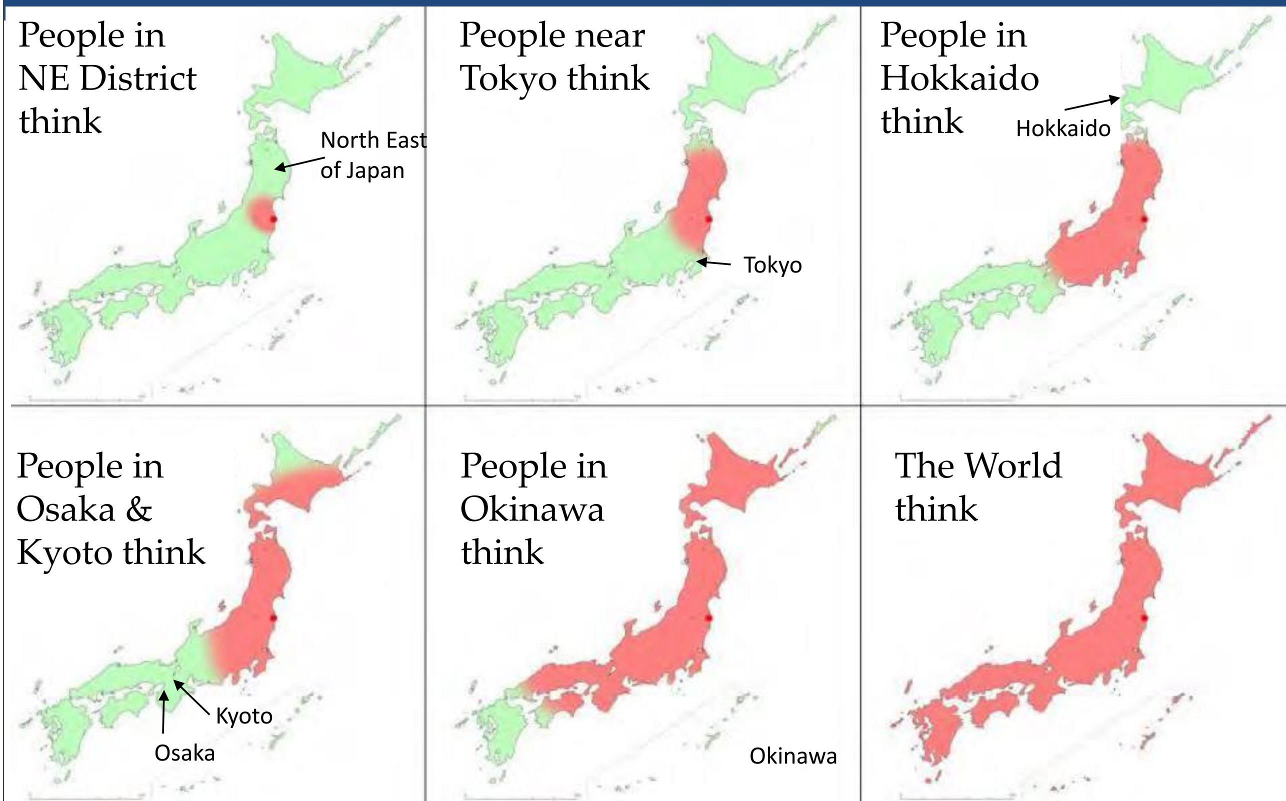
164,865 May 2012		
129,154 June 2014		
79,446 February 2017		
In Fukushima Pref.	39,608	
To outside Fukushima	39,818	

Radioactive Contamination in Fukushima (August 2011)



7

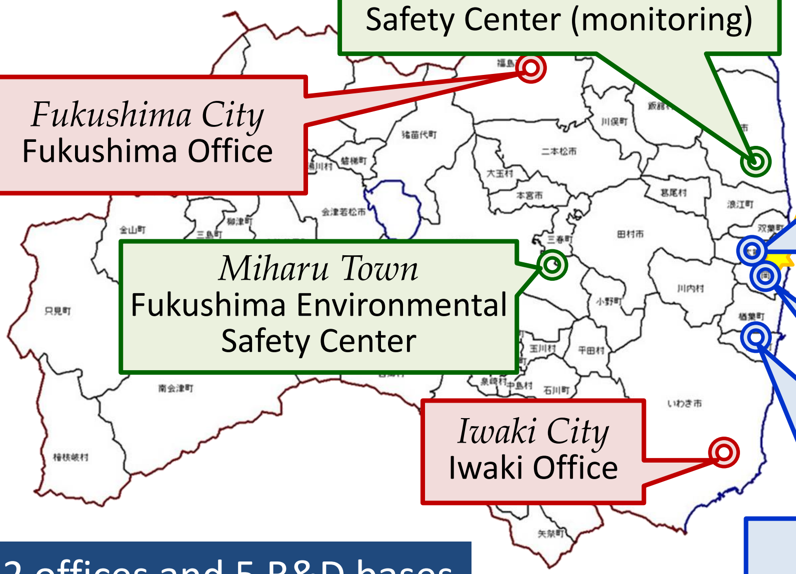
MISCONCEPTION - MY PLACE IS NOT CONTAMINATED -



http://www.yukawanet.com/archives/3930193.html

8

JAEA R&D Base in Fukushima
"Offsite" and "Onsite"



Minamisoma City
Fukushima Environmental Safety Center (monitoring)

TEPCO Holdings
Fukushima Daiichi NPS

Fukushima City
Fukushima Office

Okuma Town
Okuma Analysis and Research Center
Under construction

Miharu Town
Fukushima Environmental Safety Center

Tomioka Town
CLADS - Collaborative Laboratories for Advanced Decommissioning Science

Iwaki City
Iwaki Office

Naraha Town
Naraha Remote Technology Development Center

2 offices and 5 R&D bases
300 staff in Fukushima

9

Decommissioning R&D
Naraha – CLADS - Okuma

Naraha Remote Technology Development Center

Development of
- tele-operated and remote sensing technical tools,
- training tools for decommissioning workers, and
- emergency responding robots

CLADS - Collaborative Laboratories for Advanced Decommissioning Science (in Tomioka)

Core of JAEA's R&D,
- acting as both an international research hub and a symbol of the shared international interest
- (OECD/NEA News Bulletin)
- strongly linked with Naraha Center and Okuma Center

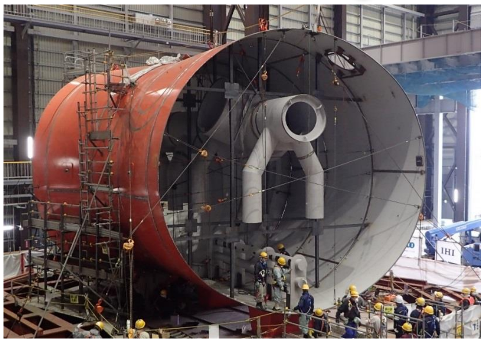
Okuma Analysis and Research Center
(to be opened 2021)

Characterization of radioactive wastes and fuel debris, for radioactive waste management, and necessary R&D

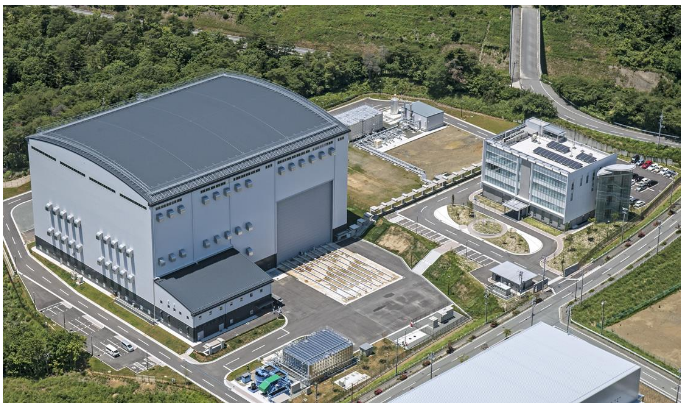
Naraha Remote Technology Development Center (1/3)

- JAEA's R&D base in cooperation with academia and industries
- Launched in autumn 2015,
- 38 users (JFY 2016) and more than 8,000 visitors since the opening

IRID Full-scale Plug Test



1/8 portion of Suppression Chamber

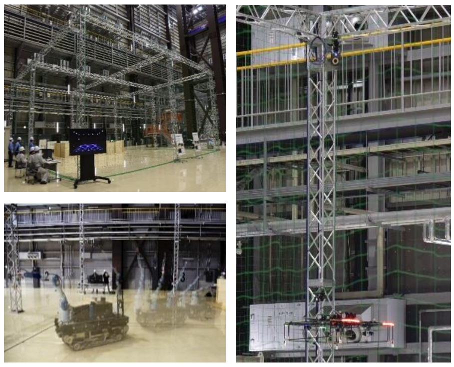


Mock-up stairs

IRID: International Research Institute for Nuclear Decommissioning

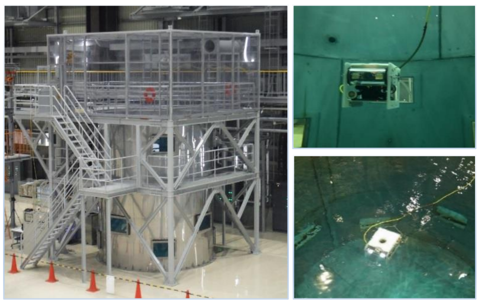
11

Naraha Remote Technology Development Center (2/3)



Motion capture studio
(equipped with 16 tracking cameras)

Virtual Reality system, 1F reactor data incorporated, for
- **operator training**
- **robot simulator**



Robot testing water tank

12

Naraha Remote Technology Development Center (3/3)
- Education &Training for Decommissioning -

Decommissioning Robot Competition

13 colleges competed

organized by
National Institute of Technology, Fukushima College

funded by
MEXT
(December 3, 2016)

Robotics Summer School

The University of Tokyo

funded by MEXT
(August 8-10, 2016)

13

DECOMMISSIONING R&D
NARAHA – CLADS - OKUMA

Naraha Remote Technology Development Center

Development of
- tele-operated and remote sensing technical tools,
- training tools for decommissioning workers, and
- emergency responding robots

CLADS - Collaborative Laboratories for Advanced Decommissioning Science (in Tomioka)

Core of JAEA's R&D,
- acting as both an international research hub and a symbol of the shared international interest
- (OECD/NEA News Bulletin)
- strongly linked with Naraha Center and Okuma Center

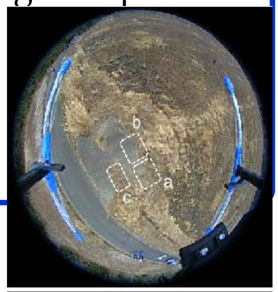
Okuma Analysis and Research Center
(to be opened 2021)

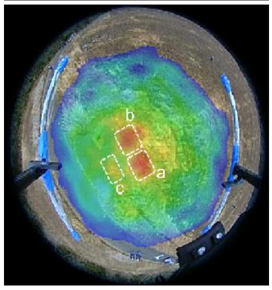
Characterization of radioactive wastes and fuel debris, for radioactive waste management, and necessary R&D

CLADS TOMIOKA

Research: R&D topics includes

- PCV dose rate evaluation
- Laser-based *in-situ* remote analysis
- Radioactive Particle Characterization
- Radiation Imaging using Compact Compton Camera mounted Drone
- BWR core degradation behavior investigation





Human Resource Development through R&D

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

DECOMMISSIONING R&D NARAHA – CLADS - OKUMA

Naraha Remote Technology Development Center

Development of

- tele-operated and remote sensing technical tools,
- training tools for decommissioning workers, and
- emergency responding robots

CLADS - Collaborative Laboratories for Advanced Decommissioning Science (in Tomioka)

Core of JAEA's R&D,

- acting as both an international research hub and a symbol of the shared international interest
- (OECD/NEA News Bulletin)
- strongly linked with Naraha Center and Okuma Center

Okuma Analysis and Research Center

(to be opened 2021)

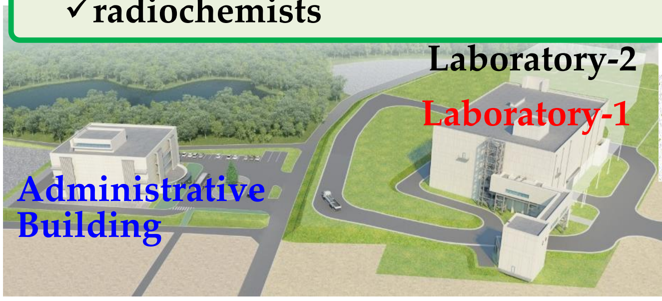
Characterization of radioactive wastes and fuel debris, for radioactive waste management, and necessary R&D

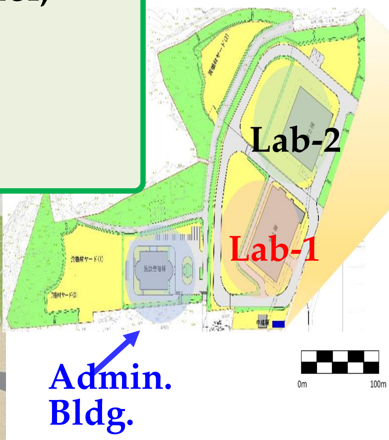
Okuma Analysis and Research Center

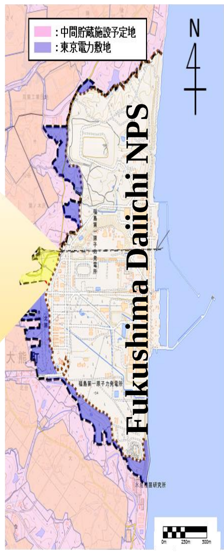
Under construction Fully open in JFY 2021

- first large scale hot laboratory constructed in Japan to deal specifically with post-accident radioactive wastes (> 1Sv/h @ surface) and fuel debris,
- world unique facility specific to severely-damaged nuclear reactors
- 300 workers including facility operators, engineers, analysis technicians and radiochemists

- plays an essential role in terms E&T/human resource development for;
  - ✓hot facility construction,
  - ✓hot facility maintenance,
  - ✓analysis technicians, and
  - ✓radiochemists







17

Distribution of Radionuclides nearby the Fukushima Daiichi Nuclear Power Station (FDNPS)

Fukushima Environmental Safety Center
Japan Atomic Energy Agency (JAEA)

Terumi DOHI

F - TRACE PROJECT
LONG-TERM ASSESSMENT OF TRANSPORT OF RADIOACTIVE CONTAMINANT IN THE ENVIRONMENT OF FUKUSHIMA
福島長期環境動態研究プロジェクト

JAEA

EAFORM 2017
27 November 2017 Osaka, Japan

Outline

F - TRACE PROJECT 2

1. Background
- Regional contamination and Waste management challenge
- Radiocaesium (Cs) distribution in the Fukushima Prefecture
- Background and Objective of the F-TRACE project

2. Researches on transport behavior of Cs in
- Forest and River system

3. Predicitive modeling
- Mechanistic approaches
- Radiocesium behavior in the Ukedo river system

4. Summary

Outline

1. Background

- Regional contamination and Waste management challenge
- Radiocaesium (Cs) distribution in the Fukushima Prefecture
- Background and Objective of the F-TRACE project

2. Researches on transport behavior of Cs in

- Forest and River system

3. Predicitive modeling

- Mechanistic approaches
- Radiocesium behavior in the Ukedo river system

4. Summary

For Revitalization of Fukushima…

Understanding of the Cs Contamination status in the living sphere

Source

- Where is the contaminated place especially ?
- What is the characteristics of Cs contamination ?
- How and When do the contaminants migrate ? (contaminant behavior)

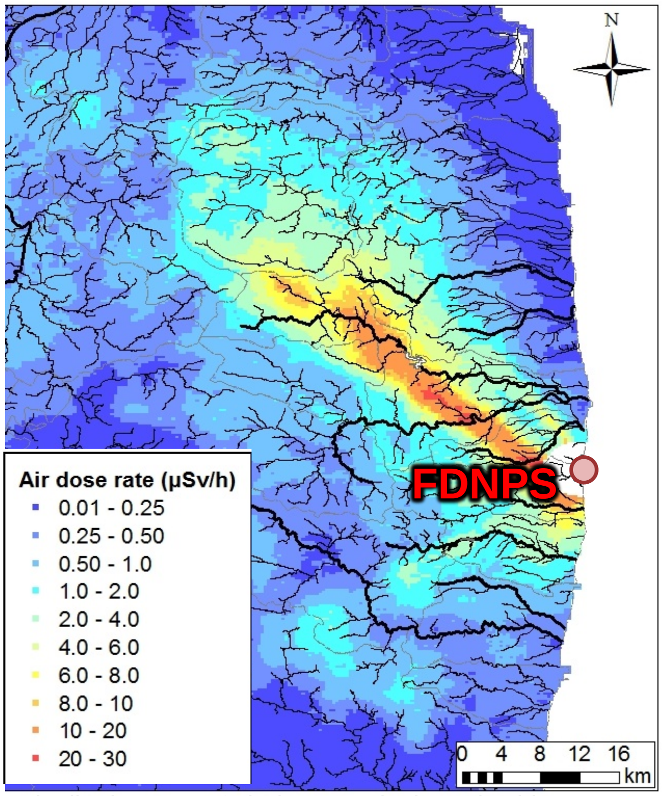
Determination of decontamination place and method

- Based on the Decontamination Pilot Project

Understanding of the kind of waste and their amount

Waste treatment and final disposal

Regional contamination (Development of decontamination)



Distribution map of air dose rate in the Fukushima prefecture. (measured from the 1st Sept. to the 7th Nov. 2014 by NRA and corrected to the 7th Nov. 2014)

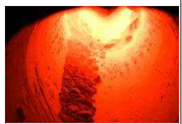
JAEA, The report of decontamination project in evacuation zone. (2012)

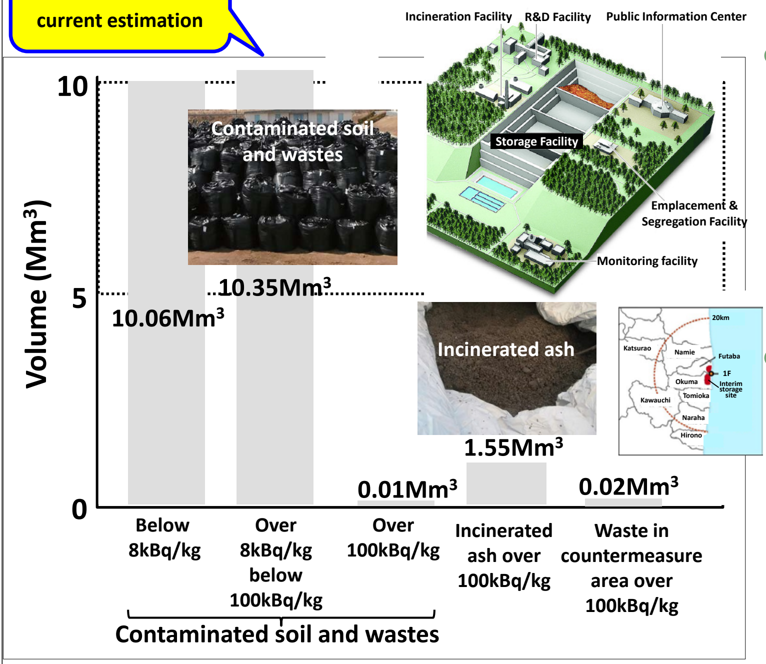
Waste Management Challenges

Soils & wastes → Volume Reduction → Cs removed or reduced materials → Reuse

Soils & wastes → Volume Reduction → Cs accumulated materials → Final disposal

16~22Mm³ current estimation





- Clean-up efforts are generating huge volumes of contaminated soil and waste, which must be managed in a safe and cost-effective manner, wherever possible implementing waste volume reduction
- Future reuse of soil for construction purposes is an important option, if constraints in terms of allowable organic and clay content can be managed

How to Enhance Fukushima Environmental Resilience

F - TRAC 7
PROJECT

- Address the needs for better scientific and technological capabilities to assess, predict, and minimize the impact of radiological contamination
- Enhance the understanding of radiation and associated risks in the public

Kai Vetter, 2015

The concept of Resilience ;
The ability to recover from or more successfully adapt to adverse events

7

Fukushima people concern about…

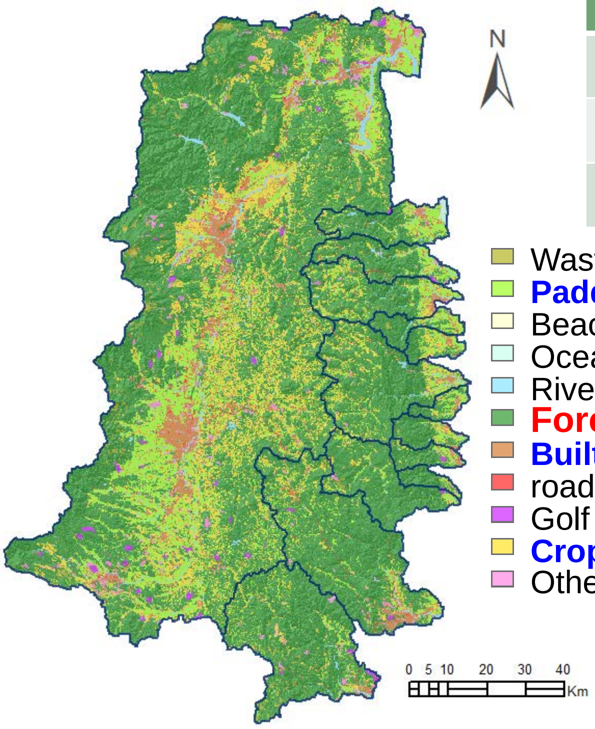
F - TRAC 8
PROJECT

- Where is the Cs contaminated places in the living sphere ?
- Will the Cs contaminants move to their living area in the future ?
- Will the Cs contaminants redistribute despite a decontamination ?

Initial Cs distribution: Forests occupied the most

F-TRACE PROJECT 9

Land use	Area (km²)	Initial Cs (TBq)
Forest	5,330	920
Total	8,370	1,300
Forest%	64%	**69%**



- Wasteland
- **Paddy field (14%)**
- Beach
- Ocean
- River and Lake
- **Forest (64%)**
- **Built-up area (5%)**
- road / railways
- Golf field
- **Crop field (10%)**
- Other land use

revised Kitamura et al., *Anthropocene* (2014).

JAEA website
https://fukushima.jaea.go.jp/QA/ftrace/QA3-1f.html

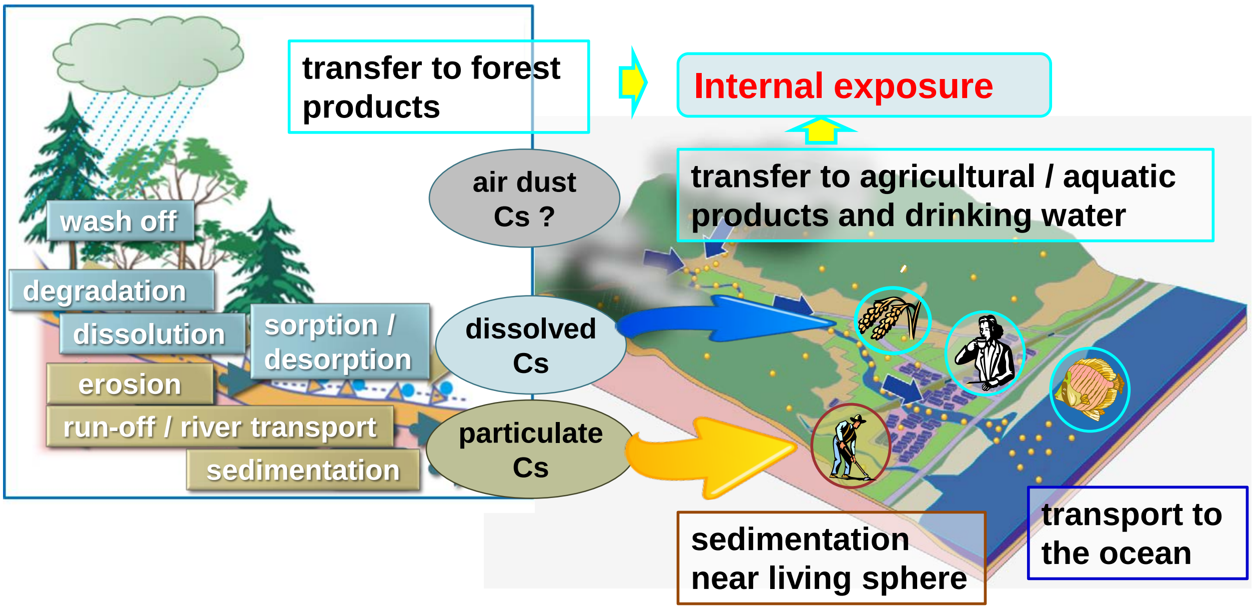
Land use distribution in eastern Fukushima

Background of the project

F-TRACE PROJECT 10

Redistribution and evolution of concentration of radioactive Cs

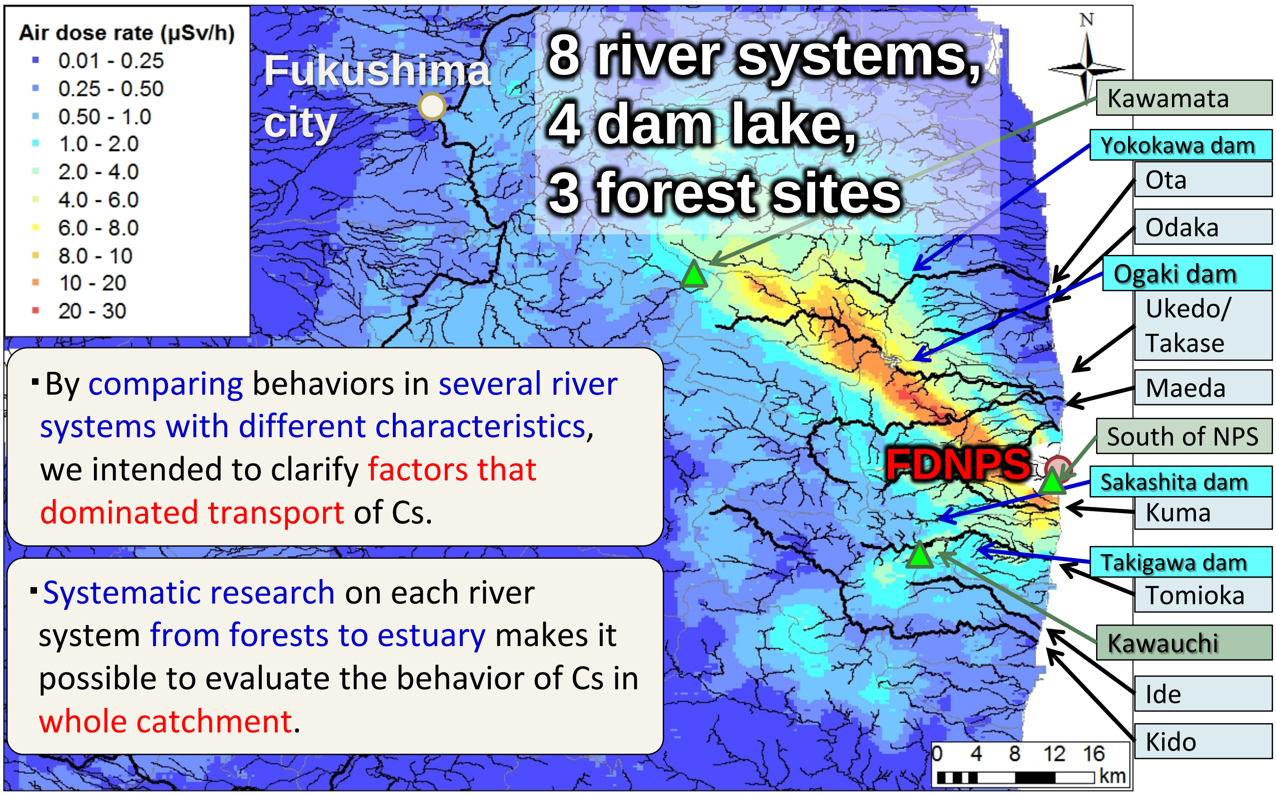
Consequence of redistribution and evolution



accumulation in forests near living sphere

External exposure

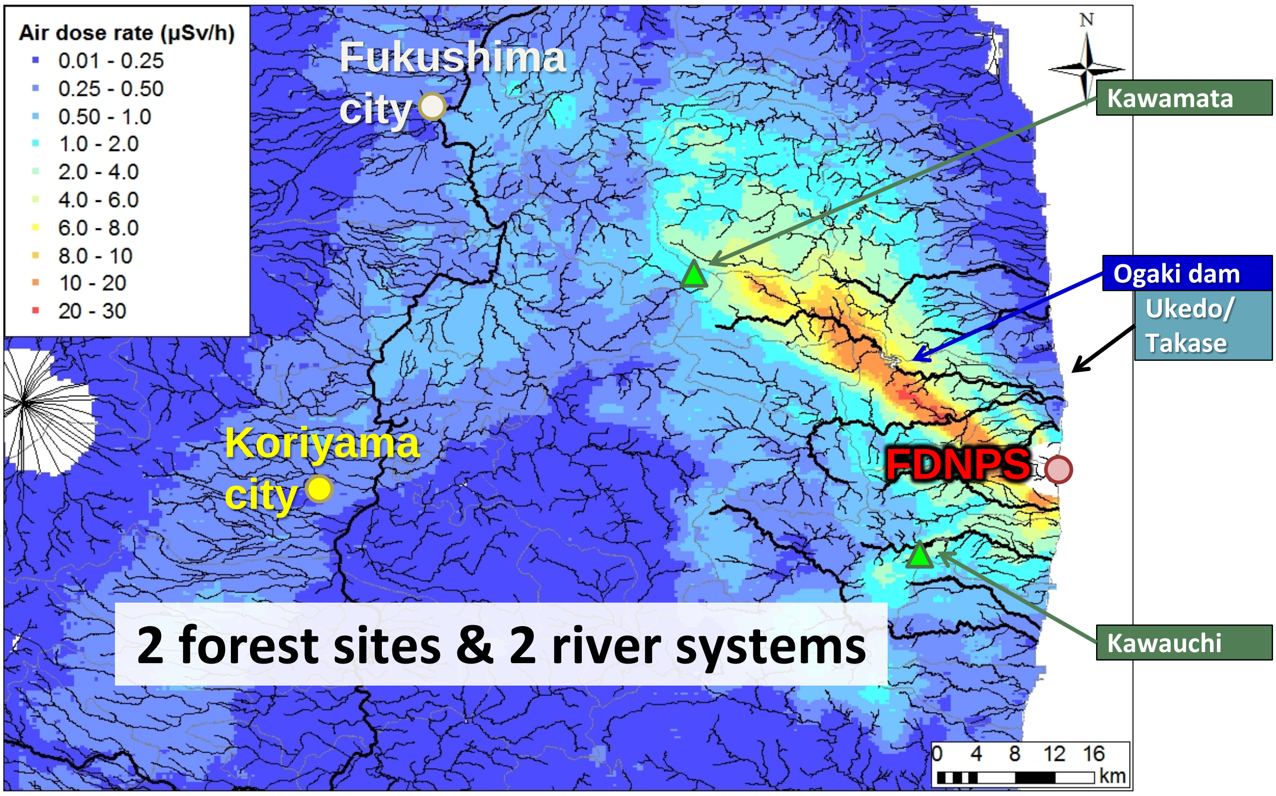
Research area



- By comparing behaviors in several river systems with different characteristics, we intended to clarify factors that dominated transport of Cs.
- Systematic research on each river system from forests to estuary makes it possible to evaluate the behavior of Cs in whole catchment.

Distribution map of air dose rate in the Fukushima prefecture.
(measured from the 1st Sept. to the 7th Nov. 2014 by NRA and corrected to the 7th Nov. 2014)

Research area reported in this presentation



Distribution map of air dose rate in the Fukushima prefecture.
(measured from the 1st Sept. to the 7th Nov. 2014 by NRA and corrected to the 7th Nov. 2014)

Outline

F-TRACE PROJECT 13

1. Background

- Regional contamination and Waste management challenge
- Radiocaesium (Cs) distribution in the Fukushima Prefecture
- Background and Objective of the F-TRACE project

2. Researches on transport behavior of Cs in

- Forest and River system

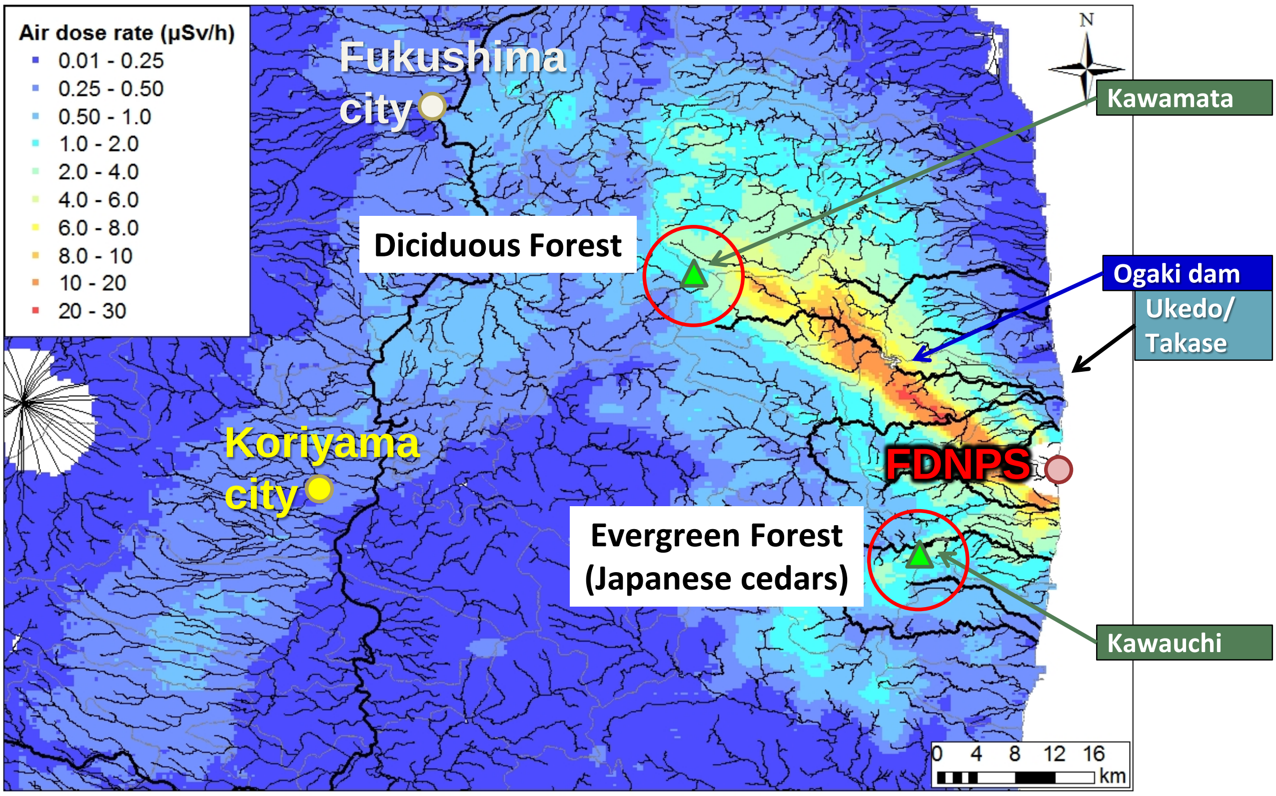
3. Predicitive modeling

- Mechanistic approaches
- Radiocesium behavior in the Ukedo river system

4. Summary

Research area reported in this presentation

F-TRACE PROJECT 14

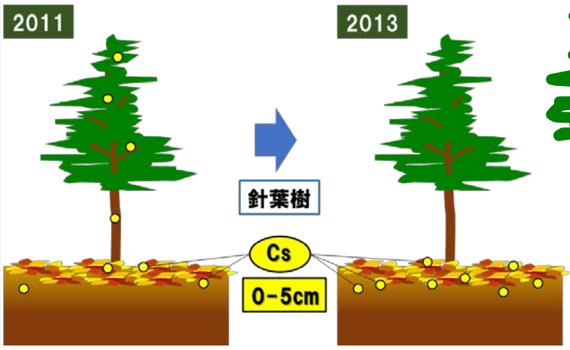


Distribution map of air dose rate in the Fukushima prefecture.
(measured from the 1st Sept. to the 7th Nov. 2014 by NRA and corrected to the 7th Nov. 2014)

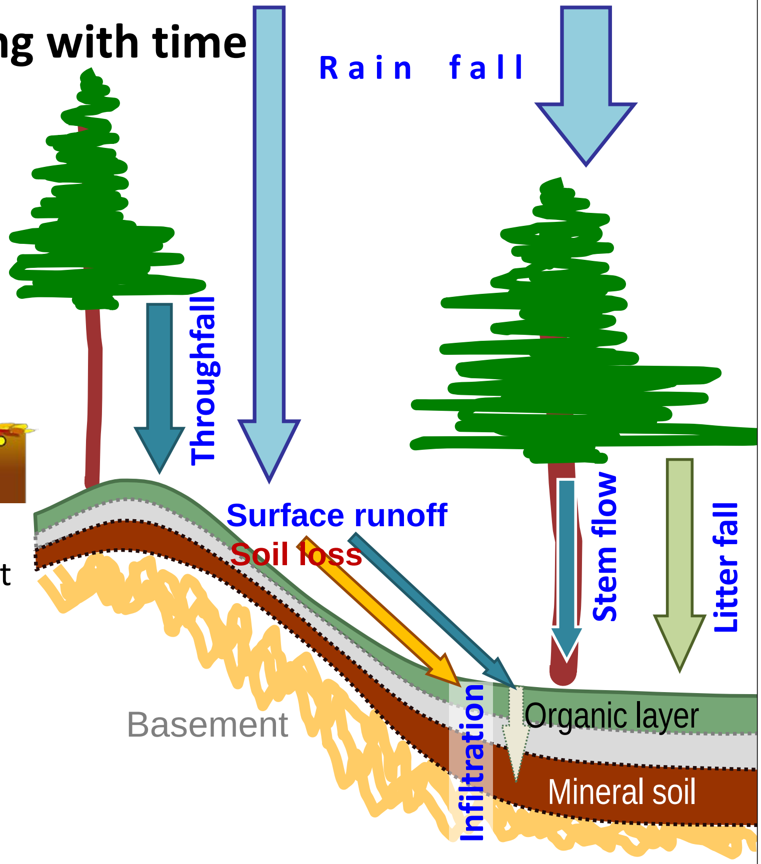
Cs transport processes in forests

15

Cs moves downward along with time

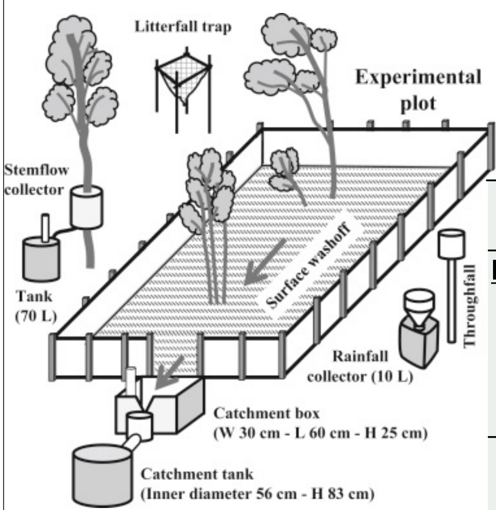


The investigation result of caesium distribution in the forest (Press release (2014.4.1) by ministry of agriculture, forestry and fisheries of Japan)



Water, litter and soil movement

16



T. Niizato et al., *J. Environ. Radioact.*, 161, 11-21 (2016).

Cs-137 wash-off rate accompanied by the particulate matter.

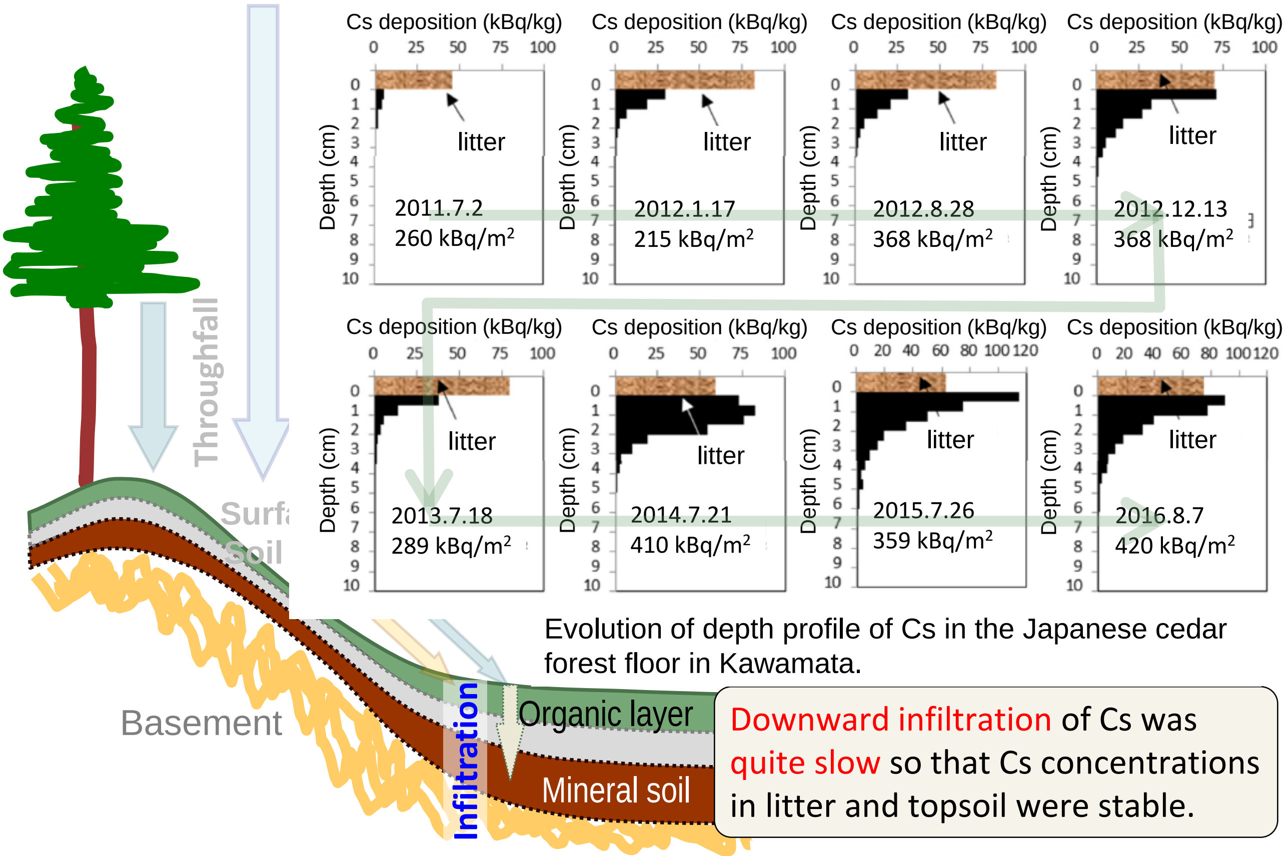
	2013 (duration)	2014 (duration)	2015* (duration)	2016 (duration)
Kawauchi (KA) Evergreen (Japanese cedar) ***Steep*** slope	**0.10%** (6.10-11.18)	**0.06%** (4.11-10.8)	**0.30%** (6.24 - 10.28)	**0.04%** (6.16 - 11.28)
Kawamata (KE) Deciduous **Gentle** slope	**0.02%** (3.29-11.19)	**0.10%** (4.7-10.20)		
Kawamata (KW) Deciduous ***Steep*** slope	**0.05%** (6.28-11.19)	**0.11%** (4.7-10.20)	**0.23%** (6.30 - 11.5)	**0.02%** (6.15 - 11.29)

*New observation plot was set up.

reivised T. Niizato et al., *J. Environ. Radioact.*, 161, 11-21 (2016).

Wash-off rates were quite low in all observation areas.

Water, litter and soil movement



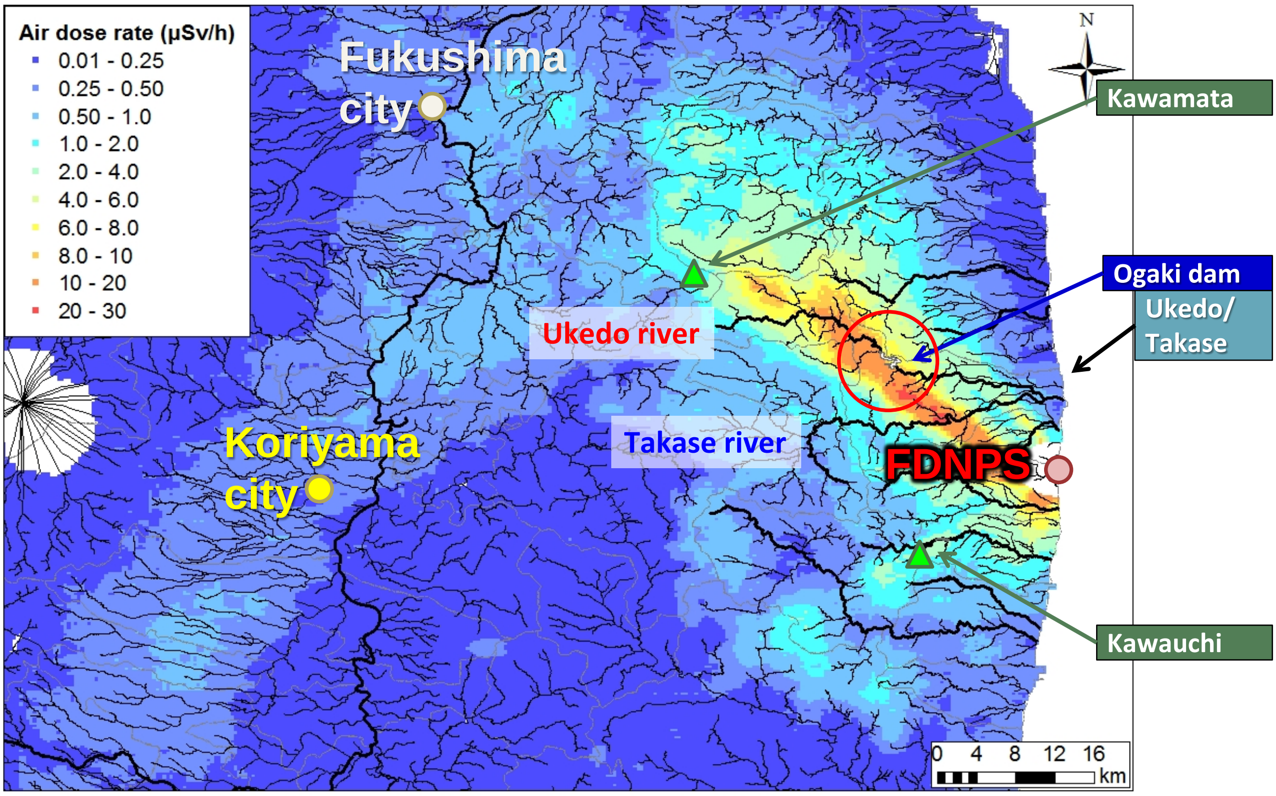
Evolution of depth profile of Cs in the Japanese cedar forest floor in Kawamata.

Downward infiltration of Cs was quite slow so that Cs concentrations in litter and topsoil were stable.

Y. Onda, results of commissioned study by JAEA

Consequently, Cs tends to be preserved on the forest floor and cycled in the forest ecosystem.

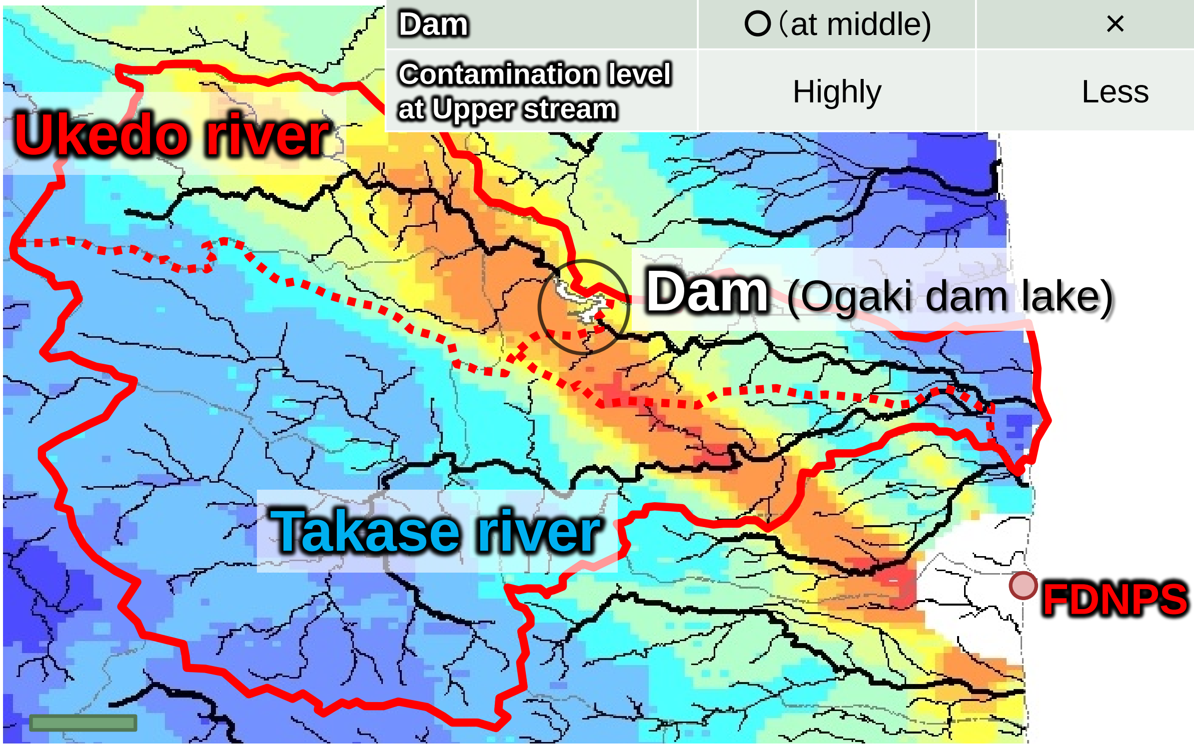
Research area reported in this presentation



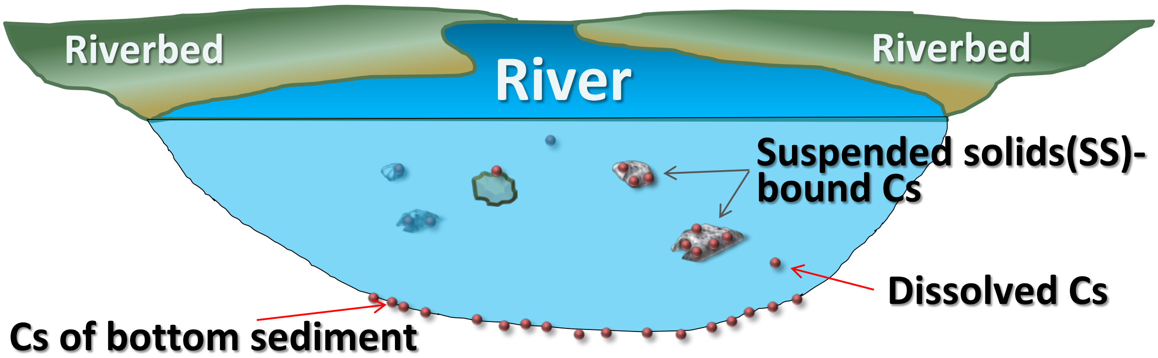
Distribution map of air dose rate in the Fukushima prefecture.
(measured from the 1st Sept. to the 7th Nov. 2014 by NRA and corrected to the 7th Nov. 2014)

Transport in river system: Ukedo/Takase river

	Ukedo river	Takase river
Dam	○ (at middle)	×
Contamination level at Upper stream	Highly	Less

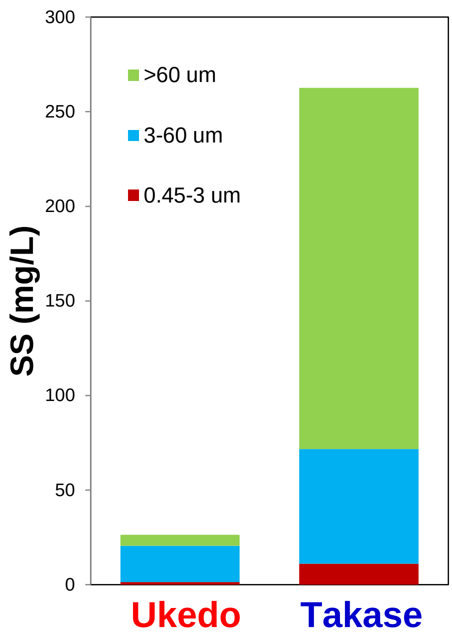


Cs in river system



Comparison of behavior in rivers with/without dam

SS (left) and radiocesium (right) concentration in lower Ukedo (with dam) and Takase (without dam) river waters in the typhoon in 2013.



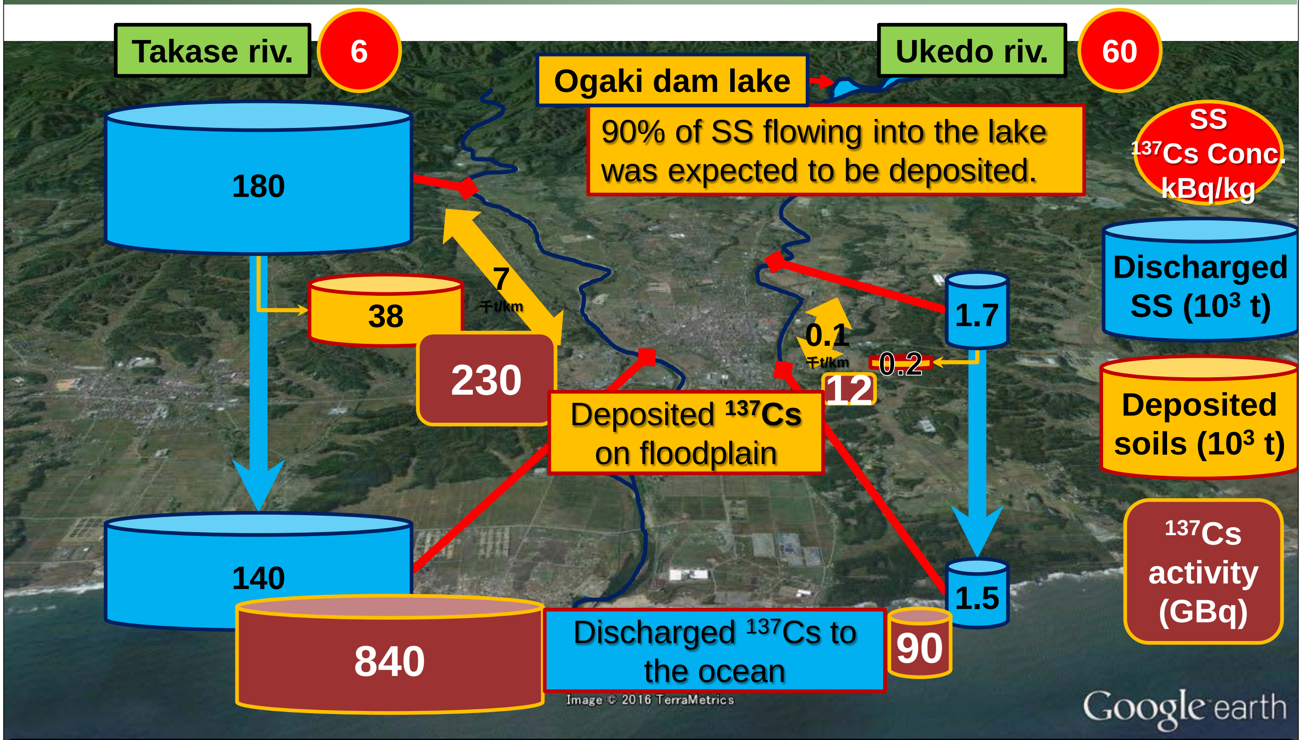
(Bq/L)	Ukedo	Takase
Dissolved ^{137}Cs	0.31 ±0.03	0.05 ±0.02
SS-bound ^{137}Cs	2.2 ±0.2	2.1 ±0.1
$^{134+137}Cs$	3.3	2.9

- ✓ SS: Ukedo << Takase
  - ✓ SS supplied upstream did not reach to lower Ukedo river due to the presence of the dam.
- ✓ Dissolved Cs: Ukedo > Takase
  - ✓ Higher Cs fallen out along mountain streams was brought.

JAEA website
https://fukushima.jaea.go.jp/QA/ftrace/QA4-1-3-2.html

Stock and flow of Cs at the high water event in Sept. 2015

F-TRACE PROJECT 23

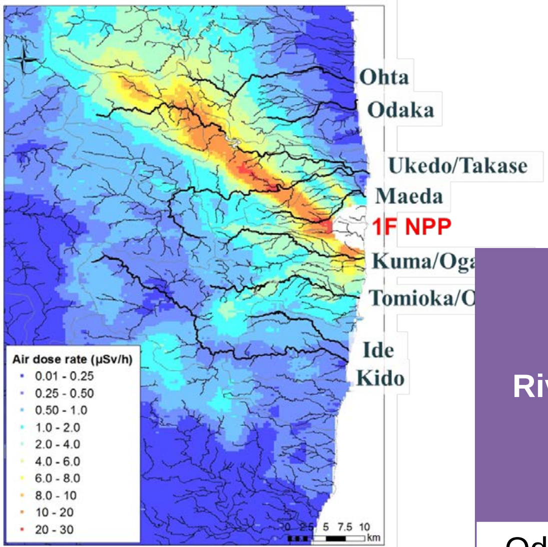


✓ In spite of highly contaminated upper, smaller amount of Cs was discharged to the ocean from Ukedo river than Takase river due to deposition in Ogaki dam lake.

JAEA website https://fukushima.jaea.go.jp/initiatives/cat01/pdf1702/hokokukai11.pdf

Cs discharged to the ocean in FY 2015

F-TRACE PROJECT 24



✓ Discharge rates of Cs to the ocean were extremely low, especially in rivers with dams.

Estimated amount of discharge

	River	Annual discharge Amount (TBq)	Annual discharge Ratio to initial deposition	Discharge at the high water event on Sept. Amount (TBq)	Discharge at the high water event on Sept. Ratio to annual discharge
	Odaka	0.074	0.5 %	0.053	72 %
with dam ⇨	Ukedo	0.22	0.1 %	0.090	48 %
	Takase	1.2	0.4 %	0.84	79 %
	Maeda	0.057	0.1 %	0.035	73 %
	Kuma	0.31	0.5 %	0.23	79 %
with dam ⇨	Tomioka	0.022	0.1 %	0.013	58 %

JAEA website https://fukushima.jaea.go.jp/initiatives/cat01/pdf1702/hokokukai11.pdf

Outline

1. Background

- Regional contamination and Waste management challenge
- Radiocaesium (Cs) distribution in the Fukushima Prefecture
- Background and Objective of the F-TRACE project

2. Researches on transport behavior of Cs in

- Forest and River system

3. Predicitive modeling

- Mechanistic approaches
- Radiocesium behavior in the Ukedo river system

4. Summary

Mechanistic approach

Suspended solid C_j (kg·m^{-3})

$$A\frac{dC_j}{dt}+UA\frac{dC_j}{dx}=\underbrace{\frac{d}{dx}\left(\varepsilon_X A\frac{dC_j}{dx}\right)}+\underbrace{Q_{Sj}-Q_lC_j}+\underbrace{B(S_{Rj}-S_{Dj})}$$

advection dispersion inflow/outflow sedimentation/resuspension

Dissolved Cs G_w (Bq·m^{-3})

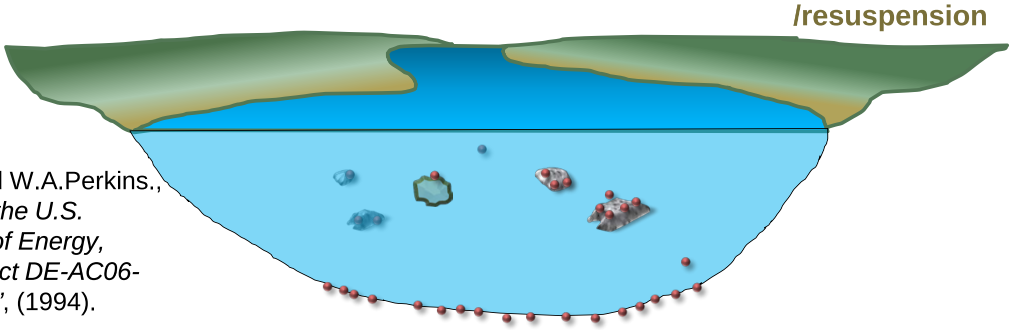
$$A\frac{dG_w}{dt}+UA\frac{dG_w}{dx}=\underbrace{\frac{d}{dx}\left(\varepsilon_X A\frac{dG_w}{dx}\right)}\underbrace{-\lambda AG_w}\underbrace{-Q_lG_w+Q_w}\underbrace{-\sum_{j=1}^{Nf}AK_j(K_{dj}C_jG_w-G_j)}\underbrace{-\sum_{j=1}^{Nf}B\gamma_j(1-n)d_jK_{bj}(K_{dj}G_w-G_{Bj})}$$

advection dispersion decay inflow/outflow sorption/desorption to SS and river bed

SS-bound Cs G_j (Bq·m^{-3})

$$A\frac{dG_j}{dt}+UA\frac{dG_j}{dx}=\frac{d}{dx}\left(\varepsilon_X A\frac{dG_j}{dx}\right)-\lambda AG_j-Q_lG_j+Q_{Pj}+AK_j(K_{dj}C_jG_w-G_j)+B\left(G_{Bj}S_{Rj}-\frac{S_{Dj}G_j}{C_j}\right)$$

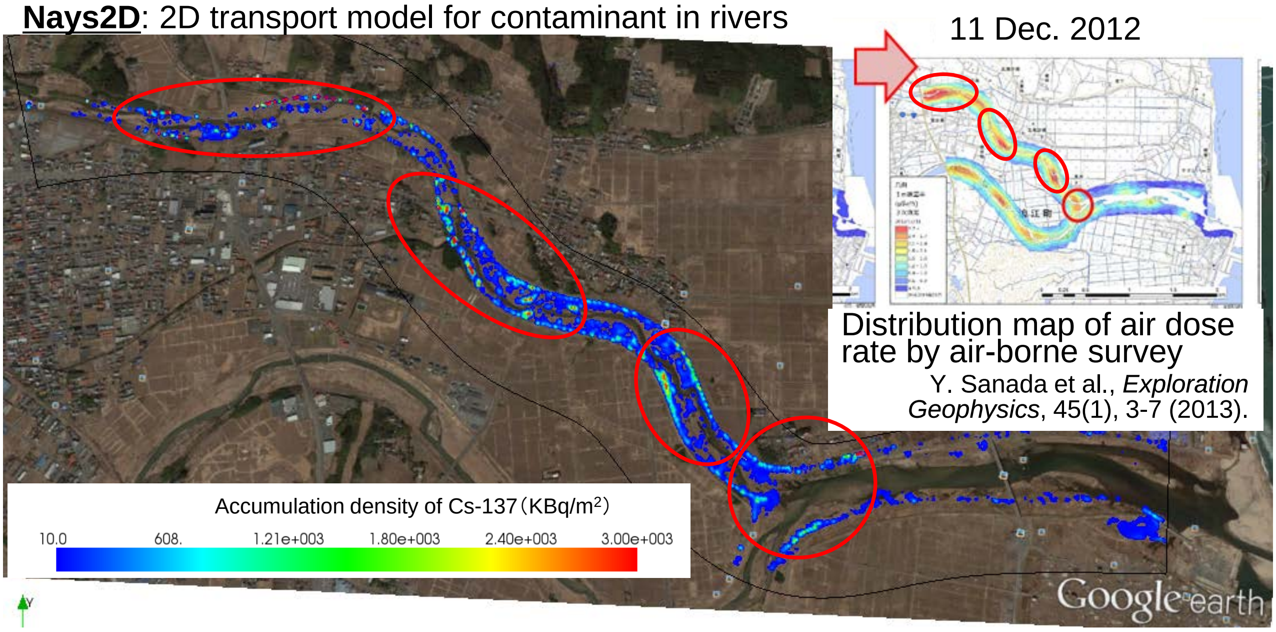
advection dispersion decay inflow/outflow sorption/desorption sedimentation /resuspension



Y. Onishi and W.A.Perkins., *TODAM. In "the U.S. Department of Energy, under Contract DE-AC06-76RLO 1830"*, (1994).

Prediction of Cs sedimentation on the flood plain

Nays2D: 2D transport model for contaminant in rivers



Distribution map of air dose rate by air-borne survey
Y. Sanada et al., *Exploration Geophysics*, 45(1), 3-7 (2013).

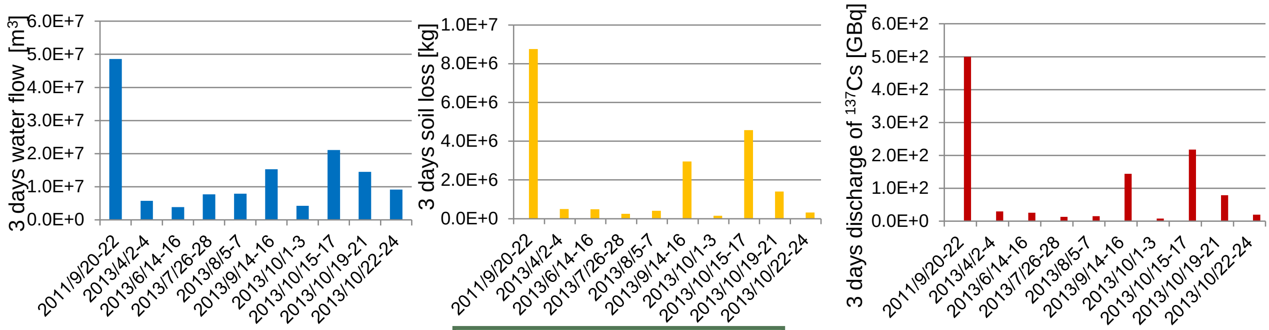
Distribution map of accumulation of Cs in Ukedo river after the typhoon on Sept. 2011.

A. Malins et al., *AGU Fall Meeting* (2015).

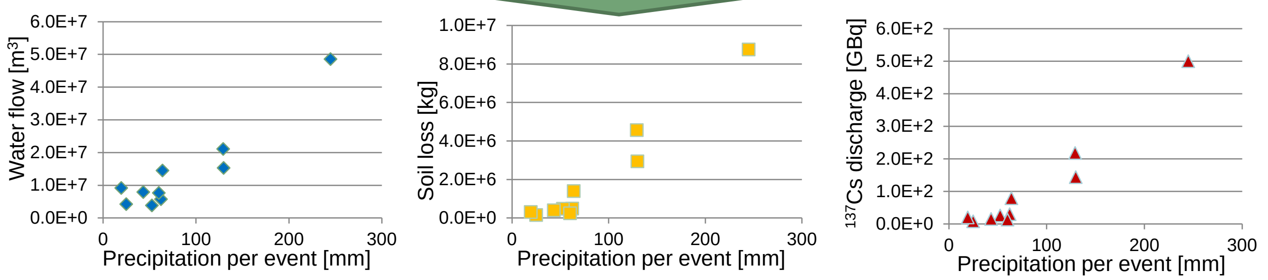
Areas of higher accumulation density of Cs seems good agreement with those of higher air dose rate. => applicable to predict sedimentation behavior.

Prediction of Cs discharge from the river

GETFLOWS (physical model for soil loss and water transportation):
Water flow, soil loss and Cs-137 discharge for 3 days during each high water event.



Relationship to precipitation



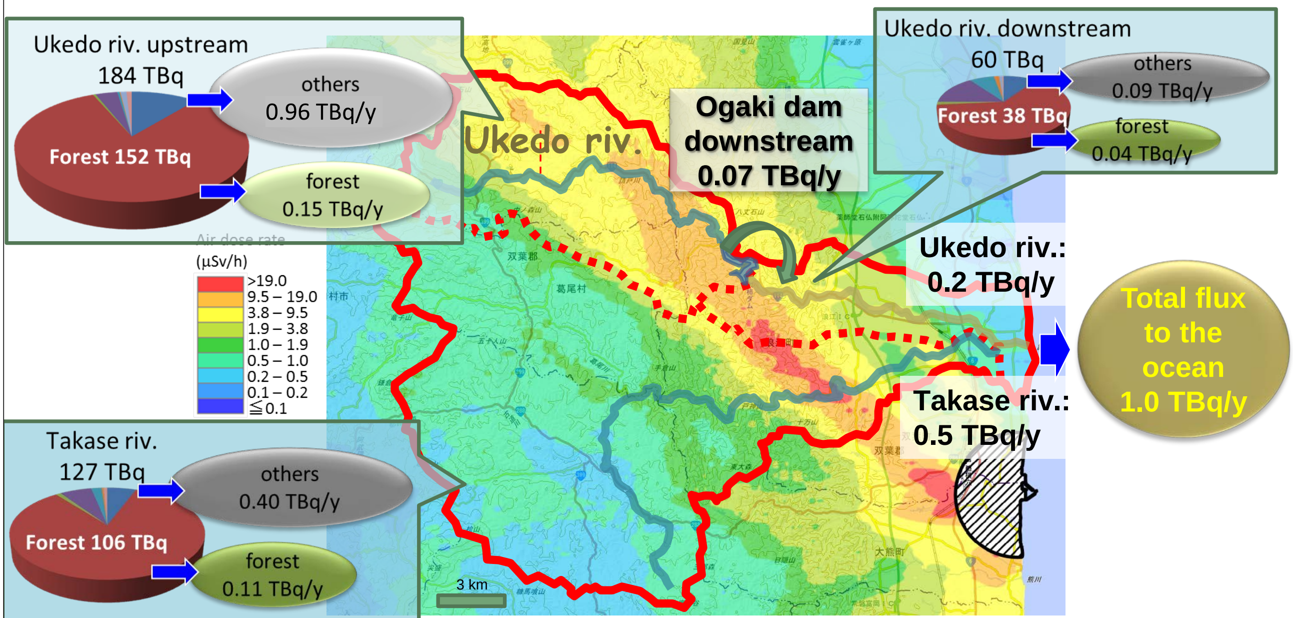
It can be applied to predict the behavior of Cs depending on precipitation.

A. Kitamura et al., *AGU Fall Meeting* (2015).

Estimation of behavior of Cs in the river system

F-TRACE PROJECT 29

- **Stock and flow of Cs in the Ukedo river system can be estimated based on the models, and discharge flux agreed with the observation results.**



Distribution mapping[1)] of air dose rate and overview of flux from each catchment of Ukedo River basin estimated from observation results[2),3),4)] and model calculation[5)].

1) http://ramap.jmc.or.jp/map/map.html (as of 2014/11/7, in Japanese)
2) Ishii et al., *Proceedings of ICONE-23* (2015).
3) Kurikami et al., *J. Environ. Radio.*, 137, 10 (2014).
4) http://fukushima.jaea.go.jp/initiatives/cat03/pdf06/2-4.pdf (in Japanese)
5) Kitamura et al., *Anthropocene*, 5, 22 (2014).

Outline

F-TRACE PROJECT 30

1. Background

- Regional contamination and Waste management challenge
- Radiocaesium (Cs) distribution in the Fukushima Prefecture
- Background and Objective of the F-TRACE project

2. Researches on transport behavior of Cs in

- Forest and River system

3. Predicitive modeling

- Mechanistic approaches
- Radiocesium behavior in the Ukedo river system

4. Summary

Summary

F-TRACE PROJECT 31

- **Forest**
  - Less discharge from forest with soil (<0.1%/y) leads to continuous accumulation of Cs in the forest floor, mostly within 10 cm depth.

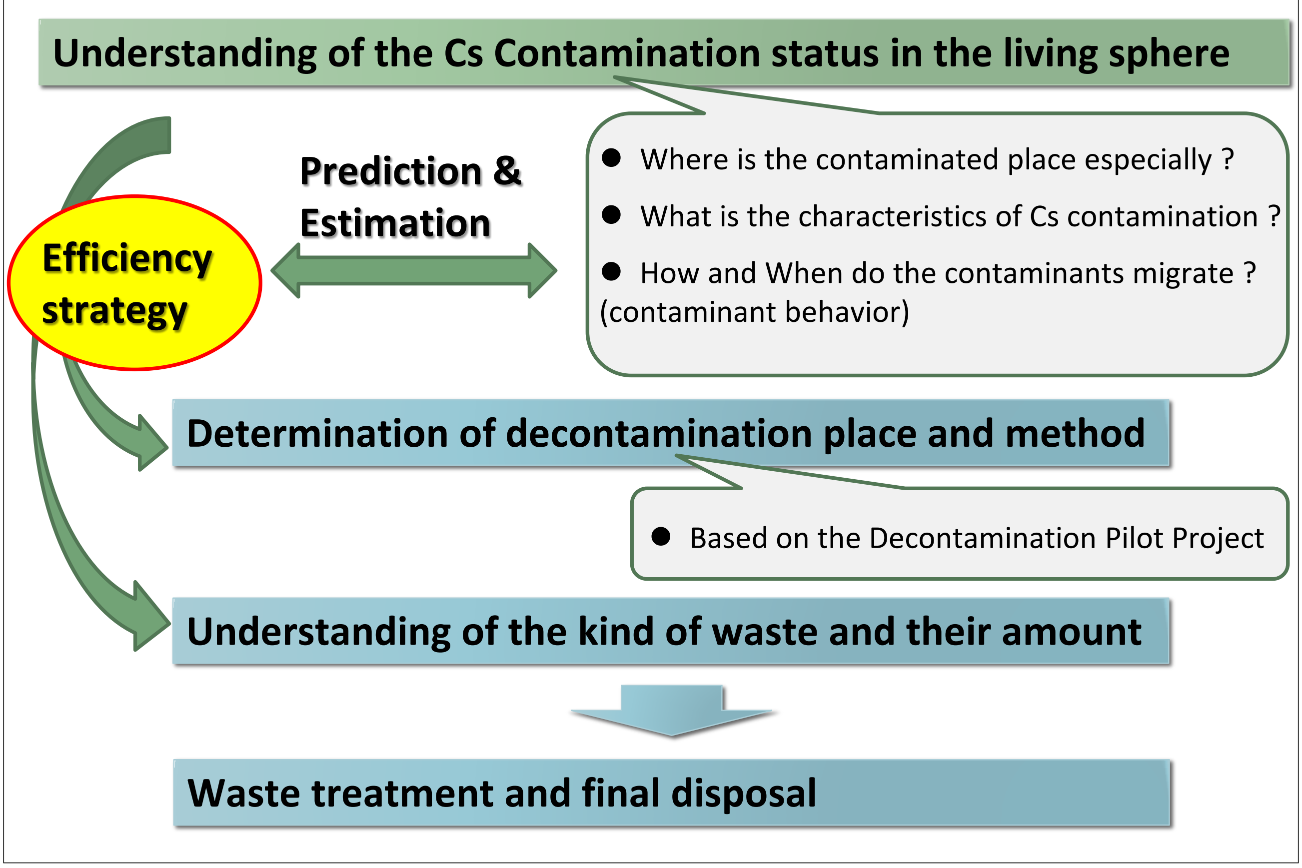
⇒ Further investigation on;
  - generation processes of dissolved Cs,
  - future cycle in the forest, especially to trees, mushrooms, wildlife, etc.

- **River system**
  - Dissolved Cs: <1 Bq/L in all river systems.
  - Discharge to the ocean: 0.1 – 0.5 %/y.
  - Transport of Cs can be predicted.

⇒ Further investigation on;
  - generation and buffering processes of dissolved Cs,
  - future transfer to agricultural and aquatic products.

For Revitalization of Fukushima…

F-TRACE PROJECT 32



Acknowledgement

F-TRACE PROJECT 33

- Regional municipalities gave us opportunities of research in forests, rivers, lakes and estuaries in detail.
  - Minami-soma city
  - Namie town
  - Futaba town
  - Okuma town
  - Tomioka town
  - Naraha town
  - Kawamata town
  - Kawauchi village

Abstracts for the Technical Sessions

* Full-Length Papers for the technical sessions will be uploaded at the following web-site.
http://eaform2017.aesj.or.jp/

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

High-frequency melting technology of radioactive metal waste

Nobutake Horiuchi, Takeshi Nishikawa, Naoto Sasaki and Hirokazu Tanaka

Energy Project & Technology Center
Mitsubishi Materials Corporation
1002-14 Mukoyama, Naka-city, Ibaraki-pref., Japan

Key words; *Melting, radioactive metal scrap, decontamination, volume reduction, recycling*

Abstract

Mitsubishi Materials Corporation has been developing a melting decontamination technology of metal waste by high-frequency melting, for volume reduction, decontamination and recycling of metal scrap contaminated with radioactive materials from nuclear power plants and nuclear facilities. By the melting treatment, high volume reduction of metal waste and decontamination of radionuclides such as cesium, strontium and α nuclides are expected. In addition, the melting process is also suitable for the metal recycling, because the process can homogenize the waste and cast it into any shape.

The boiling point of Cs is lower than the melting point of iron (1,600 deg.-C), so iron-based metal waste can be decontaminated by volatilizing Cs. On the other hand, Sr and α nuclides, such as U, utilize the property that they tend to be more oxide than iron. In the electromagnetic field of the high-frequency induction furnace, since electromagnetic force does not work on oxide, it is ejected to the outward as the metal moves to the center of the furnace. Furthermore, the metal has good homogeneity because molten metal is stirred by electromagnetic forth.

Through development, we confirmed the followings; - the volume of metal waste can be reduced from 1/5 to 1/3 by melting, - the radioactivity concentration of Cs of metal that actually contaminated due to a nuclear accident can be set below the detection limit, - demonstration scale test with simulated substances can decontaminate Cs, Sr and U. In addition, we have been developing manufacturing technology to make the metal waste containers by centrifugal casting method, which was applied to advanced volume reduction facilities of Japan Atomic Energy Agency (JAEA).

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

C-14 release behavior and thermal decomposition characteristics of crud particles collected from the coolant filter of commercial PWR

Shintaro Tsuji[a], Toshikazu Waki[a], Akira Sakashita[b] and Kenichiro Kino[c]

[a] The Kansai Electric Power Co. Inc.
[b] Mitsubishi Heavy Industries, LTD.
[c] Nuclear Development Corporation
[a] 3-6-16 Nakanoshima Kita-ku Osaka-shi, Osaka 530-8270 Japan
[b] 16-5 Konan 2-chome, Minato-ku, Tokyo 106-8215 Japan
[c] 622-12, Funaishikawa, Tokaimura Ibaraki 319-1111 Japan

Key words*; Waste Disposal, Radionuclide migration, Safety assessment, C-14, TG/MS*

Abstract

In the safety assessment of radioactive waste buried repository, it is extremely important to evaluate the migration behavior of long half-life radionuclides in the disposal environment. C-14 is a key radionuclide in waste disposal because of the long half-life (5,730years) and the considerable effect on public exposure due to the less capability of capturing C-14 by artificial barrier material. In addition, C-14 is a radioactive isotope of carbon which forms various chemical forms in the process of its formation, and the migration behavior in the buried environment greatly differs depending on its chemical form.

Some previous studies have reported the generation of insoluble C-14 in pressurized water reactor (PWR), and suggested that ion-exchange resin, which is used for purifying primary coolant, could be its origin. However, this hypothesis has not been well evidenced yet, because the information about the generation mechanism and the chemical form of insoluble C-14 is still limited.

In this study, in order to investigate the chemical form of C-14 contained in radioactive particles generated by PWR, radioactive particles collected from the coolant filter of PWR were analyzed by TG/MS, and the gas released by TG and residual C-14 in the compounds was also analyzed at the same time.

As a result, organic molecules presumed to originate from ion exchange resin were detected from the released gas components, and it was confirmed that 90% or more of C-14 was detected in residual components of heating in the inert gas.

From the results of this study, the chemical form of insoluble C-14 generated by PWR could not be clarified, but it was revealed that the majority of C-14 may exist in amorphous and thermally stable compounds.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

EVALUATION OF CARBON 14 RELEASE FROM IRRADIATED ZIRCALOY FUEL CLADDING THROUGH A LONG-TERM STATIC LEACHING TEST

Hiroyoshi Ueda, Tomofumi Sakuragi, Naoki Fujii and Hitoshi Owada

Radioactive Waste Management Funding and Research Center (RWMC)
Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan

Key words; *geological disposal, spent nuclear fuel, TRU waste, C-14, Zircaloy, corrosion*

Abstract

Zircaloy cladding of the spent nuclear fuel, which is highly activated and contaminated, is expected to be disposed of in a deep underground geological repository, both in the once-through and recycling fuel cycles. Carbon 14 (C-14), mainly originated from the nitrogen impurity in Zircaloy cladding and formed through the 14N(n, p)14C reaction in the reactor, is a typical activation product. In a preliminary performance assessment of the deep geological disposal in Japan, C-14 gave a significant dose impact, which is due to the relatively large inventory, relatively long half-life, i.e. 5730 years, higher release rate and the chemical speciation and consequent migration parameters. In a preliminary Japanese safety case, relatively high IRF (instant release fraction), 20%, was assumed regarding the oxide film formed on the metal surface as a source of the instant release.

With respect to this source term issue, we have prepared an irradiated BWR fuel cladding (Zircaloy-2, average rod burnup of 41.6 GWd/t) which has an external oxide film of 25.3 μm thickness. Although the specific activity in oxide was 2.8 times the base metal activity due to the additional C-14 generation by the 17O(n,α)14C reaction, the C-14 abundance in the oxide was less than 10% of total inventory. A static leaching test using the cladding tube was carried out in an air-tight vessel filled with a deoxygenated dilute NaOH solution (pH of 12.5) at room temperature. After 6.5 years, C-14 was found in each leachate fraction of gas phase and dissolved organics and inorganics, the total of which was less than 0.01% of the entire C-14 inventory of the immersed cladding tube. Both the C-14 abundance and the low leaching rate suggests that C-14 in oxide does not have a significant impact on the IRF in the safety case.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

The Assessments and Comparisons of RASCAL and EPZDose on Atmospheric Dispersion and Dose Consequences in Radioactive Material Release Accidents

Shaohsuan Chen[1,2], Jongrong Wang [1,2], Chunkuan Shih[1,2], YuTing Ku2, Yu Chiang[2], ShaoWen Chen[2] and WenSheng Hsu[3]

[1]: Nuclear and New Energy Education and Research Foundation
[2]: Institute of Nuclear Engineering and Science, National Tsing Hua University
[3]: Nuclear Science & Technology Development Center, National Tsing-Hua University.
No. 101, Section 2, Kuang-Fu Road, Hsinchu, Taiwan 30013, R.O.C.

Key words*; Dose, EPZDose, RASCAL, SBO*

Abstract

RASCAL has been developed by NRC for making dose projections during radiological incidents and emergencies. It evaluates atmospheric releases from nuclear power plants, spent fuel storage pools and casks, fuel cycle facilities, and radioactive material handling facilities. EPZDose is a dose assessment code designed and developed by NTHU. It calculates the dose consequences according to the input time-varying source term and the meteorology conditions and is capable of demonstrating the dose dispersion progress. In this study, we compared the atmospheric dispersion and dose consequences evaluated by RASCAL and EPZDose. First, we used RASCAL to simulate a long term SBO accident for Maanshan NPP and exported the calculated released source term. And then we converted the source term file generated by RASCAL to the input source term format of EPZDose. Finally, We used RASCAL and EPZDose respectively to evaluate the dose consequences of that specific long term SBO accident with the source term under the same postulated meteorology conditions and compared the assessment results of these two codes. The accumulated thyroid dose distribution map at 8 hours and 1 day after the start of release obtained by RASCAL and EPZDose appeared to be very similar. We went further to verify by comparing the dose values derived by the two codes at some specific locations. For example, it showed that, at EPZ boundary of 8 km in downwind direction after 8 hours of release, the difference of accumulated thyroid doses calculated by these two codes is less than 10%. More comparisons will be demonstrated and concluded in the full paper.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Confirmation of appropriate operation condition with Blasting device

Yuuki TSUHARA and Hirotaka IZUKA KANDEN POWER-TECH, Corp.

3-6-2, Bingomachi, Chuou-ku, Osaka, 541-0051, Japan

Shinro HIRANO, Yuji MATSUNAGA, Yasuhiro SUGAHARA
THE KANSAI ELECTRIC POWER CO., INC.NUCLEAR POWER DIVISION
13-8, Goichi, Mihama-cho, Mikata-gun, Fukui, 919-1141, Japan

Yoji KANAMORI
ATOX CO., LTD.
4-11-3, Shiba, Minatoku, Tokyo, 108-0014, Japan

Key words; *decommissioning, decontamination, radioactive waste, Blasting*

Abstract

The decontamination method of metallic waste was considered to reduce the radioactive waste in decommissioning the nuclear power plant. The blasting method is widely known as one of the decontamination techniques. It is necessary to introduce a blasting device that matches the type of metals and the metallic waste volume for each plant.
Stainless steel occupies most for material of system equipment of PWR. The radioactive materials are stuck in the surface in the equipment as metal oxide (e.g. chromium oxide, iron oxide). It is necessary to remove the metal oxides efficiently from the stainless steel with the blasting device.

The type of abrasives, the blasting velocity and the blasting angle as blasting operation condition were tested and confirmed abrade condition stainless steel. The type of abrasives, the blasting velocity and the blasting angle were selected as the appropriate operation conditions from the test results. And the next, the decontamination test using contaminated samples was performed under the appropriate operation conditions. The metallic radioactive waste was confirmed to be able to decontaminate to the clearance level from the decontamination test results.

Session 1B-3

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Development of In-situ Radioactivity Inspection System for radioactive waste and decontamination system using microalgae

Sujung Min[1], Dohyung Kim[1], Woyoung Kim[1], Sheunghyun Ha[1], San Chae[1], Jongman Lee[2] and Unjang Lee[1]

ORIONENC Co., Ltd.
#305, 37, Seongsui-ro 22-gil, Seongdong-gu, Seoul, 133-832, Korea[1],

Korea Research Institute of Standards and Science
267, Gajeong-ro, Yuseong-gu, Daejeon, Republic of Korea[2]

Key words; *Decommissioning, Microalgae, Inspection, Decontamination, Radioactivity*

Abstract

In 2011, Fukushima nuclear power plant accident in Japan caused contamination of lakes and rivers due to radioactive materials released. As time passes, the radioactivity of contaminated water has been lowered, but there is still some level of radioactive contamination. And, concerns about nuclear safety have been raised globally.

At present, decontamination of radioactive contaminated water uses methods of removing radioactive materials in polluted water by using resin or filter. These conventional decontamination methods can lower the radioactive concentration of contaminated water to a certain level. However, it is difficult to reduce the amount of contaminated water to a level lower than the very low level due to technical and economic reasons. Also, it is a time-consuming and costly process to dispose of a large amount of radioactive waste generated in the dismantling of a nuclear power plant, and many researches are needed to minimize and recycle radioactive waste in nuclear power plants around the world. Dismantling of Nuclear power plant is the process of decontaminating structures, equipment and polluted water, disposing them and restoring the site to a usable natural state that can be used after the nuclear power plant is permanently shut down.

In this study, we propose methods to (1) decontaminate radioactive contaminated water using microalgae, and (2) method to automatically detect the amount of activity of radioactive waste generated from nuclear dismantling process using In-situ Radiation Inspection System previously developed.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

RAPID REMOVAL OF CESIUM-137 FROM URBAN AREA AFTER THE FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT

Kazuya Yoshimura

Sector of Fukushima Research and Development, Japan Atomic Energy Agency
10-2 Fukasaku, Miharu-machi, Fukushima 963-7707, Japan

Key words; *Cesium-137, urban, distribution*

Abstract

Urbanized areas have a large impact on external exposure to residents. Diverse decontamination methods had been evaluated by the model decontamination project carried out by Japan Atomic energy Agency in 2011 and 2012 to reduce the external exposure. On the other hand, quantitative information of distribution of radioactive substances, especially ^{137}Cs, in urban area is limited, although the information is crucial for decontamination planning. To provide quantitative information of the distribution of ^{137}Cs in urban area, this study evaluated relative ^{137}Cs inventories, which are defined as the relative values of ^{137}Cs inventory on each urban component such as roof and road to that on a nearby permeable plane field, for 11 buildings in the evacuation zone in 2015 and 2016. Additionally, the results were analyzed with the data obtained in the model decontamination project to evaluate temporal trend in the distribution during the initial five years after the accident. The relative inventory obtained for paved ground were 0.2 and for other building components such as roof, wall and window were less than 0.04 in 2016. These values indicate the limited contamination of urban area. The relative inventories of paved ground, roof and wall in 2011 and 2012 showed similar values with those obtained in this study, suggesting that initial run-off and the following wash-off effects during the first year after the accident largely defined the distribution of ^{137}Cs in urban area. Some of the component showed rapid decrease in the relative inventory more than decay during five years after the accident. The fast decrease and the obviously low relative inventories on the components in urban area demonstrate the rapid removal of ^{137}Cs from urban area.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

A Study on the Performance of Flocculating agent for Radioactively Contaminated Soil by Soil Washing Process

Jong Soon Song and Sun Il Kim*

Department of Nuclear Engineering, Chosun University
309 Pilmun-daero, Dong-gu, Gwangju 61452, Republic of Korea

Key words*; Soil Washing, Flocculating Agent, Soil remediation*

Abstract

Radioactive substances that are discharged in the process of nuclear power plant decommissioning or facility maintenance cause soil pollution. Such soil pollution requires decontamination in order to ensure people's residence and reuse of land as an industrial site. Among the various soil remediation technologies, this study was selected soil washing technology which has actual example of being used on soils polluted by radioactive substances Korea and abroad of the country. Soil washing process uses washing agent to weaken the surface tension of soil and Cs in order to separate soil and Cs. For this reason, the major factor that determines decontamination efficiency is the selection of washing water. While the decontamination process which uses acidic wash water weakens surface tension greater than the one that uses water, therefore separating Cs and soil with high efficiency, but it produces much acid effluent. Using water instead of acidic washing water, which produces great amount of effluent, and reusing washing water with flocculating agent may ensure a more economical and efficient process. In order to enhance the efficiency of soil washing process, the washing water can be reused. This study used flocculating agent to perform the experiment for testing the removal performance of micro-soil and Cs that are included in the washing water. Cs removal experiment was performed by using ICP-OES. In addition, binding species of Cs to soil according to respective pH was predicted using Visual MINTEQ code and whether washing watering used in the soil washing process can be reusable was assessed by turbidity.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Spent Nuclear Fuel Final Disposal Management in Taiwan

Allan Lee

Department of Nuclear Backend Management,Taiwan Power Company
7F, Annex Bldg., 242, Sec. 3, Roosevelt Rd. Taipei, 10016, Taiwan

Key words*; Spent Fuel, Final Disposal, Radioactive Waste Management*

Abstract

Based on "Nuclear Materials and Radioactive Waste Management Act", Taiwan Power Company (TPC) has responsibility for taking good care and manage the spent nuclear fuel that generated from its nuclear power plants. So, in 2004 TPC submitted a "Spent Nuclear Fuel Final Disposal Plan in Taiwan (hereinafter referred to as the "Plan")" to the regulatory authority. According to the Plan (revised in 2014), the period from 2005 to 2017 is considered the "Potential Host Rock Characterization and Evaluation Stage", which has 2 missions including 1: Two milestone reports "Preliminary Feasibility Assessment Report for the Spent Nuclear Fuel Final Disposal Technology in Taiwan (abbreviated as the SNFD2009 report)" and "Technical Feasibility Assessment Report on Spent Nuclear Fuel Final Disposal (abbreviated as the SNFD2017 report)" are to demonstrate the technical capabilities in Taiwan and 2: A number of survey areas are recommended to continue more detailed investigation in next stage.

In this study, some achievements from SNFD2017 report and proposed siting procedures for survey areas of Taiwan are shown in this topic. Furthermore, in order to respond the new government's policy "no nuclear power plants operate in Taiwan after 2025", a "task force of nuclear-free homeland" had been established in Taiwan to discuss national nuclear strategies. Thus, the relevant current status and strategies are also presented (e.g., the status of a dedicated agency of radioactive waste management in Taiwan, the future siting procedure of candidate sites, and public engagement).

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

SCIENTIFIC BASIS FOR NATIONWIDE SCREENING OF GEOLOGICAL DISPOSAL SITES IN JAPAN

Takehiro Matsumoto[1], Hiromitsu Saegusa[1], Hideaki Hyodo[1], Akira Deguchi[1], and Hiroyuki Umeki[1]

[1]Nuclear Waste Management Organization of Japan (NUMO)
4-1-23, Shiba, Minato-ku, Tokyo, 108-0014 Japan

Key words*;* geological disposal, site selection process, nationwide screening

Abstract

The legal system was established for geological disposal of radioactive waste in 2000, which specifies three steps of siting process as literature survey, preliminary investigation and detail investigation to be conducted by the Nuclear Waste Management Organization of Japan (NUMO). NUMO has been promoting the siting process by a volunteering approach, but no volunteer so far has appeared and selection of geological disposal sites in Japan has not advanced significantly over 15 years. Taking such situation into consideration, the government reinforced measures for achieving solutions and promoting geological disposal through the “Strategic Energy Plan” published in April 2014. In association with the reinforcement, a new process for selecting repository sites, which is the nationwide scientific screening by the government before initiating legally defined siting process, has been added by the amendment in the Basic Policy in May 2015. The nationwide scientific screening is aiming at encouraging municipalities to consider accepting the literature survey.

Discussion for the nationwide screening for stepping into the literature survey was initiated in December 2014 at the Geological Disposal Technical Working Group (WG), which is an advisory committee for the Ministry of Economy, Trade and Industry. The WG identified requirements and criteria for the screening, and summarized them in the report which was published in April 2017.

The requirements and criteria are discussed from the viewpoints of 1) geological environment characteristics and their long-term stability favorable to geological disposal; 2) safety of repository facilities; 3) safety of waste transportation; 4) technical feasibility. NUMO has been developing the nationwide knowledge base that contributed to the discussion by providing the state of the art scientific basis.

This paper presents the detail of the scientific basis of these viewpoints for the requirements and criteria.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

SENSITIVITY OF WIPP PERFORMANCE ASSESSMENT RESULTS TO REGULATOR-PRESCRIBED CHANGES

Todd R. Zeitler and Brad A. Day

Sandia National Laboratories

Address: 4100 National Parks Hwy. Bldg. A, Carlsbad, NM, 88220

Key words: *performance assessment, transuranic waste, WIPP, regulatory*

Abstract

The U.S. Environmental Protection Agency (EPA) requested of the U.S. Department of Energy (DOE) a sensitivity study (CRA14_SEN4) of the current Waste Isolation Pilot Plant (WIPP) Performance Assessment (PA) model that incorporated several changes to the baseline WIPP PA model (CRA14), including: parameter changes, use of an updated code, and a revised computational grid. The modifications to the repository model resulted in increased releases in all primary release mechanisms. The impacts of each EPA-requested change to CRA14 were analyzed with respect to each release mechanism in the CRA14_SEN4 study. Overall, total high-probability (P[Release>R] = 0.1) predicted mean releases from the repository were increased by about 15%, which corresponds to a 0.6% reduction in the margin to the limit of 1. Total low-probability (P[Release>R] = 0.001) predicted mean releases were increased by about 107%, which corresponds to a 2.9% reduction in the margin to the limit of 10. The upper 95% confidence level on the mean increased for high-probability and low-probability releases by 18 and 119%, respectively. It is concluded that the EPA-requested changes to the CRA14 result in increases to the predicted total releases from the repository. However, releases calculated in the CRA14_SEN4 analysis remain below regulatory limits, demonstrating continued compliance of the WIPP.

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. SAND2017-6687A

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Geochemical modeling of water-rock interactions in granitic rocks, Eastern Taiwan

Yu-Te Chang

Material and Chemical Research Laboratories, Industrial Technology Research Institute
8F, -4, No.9, Sec. 2, Roosevelt Rd. Zhongzheng Dist., Taipei City 10093, Taiwan

Key words: *granitic rocks, groundwater, reaction-path modeling*

Abstract

Crystalline rocks such as granite have been considered as suitable host rocks of radioactive waste repository. As groundwater flows through fractured-rock aquifers, the water-rock interactions could induce dissolution and precipitation of minerals and change the geochemical, structural, and mineral characteristics of the host rocks. Therefore, study of possible water-rock reaction processes and mechanisms is crucial for suitability evaluation of potential disposal host rocks. The granitic rocks in eastern Taiwan are mainly surrounded by marble, which could be predicted that the groundwater quality (especially pH value) will mainly controlled by carbonate system. In this study, the groundwater and rock compositions in eastern Taiwan were used for reaction-path modeling by 3 scenario cases (shallow open fracture, deep open fracture and deep closed fracture), which can be used to understand the conditions of rock composition and the surrounding water quality, and their chemical changes over time, e.g., the variation of pH and Eh and the formation of secondary minerals. The simulation results show that the calcite and sericite are the major secondary minerals under the final equilibrium state. Besides calcite and sericite, the rest of the main secondary minerals will change gradually from andradite, saponite-Ca to dolomite, nontronite-Na, and dawsonite when the fugacity of carbon dioxide increases. For the fractured-rock aquifers in eastern Taiwan granitic rocks, the simulated pH and Eh ranges (pH = 7.12 to 8.93 and Eh = -0.37 volts to -0.15 volts) should be considered in the sensitivity analysis of the nuclide solubility and/or adsorption characteristics. Compared to the similar simulation results in Taiwan's granitic offshore island (pH = 6.99 to 9.75 and Eh = -0.45 volts to -0.17 volts), it shows that the groundwater characteristics (especially pH value) of granitic rocks in eastern Taiwan is obviously affected by carbonate system and with less pH fluctuations.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Centrifuge model test to gain reliability of the future prediction in terms of long term THM processes in deep geological repository

Soshi Nishimoto

Central Research Institute of Electric Power Industry (CRIEPI)
1646 Abiko, Abiko-shi, Chiba, 270-1194 Japan, soshi-n@criepi.denken.or.jp

Key words; *centrifuge, scaling law, near-field, THM processes, geomechanical interaction*

Abstract

The long-term behavior in the near-field of deep geological repository is governed by coupled thermal-hydraulic-mechanical (THM) processes. THM processes will continue for hundreds of years in the initial stage of disposal. These processes influence the overpack displacement, the swelling behavior of the buffer, the deformation of the disposal hole, and so on. The overpack displacement is influenced by the swelling behavior of buffer. The swelling pressure of the buffer generated is influenced by the depth of the repository and the stiffness of the surrounding bedrock. To clarify the long term behavior in the near-field, the researches by the full-scale tests and the numerical analyses have been carried out. However, the former are difficult due to location, time, and economic restraints, and the latter are necessary to verify the applicability of the numerical model. Centrifuge model test can be used to replicate an event, similar to what can be done with a prototype, and in fact is a reduced-scale version of a prototype. Based on scaling laws, any two investigations of the same conditions using a centrifuge model test and a prototype are similar and related. However, the centrifuge model test has the advantage that it can greatly shorten the long time needed to see behavior resulting from the typically slow flow of groundwater that satisfies Darcy's law. If the time acceleration test using the reduced-scale model of the near-field is available on the basis of the centrifugal scaling law, then the long-term reliability of the geological repository can be improved by empirical laboratory data. Our aim is; to conduct the time acceleration test using the centrifugal equipment; to measure the equivalent data of long-term behavior of the overpack, buffer and bedrock; and to evaluate the long-term THM behavior of the near-field in a geological repository by laboratory measurements.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Thermo-hydro-chemical processes influence on buffer material degradation in high level radioactive waste disposal

Wen-Sheng Lin[1], Suu-Yan Liang[2] and Chen-Wuing Liu[3]

[1]Hydrotech Research Institute, National Taiwan University
[2]Material and Chemical Research Laboratories, Industrial Technology Research Institute
[3]Department of Bioenvironmental Systems Engineering, National Taiwan University
No. 1, Sec. 4, Roosevelt Road, Taipei, 10617 Taiwan

Key words: *high-level radioactive waste, buffer material, bentonite degradation, performance assessment, geological disposal*

Abstract

The concept of geological disposal for high-level radioactive waste (HLW) is based on a multi-barrier system which comprises the natural geological barrier provided by the repository host rock and its surroundings and an engineered barrier system (EBS), including the waste form, waste canisters, buffer materials and backfill. The multi-barrier system should perform its desired functions and isolate the waste from the biosphere to achieve the performance of the HLW disposal. Due to the interaction processes of radionuclide decay heat, hydraulic and water-mineral reaction in the radioactive waste repository, to investigate the bentonite buffer material degradation resulting from the external temperature and pressure should be required. However, thermo-hydro-chemical (T-H-C) processes influence on buffer material degradation in EBS of HLW disposal repository due to the chemical reaction of smectite clay dehydration was seldom addressed in Taiwan. Therefore, the reactive chemical transport model is applied to simulate the buffer material degradation affected by the T-H-C processes of HLW disposal repository. The results can form T-H-C based information and pre-techniques for the performance assessment and safety analysis on the final disposal of HLW in Taiwan.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Coupled THMC Processes in Radionuclide Waste Management

Gour-Tsyh (George) Yeh

CAMRDA, College of Earth Sciences, National Central University
No 300 Jhongda Road, Jhongli District, Taoyuan City 32001, Taiwan

Key words*; Multiphase Flow, Thermal Transport, Reactive Transport, Geo-Mechanics*

Abstract

Physics-based mathematical-computational models provide an invaluable tool for repository design, performance/safety assessments, site clean-up, and environmental remediation in nuclear spent fuel and high level waste disposal in shallow or deep geological media. The migration of nuclear wastes is controlled by coupled THMC (Thermal-Hydrology-Mechanics-Chemical) processes. These include multiphase flow or variably saturated flow, thermal transport, reactive transport, and geo-mechanical deformation. Multiphase or variably saturated flow in subsurface media is the key driving mechanism for thermal transport, chemical transport, and geo-mechanics. Conversely thermal transport, chemical transport, and geo-mechanic deformation will affect flow directly or indirectly. Temperature changes are induced by fluid injection, associated phase changes, and chemical reactions. Conversely, temperature change will alter fluid flow, reactive transport, and geo-mechanical deformation. Faults and fractures will affect fluid pressure, thermal transport, and chemical migration. Conversely fluid pressure, thermal transport, and chemical migration will induce rock deformation and fault displacement.. Reactive transport is controlled by fluid flow, affected by thermal transport, and influenced by geo-mechanical deformation. Conversely, reactive transport will have significant feedbacks on fluid flow, thermal transport, and geo-mechanics. This talk presents the development of a series of computational models that fully or partially couple these processes. Demonstrative applications are presented to illustrate the interplay of THMC processes and their implications for radionuclide waste managements.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Efforts toward Safe, Steady and Efficient Decommissioning

Toyoaki Yamauchi, Satoshi Karigome and Hitoshi Ohata

The Japan Atomic Power Company
1-1, Kanda-mitoshiro-cho, Chiyoda-ku, Tokyo, 101-0053, Japan

Key words; *Decommissioning, Tsuruga-1*

Abstract

Before Fukushima accident, only four NPPs, Tokai (GCR), Fugen (ATR) and Hamaoka-1/2 (BWR), were under decommissioning in Japan. But other NPPs, Mihama-1&2 (PWR), Tsuruga-1 (BWR), Genkai-1 (PWR), Shimane-1 (BWR), Ikata-1 (PWR) and Monju (FBR), were decided to terminate operation after Fukushima accident, and some of those NPPs started Decommissioning work recently. It is supposed that the number of NPPs in decommissioning phase will continue to increase in the future.

In order to advance decommissioning, there are four principal conditions which have to be met, that is, 1) Spent Fuel path, 2) Radioactive Waste Disposal path, 3) Decommissioning fund and 4) Culture, mindset and organization suitable for decommissioning project.

In order to responsibly finish all the activities of the closed nuclear power plants, it is necessary for all the stakeholders involved in nuclear power generation (government, regulator, utilities and local stakeholders) to play their roles respectively to establish the conditions above. It is clear that decommissioning cannot be completed without spent fuel path and waste disposal path.

Because it is also important for Japanese utilities to learn decommissioning experience in other countries, The Japan atomic Power Company (JAPC) signed an agreement with Energy*Solutions* (ES) on strategic cooperation for Japanese decommissioning projects for the purpose of introducing successful international experiences in April 2016. As a first step in this cooperation, decommissioning know-how developed by ES in the US is being applied to Tsuruga-1 decommissioning project with verifying its applicability to Japanese decommissioning projects. Outline of JAPC and ES collaboration will be also introduced.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Decommissioning Planning for Unit 1 and 2 at Mihama Nuclear Power Plant

Shinya Kato, Koichi Kamahori, Hiromu Isaka and Shinro Hirano

Kansai Electric Power Co., Inc.
8 Yokota, 13 Goichi, Mihama-cho, Mikata-gun, Fukui-ken, 919-1141, Japan

Key words*; decommissioning plan, pressurized water reactor, Mihama Unit 1 and 2, system decontamination*

Abstract

The Mihama Unit 1 and Unit 2 has stably supplied electric power for kansai erea. There has been a new regulatory standards and a 40-year operation regulation in Japan since the accident occurred at the Fukushima-Daiichi nuclear power plant of Tokyo Electric Power Co., Inc. (TEPCO). Because it was difficult to operate these units based on the standards, we decided that both of these units would be permanently stopped on March 17 in 2015. We applied for the decommissioning plan of Mihama Unit 1 and Unit 2 on February 12, 2016, and an application for approval of changes in Tec. Spec. on August 31 in the same year. It commenced the actual decommissioning phase upon obtaining the approval from NRA after going through the review process, and finally, we accepted the approval for the decommissioning plan of Mihama Unit 1 and Unit 2 on April 19, 2017.

Our decommissioning plan is contributed of a process for about 30 years which has 4 stages. The first stage is the period to decontaminate nuclear reactor vessels(RVs) and steam generators(SGs), etc. and to investigate remaining radioactivity in the facilities. The second stage is the period when the equipment around the nuclear reactor will be dissolved and removed. The 3rd stage is the period when a nuclear reactor will be dismantled and removed. The 4th stage is the final period when a building will be dismantled and removed.

As the approval certification has been got, it is now shifted to the first stage in decommissioning. The first work in our decommissioning is the system decontamination which makes the dose for workers as low as reasonably achievable, and it is about to start the main work for system decontamination.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Radiation Survey and Waste Inventory Estimation for Decommissioning of Taiwan NPP

Chun-Cheng Lin[1*], Wei-Sin Chen[1], Jyi-Lan Wuu[1] and Shu-Jun Chang[1]

[1]*Division of HP, Institute of Nuclear Energy Research, No. 1000, Wenhua Rd., Jiaan Village, Longtan Township, Taoyuan County, Taiwan*

Keywords: *Radiation survey, radioactive wastes, MARSSIM, Decommissioning.*

Abstract

Both radiation survey and waste inventory estimate are parts of the NPP (nuclear power plant) decommissioning program issues. Radiation survey including site investigation process can provide the radiation information of a site or a facility, which can be useful for the decommissioning planning, waste inventory estimation and its characterization. The site survey results can also support the final decision on whether the site or the facility will comply with the regulations. This paper describes the radiation survey and site investigation methods based on MARSSIM (The Multi-Agency Radiation Survey and Site Investigation Manual); Waste inventory estimate for decommissioning is also essential in the whole decommissioning study, since D&D (Decommissioning and Dismantling) methods, decommissioning cost, packing containers selection and repository design for decommissioning waste etc. This paper has referred to the methodology of Westinghouse that introduced the implement for decommissioning waste estimation. The first step for the waste estimation is to define the classifications of waste by the level of radioactivity. And the second step is to confirm the origins of radioactive waste such as surface contamination, activation of materials or water processing streams. This paper presents the preliminary outcomes of radiation survey and waste inventory estimate for decommissioning of Taiwan NPP.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Status of radioactive waste and spent nuclear fuel management in Finland

Jari Tuunanen

Fortum Power and Heat Oy, Loviisa NPP
Loviisa NPP, P.O.Box 23, 07901 Loviisa, Finland

Key words; *spent nuclear fuel, radioactive waste, decommissioning*

Abstract

The main principles of the Finnish radioactive waste management program were fixed already in 1983 in the decision in principle (DiP) of the ministry of trade and industry This DiP fixed the overall responsibilities, schedule and reporting principles of the radioactive waste producers covering the operational waste, spent nuclear fuel and decommissioning. One key principle of the decision was that the waste producers are themselves responsible for management of all the radioactive waste they produce, including the costs.

The status of the program today is such that all the facilities are ready on site of the NPP's in Olkiluoto and Loviisa for management of operational radioactive waste. Both nuclear power plant operators have their own waste treatment and storage facilities as well as own LILW repositories in operation. The spent nuclear fuel is also stored on the NPP sites. The spent fuel management program is organized through Posiva, a private company owned by the NPP operators Fortum and TVO, who has got a construction license for spent fuel encapsulation and final disposal facility. Decommissioning plans have also been prepared as requested by the DiP of the ministry. The money for decommissioning is reserved in the radioactive waste fund and the aim is to dispose all decommissioning waste to the existing LILW repositories on site of the NPPs.

This paper summarizes the status of the radioactive waste management program in Finland, with the main focus on the radioactive waste and spent fuel produced at Loviisa NPP. It also presents some highlights of research and development program on radioactive waste management and gives an overview of the plans for future decommissioning.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Communication activities through dialogue in Japanese geological disposal project of high-level radioactive waste

Ayako Araki, Saki Ikeda, Kumiko Ezaki and Kenichi Kaku

Communication and Public Acceptance Department
Nuclear Waste Management Organization of Japan (NUMO)
1-23, Shiba 4-Chome, Minato-ku, Tokyo, Japan,

***Key words**; Communication, Dialogue, Geological disposal of high-level radioactive waste*

Abstract

The Nuclear Waste Management Organization of Japan (NUMO) was established in October 2000 based on the "Specified Radioactive Waste Final Disposal Act" as the authorized implementing entity approved by the Minister of Economy, Trade and Industry (METI).
Our mission is the "Realization of the Geological Disposal of Radioactive Waste". Since its establishment, NUMO has been engaging in communication and research and development (R&D) to fulfill the mission.

As a new initiative for enhancing the site selection process of geological disposal, Japanese government is now preparing for an announcement of the "Nationwide Map of Scientific Features for Geological Disposal", which categorizes all areas in Japan into four categories.
In such a situation, NUMO is working on raising awareness and enhancing understanding of the geological disposal project among the public. NUMO is also making efforts to listen to the opinions of the public on geological disposal to understand what the public concerns are.

NUMO has been carrying out PR activities such as advertising on TV commercials and newspapers to raise public awareness of geological disposal. We are currently focusing on face to face communication activities such as holding seminars with small group discussions and outdoor events with a communication vehicle, "Geo Mirai". Utilizing other measures including cross-media advertisement, opinion surveys and press releases allows us to reach out a wide range of stakeholders in Japan.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

EFFORTS IN THE FIELD OF EDUCATION FOR JAPANESE GEOLOGICAL DISPORSAL OF HIGH-LEVEL RADIOACTIVE WASTE

Kumiko Ezaki, Kenichi Kaku and Shunsuke Suzuki

Communication and Public Acceptance Department,
Nuclear Waste Management Organization of Japan(NUMO)
1-23,Shiba 4-Chome, Minato-ku, Tokyo, Japan

Key words; *Education, Nuclear Waste Management Organization of Japan*

Abstract

Nuclear Waste Management Organization of Japan (NUMO) was established in October 2000 based on the “Specified Radioactive Waste Final disposal Act” as the authorized implementing entity approved by the Minister of Economy, Trade and Industry (METI). Since its establishment, NUMO has been engaging in public communication to increase an understanding of the importance of the geological disposal project.

The geological disposal is the 100-years project from the start of investigation for exploring a repository construction site till the closure of the repository. Therefore, multiple generations will be involved in this project. For raising awareness of the geological disposal project as one of social issues among next generations, especially elementary school and junior/senior high school students, NUMO has been supporting school teachers and college students who are willing to work on developing teaching plans and materials. NUMO encourages them to actually teach geological disposal to their students in their school classes. In 2016 NUMO produced basic teaching materials for elementary school students/junior high school students/and instructional materials for teachers and distributed them to education committee and schools across Japan.

NUMO also has been supporting college debate classes on the topic of geological disposal of high-level radioactive waste since 2012. NUMO provides its supports by sending experts on radiation and geological disposal for special lectures, by organizing tours to local nuclear power plant and a research facility of geological disposal and by answering to various questions from the students. In addition, NUMO has been carrying out communication activities using a communication vehicle “Geo Mirai”, where exhibits and a 3D-animation theater are installed, throughout Japan. Thorough these activities various questions and opinions have been obtained from a wide range of generations which will be utilized to improve NUMO’s communication.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

OVERVIEW OF THE NUMO SATETY CASE AT PRE-SITING STAGE

T. Fujiyama, S. Suzuki, A. Deguchi and H. Umeki

Nuclear Waste Management Organization of Japan
Mita NN Bldg. 1-23, Shiba 4-Chome, Minato-ku, Tokyo 108-0014 Japan

Key words; *Geological disposal, Safety case, Vitrified waste, TRU wastes*

Abstract

NUMO has developed a safety case for geological disposal at pre-siting stage in Japan. This safety case provides the multiple lines of arguments and evidence to demonstrate the feasibility and safety of geological disposal, which will encourage stakeholder confidence in the safe implementation of geological disposal and will provide a basic structure for a safety case which will be applicable to any potential site.

This paper will provide a brief overview of this safety case, emphasizing practical approaches and methodology which will be applicable for the conditions/constraints during an actual siting process, with a focus on advances from the "H12 Report", which formed the basis for establishing NUMO in 2000 as the implementing organization and is considered the first generic safety case on geological disposal of HLW in Japan.

The geological environments of various potential host rocks are developed as site descriptive models, which are, as realistically as possible, based on the current best understanding of Japanese geology. A rigorous and flexible methodology for tailoring repository design to volunteer siting environments and safety assessment models and data have been developed and applied for demonstration of the technical basis of the safety assessment. The NUMO Safety Case has been extended in key areas, including assessing extreme geological events during long-term repository evolution, widening discussion of both operational and post-closure safety, scenario development based on risk-informed approaches, etc.

The safety case will feature extensive use of advanced knowledge management tools and will be presented in a web-based communication platform, which facilitates not only integration and documentation of the huge knowledge base that supports a modern safety case, but also presentation of output in a user friendly manner to all stakeholders, including the general public.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

GEOSYNTHESIS OF A STATE-OF-THE-ART KNOWLEDGE BASE INTO SDMS IN THE NUMO SAFETY CASE

Kunio Ota, Hiromitsu Saegusa, Takanori Kunimaru and Saori Yamada

Nuclear Waste Management Organization of Japan (NUMO)
4-1-23 Shiba, Minato-ku, 108-0014 Tokyo, Japan

Key words; *Safety case, Site selection, Geosynthesis, Site Descriptive Model*

Abstract

During the repository site selection process involving stages of literature survey, preliminary investigation and detailed investigation, the site geological environment is characterised and the expanding site-specific knowledge base is integrated in a geosynthesis process into site descriptive models (SDMs), at a progressively increasing level of detail. The SDMs represent the key geological characteristics and processes required for repository design and safety assessment and, as importantly, their temporal and spatial evolution. Of great importance is thus to use the SDMs iteratively to illustrate how repository designs are tailored to the site conditions identified and, with increasing understanding, tailored to optimise their practicality and performance.

The NUMO Safety Case demonstrates a state-of-the-art knowledge base of all relevant geological environments in Japan and the integration of such knowledge into the SDMs, together with the tools and experience to characterise them to the degree required. Five major rock types that commonly occur in Japan with sufficient spatial extent at relevant depths, have been characterised in terms of their structural, thermal, hydrological, geomechanical and geochemical features of significance to geological disposal. The five rock types have then been categorised into three groups (plutonic, Neogene sedimentary and Pre-Neogene sedimentary rocks) by focussing on common distinct characteristics and properties. Nested SDMs have then been developed stepwise to conceptualise illustrative geological settings for each of the potential host rock groups at scales of several tens of kilometres, several kilometres, several hundred metres and decimetres. Critical geological and hydrogeological information represented quantitatively in the SDMs is derived from an actual and quality-assured dataset of deep geological environments for particular siting environments in Japan. The chemistry of model groundwaters has also been developed through the careful interpretation of quality-assured hydrochemical data and geochemical modelling, which covers a wide range of groundwater chemistry for each potential host rock in Japan.

Session 3A-3

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

LAYOUT DESIGN OF UNDERGROUND FACILITIES TAILORED TO SDM IN THE NUMO SAFETY CASE

Takahiro Goto, Yoichi Yamamoto, Satoru Suzuki and Shigeru Kubota

Nuclear Waste Management Organization of Japan (NUMO)
Mita NN Bldg. 1-23, Shiba 4-chome, Minato-ku, Tokyo 108-0014 Japan

***Key words**; repository design, underground facility layout, HLW, TRU waste*

Abstract

NUMO has developed a generic safety case for geological disposal in Japan. This safety case provides the multiple lines of arguments and evidence to demonstrate the feasibility and safety of geological disposal, which will encourage stakeholder confidence in the safe implementation of geological disposal and will provide the basic structure for a safety case which will be applicable to any potential site. This paper provides the outline of trial underground repository layout designs tailored to the site descriptive models (SDMs) in this safety case. Suitable emplacement areas were first selected in the repository-scale SDMs based on the Layout Determining Features (LDFs) defined by the geological features such as faults and permeable rocks. Next, geometry of repository panels was determined. Regarding the high level radioactive waste, both through type and dead-end type were applied for the vertical and horizontal emplacement concepts. Then, layout of the repository panel was designed in the suitable emplacement area considering the Emplacement Determining Features (EDFs) defined by the features such as water inflow from minor faults and fractures in the disposal tunnels, ensuring the space for the reserved areas. As a result of comparison among the above design options, the dead-end type geometry with the horizontal emplacement concept could be identified as a relatively efficient and economical approach which has more flexibility to the geological structures.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

PRELIMINARY STUDY OF PRE-CLOSURE SAFETY ASSESSMENT IN THE NUMO SAFETY CASE

K. Yamashina, S. Suzuki and S. Kubota

Nuclear Waste Management Organization of Japan
Mita NN Bldg. 1-23, Shiba 4-Chome, Minato-ku, Tokyo 108-0014 Japan

Key words*; repository, safety assessments, waste treatment*

Abstract

NUMO has developed a generic safety case for geological disposal in Japan. This safety case presents technical evidence to support the feasibility and safety of geological disposal, which will encourage stakeholder confidence in the safe implementation of geological disposal and will provide the basic structure for a safety case which will be applicable to any potential site.
The target range of the safety case is not only after closure of the repository but also the pre-closure period. The ongoing update of the safety case for co-disposal of HLW and TRU waste in Japan will include a more extensive assessment of pre-closure safety than has been carried out in the past. The pre-closure safety case aims to assure both radiological and conventional safety.
After identifying the evaluation scenarios that take into account the progress of abnormal situation, an impact analysis is conducted to evaluate the damage to waste packages and/or workers. In the evaluation of the abnormal state, the relationship between the abnormal state that may occur at the geological disposal facility and the potential countermeasures are schematized by taking the same approach as the event tree analysis method.
In summary, the methodology for assessment of pre-closure safety has been developed and applied to provide feedback for optimizing repository design.
For conventional safety for workers, the working environment will be maintained to ensure worker comfort and safety during normal operation.
Radiological safety for public and workers requires radiation shielding and radionuclide containment within the disposal facilities in case of operational perturbations. Radiation control and facility design are based on guidelines applied for other nuclear facilities. Within the radiation-controlled zones, most operations will be remote-handled or will involve appropriate shielding, avoiding any significant dose to workers.
Mita NN Bldg. 1-23, Shiba 4-Chome, Minato-ku, Tokyo 108-0014 Japan
Key words; repository, safety assessments, waste treatment
Nuclear Waste Management Organization of Japan

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Conceptual Study on Disposal Facility for Waste from Decommissioning of NPPs

Norie KAWAHATA, Ryoichi HOJO, Takayuki HAMANAKA and Takashi KOZAWA

Radioactive waste disposal business division, Japan Nuclear Fuel Limited
504-22, Nozuki, Obuchi, Rokkasho-mura, Kamikita-gun, Aomori-ken, Japan

Key words; *disposal facility, low-level waste, nuclear power plant, reprocessing plant, decommissioning waste, high surface dose rate, lower radiation exposure, skyshine, external exposure, horizontal emplacement*

Abstract

1. Introduction

In Japan, low-level waste from operation of nuclear power plants (NPPs) has been contained in 200-litre drums with solidification materials and converted into waste packages. The waste packages have been disposed of in near-surface disposal facilities with engineered barriers, of the Rokkasho LLW Disposal Center.

In the near future, large-size radioactive waste with much higher radiation level will arise from decommissioning of NPPs and operation of reprocessing plant. Therefore, we studied a concept of the disposal facility which can reduce radiation exposure to the public, compared to the above-mentioned near-surface disposal facilities.

2. Concept of Disposal Facility

For the purpose of more efficient processing and containing of waste from decommissioning of NPPs or operation of reprocessing plant, waste producers have been considering the use of a cubic container (1.6 m on a side) for packaging of the waste, as well as the 200-lite drum. Additionally, the waste packages are expected to have much higher surface dose rate. Thus, there would be a concern about the increase in radiation exposure to the public caused by direct gamma-ray or skyshine gamma-ray. From the viewpoint of reduce the radiation exposure to the public, it is effective to adopt not a pit-type facility but a box-culvert-type facility with higher shield effect.

In consideration of the adaptation of the box-culvert-type facility, waste packages will be emplaced horizontally by use of a forklift truck, not by a crane as used in the Rokkasho LLW Disposal Center.

3. Advantages of the Concept

There are the following advantages of the box-culvert-type facilities over the pit-type ones;

(1) Lower radiation exposure to the public.
(2) All weather operation
(3) May use a candidate area effectively, in case of multi-layered structure

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

An Integrated Framework for Simulating Radionuclide Decay Transport of Low-level Radioactive Waste with Tunnel Disposal in Nearshore Environment

Chin-Chang Lu, Ming-Hsu Li and Yu-Ru Chen

Graduate Institute of Hydrological and Oceanic Sciences,
National Central University, Taiwan
#300 Jhongda Rd., Jhongli, Taoyuan City, Taiwan

Key words: *Tunnel disposal, Nearshore, Radionuclide decay transport, Low-level waste*

Abstract

Tunnel disposal at nearshore was tentatively proposed as one of final disposal sites for low-level wastes in Taiwan. The potential disposal facilities was located at 50m~200m below ground surface and designed with several disposal tunnels. Concepts of safety function are retardation and contaminant provided by disposal tunnels with multiple engineered barriers and host rock to prevent leaching of radionuclides into biosphere. An integrated simulation framework was developed with three levels of finite element grids to facilitate simulations of radionuclide decay transport with 3-D HYDROGEOCHEM5.6 numerical models. Steady flow and transient transport were performed in this study. The coarsest level grids serve as far-field simulations. The middle level grids were developed to describe distributions of all deigned disposal tunnel to serve as near-field (all tunnels) simulations. The finest grids were developed to investigate near-field phenomena at selected tunnel section. Total radioactive activities of source term and a total of 11 radionuclide (Pu-238, Am-241, Tc-99, Co-60, I-129, Cs-137, Ni-59, C-14, Sr-90, Y-90, Ni-63) decay chains as given in the report of Taiwan Power Company were simulated in this study. Flow boundary conditions at finer level grids were obtained from flow simulations of coarser level grids. Release rates of radionuclides at coarser grids were obtained from simulations of radionuclide decay transports at finer grids. For the first 100 years, release rates of C-14, Tc-99, and I-129 are higher than others. After 100 years, release rates of Ni-59, C-14, and Tc-99 are higher than others. Owing to high sorption of Ni-59 onto bentonite barrier, long-lived Ni-59 with high initial concentration deliver low release rates for the first 100 years. Low release rate of I-129 after 100 years was caused by low initial concentration of I-129. Results demonstrate complicated interactions among initial concentration, half-life, decay chains, near-field processes, and far-field processes on radionuclide decay transport.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Sensitivity Analysis of Simulating Radionuclide Decay Transport of Low-level Radioactive Waste in Nearshore Environment

Yu-Ru Chen, Chin-Chang Lu and Ming-Hsu Li

Graduate Institute of Hydrological and Oceanic Sciences,
National Central University, Taiwan
#300 Jhongda Rd., Jhongli, Taoyuan City, Taiwan

Key words: *Sensitivity analysis, Radionuclide decay transport, Low-level waste, Geosphere parameters*

Abstract

Tunnel disposal at nearshore environment is one of potential final disposal sites proposed for the low-level waste in Taiwan. The proposed tunnel disposal facilities were located roughly 800 m away from the shoreline and below sea levels. Geosphere parameters, sea-level, and infiltration rates are critical to radionuclide decay transports in far-field simulations. A radionuclide decay chain of 4N+2, including Pu-238 → U-234 → Th-230 → Ra-226, was used as the study case. The 3-D HYDROFEOCHE5.6 numerical model was used to perform sensitivity analysis of far-field radionuclide decay transport for 100,000 years with simulations of steady flow transient transport. Hydraulic conductivities, diffusion coefficients, and dispersivities were selected for sensitivity analysis of geosphere parameters. With 10 times higher of hydraulic conductivities than reference values, the Pu-238 concentrations are higher and peak concentration appear earlier at shorelines. However, the Ra-226 concentrations simulated with 10 times higher/lower hydraulic conductivities are all lower than those with reference values at shorelines. Higher hydraulic conductivities will favor migration of mother radionuclides of Pu-238, U-234, and Th-230 before seeing Ra-226 at shorelines, while 10 times lower of hydraulic conductivities will hinder migrations of all radionuclides considered in this study. Sensitivities of diffusion coefficients on radionuclide decay transport are not significant in this study. Cases with 10 times higher/lower dispersivities than reference values deliver higher/lower concentrations for all radionuclides at shorelines. Considering radionuclide decay transport in association with changes of geosphere parameters are much more complicated than single species simulations. Changes of sea-level and infiltration rates are designed to investigate changes boundary conditions on radionuclide decay transport through changes of fields. Reliable site investigations are crucial to reliabilities of far-field radionuclide transport simulations.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Seismic response of canister in buffer material under water invasion condition by centrifuge modeling

W.Y. Hung[1], J.J. Xu[2], Y.C. Wu[3] and M.H. Hsieh[4]

[1]Assistant Professor, Dept. of Civil Engineering, National central University, Taiwan (R.O.C)
[2]Master Student, Dept. of Civil Engineering, National central University, Taiwan (R.O.C)
[3]Supervisor, Institute of Nuclear Energy Research, Atomic Energy Council, Executive Yuan, Taiwan (R.O.C)
[4]Engineer, Institute of Nuclear Energy Research, Atomic Energy Council, Executive Yuan, Taiwan (R.O.C)
No. 300, Zhongda Rd., Zhongli District, Taoyuan City 32001, Taiwan (R.O.C.)

Key words; *Canister, Seismic test, Centrifuge modeling test*

Abstract

For high-level waste (HLW) disposal, the HLW is isolated from natural environment by multi-barrier systems including engineering and natural barriers in the deep ground. The disposal holes would be drilled in host rock and set up with canister and buffer. Then the canister is not easily affected by natural operation, humanity activities and tectonic movement with high stability. However, Taiwan is located at Circum - Pacific seismic zone which earthquake occurs frequently. As a result, the effect of earthquake-induced vibration on the canister, buffer and disposal hole is needed to be investigated.

This research assumes that the deposition is set up in granite layer at certain depth. The disposal hole is regard as an entire intact space without deformation and cracks. Referring to KBS-3V concept and geometry, the test model is built with 1/10 scale of prototype. Through the centrifuge modeling, 10 g artificial acceleration field is created to simulate in situ stress of canister from buffer material. Seismic events are input by shaking table with 15-cycle sinusoidal waves. During shaking, acceleration, pore water pressure and total pressure histories are measured in order to realize the seismic behavior of canister and buffers in the disposal hole.

Considering different states of buffer material and conditions, in total, 6 dynamic models are conducted. In 17% water content condition, large acceleration and contact pressure is measured at the surface of canister. When water invades to 17% water content buffer, the acceleration and the contact pressure on the canister are both reduced. After the test, cracks were found on the surrounding buffer materials for the model with 17% water content condition and water invasion case.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

STUDY ON THE APPLICABILITY OF CAST STEEL OVERPACK -EVALUATION OF CASTING DEFECTS AND CORROSION RESISTANCE USING FULL-SCALE PROTOTYPE-

Yusuke Ogawa, Satoru Suzuki, Kazuhisa Yamashina and Shigeru Kubota

Nuclear Waste Management Organization of Japan (NUMO)
2F, Mita NN Bldg, 4-1-23, Shiba, Minato-ku, Tokyo, Japan

Key words*; Geological disposal, Overpack, Cast steel, Non-destructive test, Corrosion, Polarization tests*

Abstract

n the geological disposal concept in Japan, forged steel and cast steel can be considered as candidate materials of carbon steel waste container, namely overpack. So far, research and development of overpack has been carried out mainly on forged steel, while that of cast steel is still lack. We therefore studied influence of casting defects and heterogeneity of chemical composition and microstructure on the long-term integrity of cast steel overpack.

In order to evaluate the influence of casting defects on structural integrity, the realistic distribution of defects were simulated by producing the full-scale cast steel overpack. Although small casting defects such as shrinkage cavity were founded, there was not so large defect as compared with general cast steel products.

In order to evaluate the influence of heterogeneity of chemical composition and microstructure on corrosion resistance, the specimens were collected from the various locations in the full-scale cast steel overpack. As a result, no significant difference was observed in chemical composition and microstructure. In addition, the anode and cathode polarization test was carried out and corrosion rates obtained by the Tafel extrapolation method were compared. The result shows no significant difference among the specimens. From these results, it can be considered that the variation in corrosion resistance in a cast steel is negligibly small.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

STRUCTURAL INTEGRITY ASSESSMENT OF DISPOSAL PACKAGE FOR RADIOACTIVE WASTE FAILURE ASSESSMENTS FOR OVERPACK USING FINITE ELEMENT ANALYSIS

Masahiro KAWAKUBO[*1] and Masato KOBAYASHI[*1]

*1 Radioactive Waste Management Funding and Research Center
Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan

Key words; *Geological disposal, Disposal package, Structural integrity, Failure assessment*

Abstract

In Japan, high-level radioactive wastes have been planned as geological disposal after vitrified and encapsulated into an overpack. The carbon steel overpack is required for at least 1,000 years isolation of the vitrified waste from coming into contact with groundwater. The overpack is cylindrical package and made of carbon steel as primary candidate material. The basic specification of the overpack was set as the wall thickness of 190 mm and it is considered for corrosion allowance layer (40 mm), radiation shielding layer (150 mm) and mechanical withstanding layer (included in radiation shielding layer).

In this study, to ensure the integrity of the period required for the overpack, failure assessments of the overpack using finite element analysis were performed for all failure mode assumed during operation and after emplacement. From the results of failure assessment, it was showed that the relationship between collapse load and the overpack thickness, and the relationship between welding residual stress and critical crack size of welded part. And it was clarified that the strength of the weld joint can be sufficiently ensured by partial welding.

This research is under a grant from the Japanese Ministry of Economy, Trade and Industry (METI).

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Stress Analysis for the Canister under Earthquake Induced Fracture Shear Displacement considering Long-term Creep Effect of Copper Shell

Yuan-Chieh Wu*, Hsi-Ting Lo and Yi-Ren Wang

Institute of Nuclear Energy Research, Atomic Energy Council
1000 Wenhua Rd. Jiaan Village, Longtan District, Taoyuan City 32546, Taiwan

Key words; *ANSYS, Creep, Canister*

Abstract

The design for spent nuclear fuel canister should consider three containment failure modes, rock confining pressure, rock deformation, and corrosion. For deposal concept in hard rock such as KBS-3 in Sweden, Finland, and current Taiwan test sites, the rock fractures surrounding deposition hole may turn into the permanent shear displacement during earthquake; therefore, the stress analysis should be performed to evaluate seismic capacity for shear displacement. Also, for long-term disposal environment, copper canister needs to consider the creep of copper shell, so the capability to perform analyses combing these two phenomena should be established in final disposal research team. To perform the analyses, a three dimensional canister and buffer assembly model was built, and model test was carried out by comparing the results with SKB data to achieve the model confidence. Several shear displacement scenarios including different loading position and direction were carried out to understand the safety margin of canister design through von Mises results compared with allowable stress of copper material for canister shell and cast iron material of canister insert, and also the long-term creep effect was considered in the analysis procedure. Based on the results, the influence of copper creep effect will lead different stress distribution on copper and cast iron, and reduce the stress of cast iron insert; also, it demonstrates canister can maintain integrity either considering creep from strain perspectives. The analysis capability not only shows we can handle earthquake issue for final disposal in Taiwan where the earthquake issue always be the first natural hazard to face, but also we can reduce the canister failure rate due to fracture shear displacement if we further consider adjusting deposition hole location or rejecting holes when the intersecting fractures occur around deposition holes.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

PRELIMINARY STUDY OF POST-CLOSURE SAFETY ASSESSMENT IN THE NUMO SAFETY CASE

K. Ishida, T. Hamamoto, S. Shibutani, K. Fujisaki and M. Yamada

Nuclear Waste Management Organization of Japan
Mita NN Bldg. 1-23, Shiba 4-Chome, Minato-ku, Tokyo 108-0014 Japan

Key words; *post-closure safety assessment, risk informed approach, radionuclide migration*

Abstract

NUMO has developed a generic safety case for the geological disposal in Japan. This safety case provides the multiple lines of arguments and evidences to demonstrate the feasibility and the safety of the geological disposal, which will encourage stakeholder confidence in the safe implementation of geological disposal and will provide a basic structure for a safety case which will be applicable to any potential site.

The key distinguishing features of the safety assessment are “application of the risk-informed approach”, “scenario development with comprehensiveness, traceability and transparency”, and “realistic radionuclide migration model reflecting the repository design”.

For the purpose of optimization of protection, the disaggregated approach, as one of risk-informed approaches, which makes it possible to evaluate a potential impact of a future event and its probability separately, is applied as a frame of the safety assessment. Developed scenarios are classified into 4 categories on the basis of their probabilities; “Likely scenario”, “Less likely scenario”, “Very unlikely scenario” and “Human intrusion scenario”.

The methodology of the scenario development results from a desire to combine a bottom-up what is called FEP-based approach and a top-down method based on the safety functions, appropriate to risk-informed assessment. The scenarios considered to be “likely” are developed to be as realistic as possible, representing comprehensive current understanding of relevant FEPs in terms of extent and rate of impact on radionuclide containment and eventual release and transport. The methodology consisting of overall procedure and associated toolkits is aiming to increase traceability and transparency. For a rational repository design, it is important that the assessment model can show the difference of the performance among candidate designs, such as the panel layout and the disposal galleries. Then NUMO’s model is based on the 3D particle tracking method which can effectively describes the radionuclide migration behavior reflecting the repository design.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

ASSESSMENT OF SORPTION AND DIFFUSION IN THE ROCK MATRIX IN THE NUMO SAFETY CASE

T. Hamamoto[a], S. Shibutani[a], K. Ishida[a], K. Fujisaki[a], M. Yamada[a] and Y. Tachi[b]
[a] Nuclear Waste Management Organization of Japan (NUMO)
[b] Japan Atomic Energy Agency (JAEA)

[a] Mita NN Bldg. 1-23, Shiba 4-Chome, Minato-ku, Tokyo 108-0014 Japan
[b] 4-33, Muramatsu, Tokai-mura, Naka-gun, Ibaraki, 319-1194 Japan

Key words;*Geological disposal; Performance assessment; Radionuclide migration; Sorption; Diffusion*

Abstract

NUMO has developed a generic safety case to demonstrate the feasibility and safety of geological disposal of HLW and TRU waste in Japan and to provide a basic structure for the safety case which will be applicable to any potential site. In this pre-siting safety case, the performance assessment was carried out for the repositories tailored to site descriptive models (SDMs) developed for three representative rock groups (plutonic, Neogene sedimentary and Pre-Neogene sedimentary rocks). Radionuclide migration parameters in rocks, *i.e.* distribution coefficients and effective diffusion coefficients, were derived to allow performance assessment for a range of scenarios. The values of these parameters were given statistically from laboratory data for certain rock types. The data were extracted from the latest sorption and diffusion database, with interpretation based on the speciation by thermodynamic modeling using relevant groundwater chemistry.

These parameters have some uncertainties, resulting from simplifications of sorption and diffusion processes, simplified groundwater chemistry model, insufficient understanding of the evolution of geosphere and the engineered barriers. In the performance assessment, the parameters assessed as the most realistic were used for a dose calculation of a “likely” scenario. The assessment of the parameters was based on scenario analysis and numerical analysis. The variations of the parameters to account for the uncertainties were analyzed in “less-likely” scenarios.

The paper will describe the data selection process in more detail with emphasis on uncertainties and identify open questions and required R&Ds to resolve them.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

How will new knowledge be reflected to the management of geological disposal? - Influence of an FEP not considered so far to Some sub-scenarios -

Koichi Shin

Central Research Institute of Electric Power Industry
Abiko 1646, Abiko-shi, Chiba-pref, 270-1194 Japan

Key words; *Public Involvement, Stakeholder, Stepwise Decision, Safety Case, FEP, Pressure Solution*

Abstract

Since it became clear that the geological disposal of radioactive high level waste is not realized without the understanding from the society when all siting approaches in western countries in around 1980s tumbled, international communities and OECD/NEA have made efforts to attain the understanding from the society and established important principles concerning social and ethical aspects. Some of the key words are responsibility of present generation, safety case, stepwise decision, stakeholder involvement, preservation of RKM (records, knowledge and memory), and so on. Safety case is stipulated to include the assessment of all features, events and processes (FEPs) that could significantly influence the performance of the disposal system. And as such, the safety case is a document to share the consensus on the safety of a disposal system among the present generation, to serve as the ground for stepwise decision, and to transmit the technical information about the disposal system and our sincere endeavor on it to the future generation. In the stepwise decision, decisions made in the previous steps may be changed based on new scientific knowledge and others.

Meanwhile, an FEP, pressure solution, which has not been dealt with in previous safety case documents, has been pointed out that it can affect the geological disposal system through two sub-scenarios. One is a process of permeability evolution around a disposal tunnel due to mass transfer through pressure solution, diffusion and precipitation. Another one is a process of the sinking of a heavy container in the buffer due to pressure solution creep. This report reviews the pressure solution phenomena and above mentioned two sub-scenarios, points out that the phenomena and sub-scenarios need to be duly addressed in a safety case, and gives a humble thought to fulfilling the responsibility of present generation.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

BARRIER OF NEAR-SURFACE LILW DISPOSAL FACILITY IN KOREA : HYDRAULIC MODEL DEVELOPMENT

Mi-Jin Kwon[1] , Ki-Jung Kwon[2] and Jin Beak Park[1]

Korea Radioactive Waste Agency
[1]Technology institute, Korea Radioactive Waste Agency,
168 Gajeongro, Yuseong-gu, Daejeon 34129, KOREA

[2]Technology institute, Korea Radioactive Waste Agency,
168 Gajeongro, Yuseong-gu, Daejeon 34129, KOREA

Key words; *Low and Intermediate level Radioactive Waste (LILW), vault type near-Surface disposal, multiple engineered barrier cover system, FEFLOW*

Abstract

The primary objective of engineered barrier of low and intermediate level radioactive waste disposal facility is to limit the amount of water ingress that passes through the engineered barrier and to limit the amount of water contacting to waste packages. From the mid of 2015, the silo type disposal facility for low and intermediate level radioactive waste disposal started for its operation as first stage. As second stage, the vault type near-surface disposal facility is being prepared in Korea. The second stage facility is composed by the multiple engineered cover barrier system so that the influences by rainfall are reduced, and thus leakage of radioactive substances can be minimized. The cover barrier is composed of different layers including surface layer, protective layer, drainage layer and barrier layer. In this paper, Hydraulic model to predict the rainfall infiltration through the engineered cover barrier is prepared and assessed by two-dimensional groundwater flow model FEFLOW.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Numerical Simulation of the Thermal Performance of a Dry Storage Cask for Spent Nuclear Fuel

Chi-Ming Lai, University Distinguished Professor
Department of Civil Engineering, National Cheng Kung University
1, University Rd., Tainan City, 701, Taiwan R. O. C.; cmlai@mail.ncku.edu.tw

Rong-Horng Chen, University Distinguished Professor
Department of Mechanical and Energy Engineering, National Chiayi University
300, Syuefu Rd., Chiayi City, 600, Taiwan R. O. C.

Chu-Tsen Liao, Assistant Professor
Department of Creative Design and Architecture, National Kaohsiung University
700, Kaohsiung University Rd., Kaohsiung City, 811, Taiwan R. O. C.

Ting-Yi Wang, Undergraduate Student
Department of Civil and Environmental Engineering, National Kaohsiung University
700, Kaohsiung University Rd., Kaohsiung City, 811, Taiwan R. O. C.

Heui-Yung Chang, Associate Professor
Department of Civil and Environmental Engineering, National Kaohsiung University
700, Kaohsiung University Rd., Kaohsiung City, 811, Taiwan R. O. C.

Keywords: *dry storage cask; spent nuclear fuel; salt particle collection; thermal performance; heat transfer*

Abstract

In this study, the heat flow characteristics of a dry storage cask were investigated and the effect of installing a salt particle collection device on the thermal performance of the dry storage cask was evaluated, via thermal flow experiments and a computational fluid dynamics (CFD) simulation. The results indicate that there are many inner circulations in the cask's flow channel (the channel width is 10 cm). They affect the channel airflow efficiency, which in turn affects the heat dissipation of the dry storage cask. The daily operating temperatures of the top concrete lid and the upper locations of the concrete cask are higher than permitted by the design specification. The installation of the salt particle collection device has no negative impact on the thermal dissipation performance of the dry storage cask.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Influence of inherent and stress-induced anisotropy of hydraulic conductivity on the Groundwater Flow around a rock tunnel

[1]Huang-Kuei Chu, [1]Po-Sung Lai and [1]Jia-Jyun Dong

[1]Graduate Institute of Applied Geology, National Central University, Taiwan (R.O.C.)
No. 300, Zhongda Rd., Zhongli District, Taoyuan City 32001, Taiwan (R.O.C.)

Key words: *inherent anisotropy, stress-induced anisotropic, tunnel excavating, Oda model*

Abstract

The hydraulic conductivity around the disposal tunnel is one of the key parameters for the safety assessment of radioactive waste disposal. This study aims to explore the inherent anisotropy (orientation of the discontinuities) and stress induced anisotropy of the hydraulic conductivity around a rock tunnel. JRC-JCS model is used to estimate the aperture of discontinuities under stress. Based on the calculated stress field via Kirsch solution and the equivalent continuum model, the hydraulic conductivities around a circular tunnel can be calculated. The groundwater inflow of the tunnel is further evaluated via finite difference method. The result shows that the hydraulic conductivity on the tunnel wall is about 1 ~ 2 orders of magnitude larger than the one away from the tunnel (or the one of rock mass under boundary stress). The major principal hydraulic conductivity on the tunnel wall can be 6 ~ 9 times larger than the minor principal value. The principle directions of the hydraulic conductivity near the tunnel wall are also significantly deviated from the tangential and radial directions when the inherent anisotropy is considered. Groundwater flow analysis shows that the total head and the flow velocity are dominated by the inherent and stress induced anisotropy of hydraulic conductivity. Surprisingly, the inflow of the tunnel is insignificantly influenced by the spatial variation of hydraulic conductivity around the tunnel wall.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

DATA QUALIFICATION METHODOLOGY IN THE LITERATURE SURVEY STAGE

Saori Yamada[1], Takanori Kunimaru[1], Kunio Ota[1], Stratis Vomvoris[2] and Niels Giroud[2]

[1]Nuclear Waste Management Organization of Japan (NUMO)
[2]National Cooperative for the Disposal of Radioactive Waste (Nagra)

[1]4-1-23 Shiba, Minato-ku, 108-0014 Tokyo, Japan
[2]Hardstrasse 73, CH-5430 Wettingen, Switzerland

Key words; *Quality Management System, site investigation*

Abstract

The site selection for a deep geological repository in Japan will be undertaken by means of a three-stage process. The initial literature survey (LS) aims at selecting areas for the next preliminary investigation (PI) only on the basis of data from the existing literature. The results of geological characterisation in the PI stage lead to the final detailed investigation.

Key to the LS stage and the evaluation process is the development of a qualified assessment basis for each area. The challenge at this stage is that the vast amount of data in the assessment basis originates from a wide spectrum of activities by third parties – field investigations, laboratory tests and underground constructions – none of which has been performed under NUMO's Quality Management System.

NUMO has been executing a project to develop a strategy on how to evaluate, qualify and include data and information collected by the third parties in the assessment basis. The basic policy for data qualification was defined and a qualification methodology was derived and applied to the data.

The methodology consists of three steps: 1) the assessment of the level of information in a given data record; 2) the assessment of the reliability of the reported values; and 3) the assignment to a qualification level. As an example, for hydraulic data from borehole investigations, the first step considers availability of geological information, information on the location and depth of the test and the reliability of the data source. The second step considers the test method and/or the interpretation method applied. The results of these steps are combined to provide the final qualification level of data: (A) qualified, (B) qualified with some degree of uncertainty or limitation in level of information, (C) high uncertainty in the data value or metadata and (D) disqualified.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Mizunami Underground Research Laboratory Project
- Achievment during Phase I/II and Important Issues for Phase III -

Katsuhiro Hama

Tono Geoscience Center
Japan Atomic Energy Agency
1-64, Yamanouchi, Akiyo-cho, Mizunami-city, Gifu prefecture 509-6132 JAPAN

Key words; *MIU Project, Site Characterization Technology*

Abstract

The Mizunami Underground Research Laboratory (MIU) project is being pursued by the Japan Atomic Energy Agency (JAEA) to enhance the reliability of geological disposal technologies in the crystalline host rock (granite) at Mizunami City in Gifu Prefecture, central Japan. The project proceeds in three overlapping phases, Surface-based investigation Phase (Phase I), Construction Phase (Phase II) and Operation Phase (III). The MIU Project has been ongoing the Phase III. During Phase I, a step-wise investigation was conducted by iterating investigation, interpretation, and assessment, thereby understanding of geologic environment was progressively and effectively improved with progress of investigation. An optimal procedure from investigation to assessment was compiled as a set of geosynthesis data flow diagram for each investigation step. During Phase II, we have evaluated adequacy of techniques for investigation, analysis and assessment of the deep geological environment established in the Phase I. For Phase III, three important issues were identified based on the latest results.

(1) Development of countermeasure technologies for reducing groundwater inflow,
(2) Development of modeling technologies for mass transport,
(3) Development of drift backfilling technologies.

For the issue (1), post-grouting works have been applied to a gallery at 500 m depth. Three grouting concepts were applied to the post-grouting works; a new grout material, a new injection system, and a new post-grouting zone. For the issue (2), in-situ and laboratory mass transport experiments have been carried out. The macroscopic and microscopic observations were carried out to understand the distribution of tracer (uranine) after the laboratory diffusion experiment. For the issue (3), with a focus on hydraulic pressure and hydrochemical recovery processes around underground galleries in fractured crystalline rock, the groundwater recovery experiment has been conducted to evaluate the natural groundwater and hydrochemical recovery of the rock mass.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Virtual reality geological modeling for the Horonobe Underground Research Project

Takayuki MOTOSHIMA, Civil Engineering Dept., Nuclear Facilities Division, TAISEI Corporation
Makito NAGO, Advanced Technology Development Dept., Taisei Technology Center, TAISEI Corporation
Yuji Ijiri, Civil Engineering Dept., Nuclear Facilities Division, TAISEI Corporation
1-25-1 Nishi Shinjuku, Shinjuku-ku, Tokyo

Key words; *Virtual Reality, Horonobe URL, geological information*

Abstract

Since the high level waste disposal program is a project with high public interest, the site selection process should be carried out through open discussion with necessary and sufficient information. Providing only information requiring expert knowledge in interpretation, such as conventional two-dimensional drawings (geological map and etc.) and one-dimensional information (boring log and etc.) may not be sufficient to develop public understanding at the discussion forum.

Virtual reality (VR) and Construction Information Management technology are considered to be effective for collection, analysis and visualization of the geological information of the underground, which cannot be visually confirmed easily. In this study, focusing on the effect of VR, a VR model was created by integrating geological data, photographs, and three-dimensional profile of tunnel face acquired during the construction of the Horonobe Underground Research Laboratory owned and operated by Japan Atomic Energy Agency. The VR model is new and significant in that it uses measurement data of the field.

In the VR model, various information could be viewed at any point and compared. The use of the VR model allowed stakeholders to have simultaneous visual access to the geological information and to achieve a smooth communication. In addition, the model provided visually clear discussion materials, such as allowing access to geological information covered with concrete even after construction. The model can also be used for planning the subsequent construction work and research studies. The use of the VR model will not only provide information for the discussion forum during the investigation stage but also contribute to enhance the safety and the interpretability of the disposal project by incorporating and updating the geological information acquired during the construction and the operation of the repository into the model.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Latest rock grouting technologies under sea water in Nordic countries and Japan

Masakuni Tsuji, Civil Engineering Technology division, Shimizu Corporation;
Mitsunobu Okihara, Civil Engineering Technology division, Shimizu Corporation;
Hitoshi Nakashima, Research Institute of Technology, Shimizu Corporation;
Toshinori Sato, Horonobe Underground Research Center, JAEA;
Kazuhei Aoyagi, Horonobe Underground Research Center, JAEA.

No. 16-1, Kyobashi 2-chome, Chuo-ku, Tokyo 104-8370, JAPAN

Key words; *geological disposal, Nordic countries, sea water condition, rock grouting, activated silica colloid, colloidal silica grout*

Abstract

In Japan, the coastal area is discussed to be a more suitable area for the geological disposal in the aspect of transportation in the council held by Agency for Natural Resources and Energy. However, the engineering technology or safety assessment has not been fully studied as an aspect for applying to the coastal area. Regarding the engineering technology, the rock grouting for the geological disposal has been recently studied as one of the most important engineering technologies. Although the cement grout has not been reported to be affected by the sea water, the latest material for rock grouting called “colloidal silica” is known to be affected by the saline water. The colloidal silica grout is composed of activated silica colloid and the mechanism of gelling and the grouting methodology under the sea water is not yet established.

Therefore, a research project on grouting under the sea water was established, as a part of the public offered project by Agency for Natural Resources and Energy, in order to enhance the rock grouting technology under the sea water. During this project, we studied the latest grouting technologies for geological disposal in Nordic countries and Japan by article survey and a grouting workshop held in Helsinki, Finland in January 2017.

As a result, it was found that the problems and the approach for countermeasures for grouting under sea water are different between Japan, Sweden, and Finland, which are based respectively on the mixture, on the design method, and on the controlling method. It seems the best solution for developing this grouting technology is to combine each technology and to optimize grouting design, mixing, and controlling method. As for this Japanese project, it was found important to develop the generic mixing method under the saline water by referring to a previous project in Japan.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Strategic and Technical Aspects in RD&D Program Development for HLW Disposal System in Korea

JeongHyoun Yoon*, JeongHwan Lee, and SeungHyun Kim

Radioactive Waste Disposal R&D Dept,
Korea Radioactive Waste Agency (KORAD)
168 Gajeongro, Yuseong-gu, Daejeon 34129, KOREA

***Keywords: HLW** disposal, RD&D, Disposal system, URL(Underground Research Laboratory)*

Abstract

This paper is focused on Strategic and Technical Aspects in RD&D Program for Development of HLW Disposal System in Korea. As the High-Level Radioactive Waste Management Basic Plan was deliberated and voted by the final Nuclear Energy Promotion Committee in 2016, the URL for licensing is to be constructed and operated within the permanent disposal site to ensure timely management facilities. In addition to a permanent disposal facility, the research URL(generic) is to be built separately from the management facility so that the programs for the site selection, design, construction and operation of the disposal facility would be materialized in a timely manner. Therefore, it is required to develop a RD&D program for the URL operation for the demonstration of the disposal system considering the site selection schedule and the status and characteristics of domestic high-level radioactive waste. The preconditions for deriving RD&D programs for research URL are the preferred rocks to be disposed of, the standard disposal system, the type of spent fuel, and the regulatory technology guidelines. Consequently, RD&D program in associated with disposal program should be prepared taking into accounted of strategic and technical aspects to minimize trial-and-error. This paper shows what are strategic and technical factors in preparation of RD&D program to implement Korean HLW disposal system and a future plan for the elaboration of the program.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Study on gas migration behavior through bentonite buffer material

Tomoyuki SHIMURA*, Shinichi TAKAHASHI*, Masanobu NISHIMURA*,
Kazumasa KOGA** and Hitoshi OWADA**

* Obayashi Corporation,
** Radioactive Waste Management Funding and Research Center

* 2-15-2, Konan, Minato-ku, Tokyo, Japan
** Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan.

Key words; *Radioactive waste disposal, bentonite buffer, gas migration, performance assessment*

Abstract

Gasses generated due to the corrosion of metals contained in the waste packages and engineered buffer materials will accumulate in the engineered buffer system (EBS) of a radioactive waste repository, and may affect long-term stabilities of the EBS. To evaluate gas migration behavior through the bentonite buffer materials in conjunction with a reasonable design model is one of the challenges to be solved for the performance assessment of a radioactive waste repository.

A series of studies funded by the Ministry of Economy, Trade and Industry (METI) have been conducted for more than 10 years under the leadership of Radioactive Waste Management Funding and Research Center (RWMC) in Japan to better understand gas migration behavior through bentonite. In this report, the outline of the framework of the gas migration study by RWMC as well as some of the results from laboratory gas injection tests are presented.

The laboratory test results focusing on the interface of bentonite materials showed that water flow through the interface part was blocked (self-healed) due to the swelling of the bentonite. In addition, the gas injection test after full saturation indicated no significant differences in breakthrough pressure compared to the intact (e.g. no interface) specimen. These findings suggest that the interface is unlikely to become a dominant gas migration pathway in a saturated buffer.

It is expected that all of findings acquired through this decade of study are summarized and integrated within this fiscal year (2017) taking into consideration the parallel studies on gas scenario development and integration of coupled modelling, and contribute to the reliable advanced repository design and performance assessment.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

MIGRATION EXPERIMENT OF VOID AIR IN BUFFER MATERIAL DURING SEEPAGE

Naohiko TAKAMOTO[*1], Ichizo KOBAYASHI [*2], Masahiro KAWAKUBO[*1], Masataka IMAI[*1] and Tomoko ISHII[*1]

*1 Radioactive Waste Management Funding and Research Center
Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan

*2 Kajima Corporation
2-19-1, Tobitakyu, Chofu city, Tokyo, 182-0036, Japan

Key words; *Geological disposal, Engineered barrier, Buffer material, Seepage, Void air*

Abstract

The buffer material composing engineered barrier system (EBS) for the geological disposal of high-level radioactive waste in Japan plays many important roles, e.g. mechanical protection, hydraulic barrier, chemical buffer, controlling migration radionuclides.

Radioactive Waste Management Funding and Research Center has been focusing on the re-saturation process of the buffer material with groundwater after the emplacement and researching mainly on the mechanical behavior of the buffer material. The state transition of the buffer material is the most intense during this period, and the state after the period will impact to the continual long-term behavior. Thus, it is important to predict the state after re-saturation process for assessing the long-term integrity of the buffer material. In this study, we investigated the migration of void air, which is one of the phenomena affecting the state transition of the buffer material during the re-saturation period. In order to understand the pressure increasing of void air in the swelling buffer material, one-dimensional long-term simulations were conducted. As a result, it was obtained that the pressure increasing of void air was mitigated by dissolution of the void air to water in parallel with water seepage into the buffer material. Therefore, unless the influence of heat and gas from the overpack is taken into account, it was estimated that there is little concern that the buffer material breaks by pressure increasing of void air.

This research is under a grant from the Japanese Ministry of Economy, Trade and Industry (METI).

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

STUDY ON PIPING AND EROSION OF BUFFER MATERIAL DURING THE RE-SATURATION PERIOD

Takayuki ABE[*1], Ichizo KOBAYASHI [*2], Masahiro KAWAKUBO[*1], Masataka IMAI[*1] and Tomoko ISHII[*1]

*1 Radioactive Waste Management Funding and Research Center
Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan

*2 Kajima Corporation
2-19-1, Tobitakyu, Chofu city, Tokyo, 182-0036, Japan

Key words; *Geological disposal, Engineered barrier, Buffer material, Piping, Erosion*

Abstract

The state transition of buffer material (clay) which composing engineered barrier system (EBS) for the geological disposal of high-level radioactive waste is the most intense during the re-saturation period after the emplacement into the disposal cell. For evaluating and predicting of long-term evolution of buffer material, it is important to grasp the behavior of the buffer material during the re-saturation period.

The buffer material have to maintain a range of its density in order to perform its long-term safety function. However, it is concerned that buffer material flows out by piping and erosion during the re-saturation period.

In this study, several laboratory tests for piping and erosion of buffer material concerned during the re-saturation period were conducted with various conditions, e.g. material form, interface condition, liquid type, water flow and water pressure. As a result, it was obtained knowledge on the flow out of buffer material, and engineering countermeasures against it.

This research is under a grant from the Japanese Ministry of Economy, Trade and Industry (METI).

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

NUMERICAL ANALYSIS OF INFLOW CONTROL FOR QUALITY MANAGEMENT OF BUFFER MATERIAL USING DISCRETE FRACTURE NETWORK MODEL

Kazuhiko MASUMOTO[*1], Makoto NAKAJIMA[*1], Hayato NONAKA[*1],
Tomoko ISHII [*2] ,Mayumi JO[*2] ,Masataka IMAI[*2] and Hiroyuki ATSUMI[*2]

*1 Kajima Corporation
2-19-1, Tobitakyu, Chofu city, Tokyo, 182-0036, Japan

*2 Radioactive Waste Management Funding and Research Center
Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan

Key words; *Numerical analysis, Groundwater inflow analysis, Discrete fracture network model, Geological disposal, Engineering barrier, Buffer material, Grouting technique*

Abstract

In the vertical disposal concept of high level radioactive waste, it is important to evaluate influence of the groundwater inflow into the disposal pits against performance of buffer material as an engineering barrier because the inflow might cause the erosion of buffer material. The target of this study was to estimate the inflow control technique (e.g. grouting) around the disposal pits using numerical analysis. The model for the inflow simulation should be a discrete fracture network model when the groundwater mainly flows along the fractures in the rock mass, therefore, the discrete fracture network model was selected to estimate the inflow control technique in this study.

The numerical flow analysis was conducted by LT-Flow, that is, the groundwater simulation program using pipe network structure, into which the fracture network was converted. Firstly the single disposal tunnel was modelled for the simulation, and secondly the five disposal tunnels were modelled assuming the disposal panel. The results of numerical flow analysis shows that the effectiveness of grouting for the disposal pits to control the inflow and the impact of grouting for the other disposal pits or surrounding disposal tunnel could be evaluated quantitatively.

This research is a part of “Development of Advanced Technology for Engineering Components of HLW Disposal” under a grant from the Japanese Ministry of Economy, Trade and Industry (METI).

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

DEVELOPMENT OF WIRELESS MONITORING SYSTEMS FOR GEOLOGICAL DISPOSAL

Kazuhiro TSUBONO[*1], Masato KOBAYASHI[*1], Hiromitsu YAMAKAWA[*1], Akinori HASUI[*1]
Kazuhiko MASUMOTO[*2], Tomoaki MATSUSHITA[*2], Norihisa SUGAHARA[*3],
Tatsuya TANAKA[*4] and Chiaki NAGAI[*4]

*1 Radioactive Waste Management Funding and Research Center
Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan
*2 Kajima Corporation
2-19-1, Tobitakyu, Chofu city, Tokyo, 182-0036, Japan
*3 Sakata Denki Co., Ltd.
2-17-20, Yagisawa, NishiTokyo city, Tokyo, 202-0022, Japan
*4 Obayashi Corporation
Shinagawa Intercity Tower B 2-15-2, Konan, Minato-ku, Tokyo, 108-8502, Japan

Key words; *Radioactive waste, Geological disposal, Engineering barrier, Wireless monitoring systems, Wireless transmission, Low frequency electromagnetic waves, Wireless power transfer, Magnetic resonance coupling*

Abstract

In developing a monitoring program for geological disposal of radioactive waste, it is important that measuring instruments and cables do not affect the performance of the engineering barriers. Several studies have been conducted with underground wireless transmission systems; wireless transmission technology for data transmission and wireless power transfer technology for long-term power supply for monitoring systems.

We have studied a wireless transmission technology with low frequency electromagnetic waves and its applicability to geological disposal monitoring systems. The applicability has been increased by reducing the size of both transmitting and receiving devices. We have also increased the redundancy of the wireless transmission systems by developing multistage relay devices and transmission path changing technologies. Moreover, in cooperation with the Horonobe Underground Research Center and the Mizunami Underground Research Laboratory of Japan Atomic Energy Agency, verification tests for radio communication have been conducted, with the use of the transmitter and receiver, and we have confirmed its technical feasibility.

Meanwhile, underground monitoring devices have some challenges such as the limited capacity of the battery. In view of this, we have studied a wireless power transfer technology using a magnetic resonance coupling method. Through design and trial productions of transmission and reception coils, and experiments for power transfer efficiency and optimum frequency, the power transfer over a buffer material has been confirmed to be viable. In the elemental tests carried out so far, we evaluated the effects on the power transfer efficiency of cementitious structures and reinforcement steel used in plugs in the repository, demonstrating its applicability to geological disposal facilities. In the presentation, we report the latest development results of the underground wireless transmission technology and the wireless power transfer technology.

This research and development is under a grant from the Japanese Ministry of Economy, Trade and Industry (METI).

Session 5C-2

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

FEASIBILITY STUDY OF VENTILATION DESIGN FOR UNDERGROUND FACILITIES

Naoki Katsumata[1)], Ryoji Yahagi[2)], Hiromi Kurosaki[2)] and Shigeru Kubota[1)]

Nuclear Waste Management Organization of Japan (NUMO)[1)]
1-23, Shiba 4-chome, Minato-ku, Tokyo 108-0014 Japan

SHIMIZU CORPORATION[2)]
2-16-1, Kyobashi, Chuo-ku, Tokyo 104-8370 Japan

Key words; *operational safety, ventilation system, underground facility layout*

Abstract

NUMO has developed a generic Safety Case on deep geological disposal repository in Japan. In this report, based on the safety assessment results, the prospect will be shown that safety in the pre-closure and post-closure phases will be ensured.

This paper provides the outline of the ventilation system design during construction and operation. The underground facility has very long disposal tunnels and complicatedly. Therefore, to confirm the feasibility of design for ventilation system essential to the workers during construction and operation is difficult.

Consequently, to confirm the feasibility of design for ventilation system not only in the normal state but also in the abnormal state is important for the operational safety.

The outbreak of the fire should be considered as one of the accident in relation to the ventilation system in the underground facilities.

It is suitable countermeasures that non-flammable and/or flame-retarding materials are utilized for all construction as measures to prevent occurrence of fire in the underground facilities. On the other hand, the unusual fire event of vehicle failure or collision should be considered.

In spite of these preventing measures, if the incident is greatly beyond the assumption, fire would occur due to the failure or collision of transport vehicle. In case of fire in the underground facilities, workers safety evacuation and disaster expansion prevention is what it’s all about.

Therefore, it is indispensable for securing of operational safety to get a prospect of the feasibility of the ventilation system not only in normal state but also in abnormal state.

As a result, by considering the ventilation system during the operation phase for the safety, the requirements to the layout of the underground facilities was clarified in this paper.

Currently no potential site has been decided yet, these requirements can be used in future reference.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Establishment and application of control room habitability methodology for Maanshan nuclear power plant

Kai-Chun Yang [1],Jong-Rong Wang [1,2], Hsiung-Chih Chen [1,2,3], Shao-Wen Chen [1,2], Chunkuan Shih [1,2] and Wen-Sheng Hsu [3]

[1] : Institute of Nuclear Engineering and Science, National Tsing Hua University
2 : Nuclear and New Energy Education and Research Foundation
3 : Nuclear Science and Technology Development Center. (R.O.C.)
No. 101, Section 2, Kuang-Fu Road, Hsinchu, Taiwan 30013, R.O.C.

Key words*; RADTRAD, HABIT, Habitability*

Abstract

In this study, we focus on the establishment and application of the control room habitability methodology for Maanshan PWR nuclear power plant (NPP) by using RADTRAD and HABIT codes. Therefore, there are two steps in this study. The first step is to use RADTRAD and HABIT codes to establish the analysis methodology. The Final Safety Analysis Report (FSAR), reports, and other data for Maanshan NPP were used in this step. In addition, the RADTRAD and HABIT models were also established in this step. Second, this analysis methodology was applied to evaluate the control room habitability for the LOCA and CO2 storage burst cases. The analysis results of RADTRAD for the LOCA were similar to FSAR data. The HABIT results for the CO2 storage burst case were below the R.G. 1.78 failure criteria. The above results indicate that Maanshan NPP habitability can be maintained.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

international cooperation activities of KORAD including mid-term and long-term strategy of international cooperation for radioactive waste management

Ou Jeong YOO and Gyeong Hwan PARK

International Cooperation Team, Korea Radioactive Waste Agency (KORAD)
Chunghyocheong-gil 19, Gyeongju-si, Gyeongsangbuk-do, Republic of Korea,

Key words; *international cooperation strategy, international cooperation activities, consistent with radioactive waste management project, meeting, joint work, IAEA projects*

Abstract

As radioactive waste management has been a challenging issue in every country using nuclear energy, international cooperation is an important tool for competency building of each organization responsible for radioactive waste management and related activities. Efforts have been increasingly made in order to find out the solutions to safe and effective management of radioactive waste by means from information and knowledge sharing to joint work among the nations.

Under this circumstance, KORAD established the mid-term and long-term strategy of international cooperation, consistent with the roadmap and plan of radioactive waste management, assuming that international cooperation activities should have the function of support to the radioactive waste management project. The international strategy was set as result of the analysis of political, economic, social and technical environment, level of competency of KORAD and overseas implementing organizations, and analysis of SWOT (Strength, Weakness, Opportunity and Threat). Based on the strategy, KORAD has carried out various international cooperation activities, such as having cooperation meetings, launching joint works, and initiating IAEA projects by sending the expert and providing extra budgetary contribution to IAEA. Also, the international cooperation strategy is regularly revised to enhance its feasibility by reflecting the changes of internal and external environment regarding radioactive waste management.

The process and result of the international cooperation strategy-making will be introduced and its implementation will be presented in detail at the paper.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Metadata in Geological Disposal of Radioactive Waste: The RepMet Libraries

[1]CAMPHOUSE, Russell C., [2] CIAMBRELLA, Massimo; [1] MCMAHON, Kevin

[1] Sandia National Laboratories
Performance Assessment and Decision Analysis Department
Carlsbad, New Mexico USA

[2] Nuclear Energy Agency (NEA)
Radioactive Waste Management Division
Paris, France

Key words; *repository, waste package, site characterization, waste management*

Abstract

OECD Nuclear Energy Agency (NEA) launched the Radioactive Waste Repository Metadata Management initiative (RepMet) in 2014 under the auspices of the Integration Group for the Safety Case (IGSC) technical body. RepMet's goal is to recommend sets of metadata that can be used by national radioactive waste repository programmes to manage their data, information, and records thereof, in a way that is both harmonised internationally and suitable for long-term management and utilisation, e.g., in safety cases. Furthermore, the initiative that involves over ten different countries' programmes worked on the formulation of a consistent set of guiding principles for capturing and generating metadata, recommending a shortlist of selected relevant standards and guidelines on international good practises.

A main intent of RepMet is to provide descriptions of conceptual data models and controlled vocabularies, forming the so-called "libraries" in the project context, which support data and metadata use for relevant topics within radioactive waste repository programmes. The data models are logically structured collections of relationships between types of data, metadata and real-world objects. They are developed at the conceptual level, providing a high-level description of the logical and semantic organisation between different library data and metadata elements. The controlled vocabularies enhance the semantic description and searchability of the library contents, providing important tools and methodologies for the eventual data system interoperability. Libraries are well defined and can be easily customised and implemented by a radioactive waste management organization within their data storage system.

RepMet has developed libraries across three disciplines relevant to radioactive waste repositories. This paper describes the three libraries and discusses their relationship to the overall RepMet initiative. The topic libraries are reported in the table below, together with the corresponding disciplines and topics.

Disciplines	RepMet Libraries	Topics
Geoscience	*Site Characterisation Library*	Geological and geophysical characterisation of the repository site.
Radioactive Waste Management	*Waste Package Library*	Packaged waste and spent nuclear fuel ready for final disposal at the repository.
Engineering	*Repository Library*	Repository requirements and structure at closure.

Sandia National Laboratories is a multimission 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. SAND2017-6741 A

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Metadata in Geological Disposal of Radioactive Waste: The RepMet Initiative

[1] CIAMBRELLA, Massimo; [2] MCMAHON, Kevin; [3]FEKETE, József I.

[1] Nuclear Energy Agency (NEA)
Radioactive Waste Management Division
Paris, France

[2] Sandia National Laboratories
Nuclear Waste Disposal Research and Analysis
Albuquerque, New Mexico USA

[3]Public Limited Company for Radioactive Waste Management
Budaörs, Hungary

Key words*; repository, metadata, waste management*

Abstract

OECD Nuclear Energy Agency (NEA) launched the Radioactive Waste Repository Metadata Management initiative (RepMet) in 2014 under the auspices of the Integration Group for the Safety Case (IGSC) technical body. RepMet's goal is to recommend sets of metadata that can be used by national radioactive waste repository programmes to manage their data, information, and records thereof, in a way that is both harmonised internationally and suitable for long-term management and utilisation, e.g., in safety cases. Furthermore, the initiative that involves over ten different countries' programmes worked on the formulation of a consistent set of guiding principles for capturing and generating metadata, recommending a shortlist of selected relevant standards and guidelines on international good practises.

National radioactive waste repository programmes require large amount of data across multiple disciplines (e.g. geoscience, radioactive waste management, engineering) that increase as these programmes proceed in number, type and quality for multiple reasons and goals (e.g.: site characterisation, licensing, safety case elaboration, etc.). Considering these boundary constraints, the core idea of long-term data management is that "data are being collected and managed for others to use them". Next generations of data-users have to be able to understand and access the information that the preserved data represent. Individual scientists and research teams, as well as managers and communications specialists, need to be aware of this and document their work accordingly.

RepMet is facilitating their task by bringing about a better understanding of a key aspect of the modern data management within the field of radioactive waste disposal, namely the identification and management of metadata. The initiative has analysed the metadata implementation both from the high-level point of view (i.e. methodologies, approaches, organisation policies) and from a more technical one (i.e. recommendation and application of selected metadata standards, data modelling techniques and implementation of controlled dictionaries).

The RepMet initiative fills a unique and important niche in the broader programmes on data, information and knowledge management that are conducted nationally and internationally by operators, regulators and other relevant actors in the radioactive waste management field. This paper provides an overview of the initiative and the status of the initiative as of the time of this writing.

Sandia National Laboratories is a multimission 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. SAND2017-6740 A

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Spent Nuclear Fuel Final Disposal
Knowhow, Methodology and Technology Transfer

Magnus Holmqvist

SKB International AB
Box 1091, SE-101 39 Stockholm, Sweden

Key words*; final disposal, design, performance assessment, safety assessment, competence development, knowhow transfer, technology transfer, KBS-3*

Abstract

Taiwan Power Company (TPC) has been tasked by the government to make a Technical Feasibility Assessment Report on Spent Fuel Final Disposal (SNFD2017) to show the status and the technical capability of spent fuel disposal in Taiwan. The starting point has been using a granitic rock reference case and adopting the KBS-3 concept developed in Sweden and Finland.

The basis for the SNFD2017 report is a design and a performance and safety assessment based on Taiwanese conditions. TPC identified the need for competence development through the transfer of knowhow, methodology and technology for the successful completion of the SNFD2017 report.

SKB International has since 2015 provided support and advice to TPC based on the best knowledge worldwide and the most up to date methodology for performance and safety assessment. The support has been given as a series of seminars and workshops to transfer knowhow, methodology and technology gained and developed by SKB since the mid 1970-ties. The Taiwanese team has in parallel to the seminars and workshops developed the performance and safety assessment for disposal in Taiwan. The work, as well as the report has been reviewed and commented by KBS-3 experts in an iterative process.

The most evident result of the cooperation has been the completion of the SNFD2017 report, behind which lies a quick learning process and subsequent utilization within TPC and its suppliers. It is evident that TPC and its suppliers has gained a good understanding of the thinking and reasoning that lies behind assessments, decisions and designs and are hence in a much better position to continue the work to realize a repository in Taiwan.

It can be concluded that transferring knowhow, methodology and technology in an iterative process where transfer and support activities are mixed with actual work on a prioritized activity such as the SNFD2017 report is successful. The SNFD2017 provided a strong driving force and a clear end goal, which has motivated all involved to excel.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Sulfide Corrosion by Sulphate-Reducing Bacteria in MX-80 Bentonites

Lee, Szu-Wei* and Chang, Ching-Tu

Institute of Nuclear Energy Research, Atomic Energy Council
1000 Wenhua Rd. Jiaan Village, Longtan District, Taoyuan City 32546, Taiwan

Key words; *Sulphate-Reducing Bacteria, safety assessment, diffusion coefficients*

Abstract

In the safety assessment of the Spent Nuclear Fuel Final Disposal Program, the corrosion behavior of copper canister caused by the sulfide is an important issue. One of the engineered barrier materials bentonite adjoining the canisters function is to prevent the harmful substances from the outside to be in contact with the canisters; however, the corrosive sulfide could exist in bentonites, and corrosion of the copper canisters could happen. One of the most important sources of sulfide comes from the sulphate-reducing bacteria (SRB) group, which live naturally in underground water and clays. When active, the bacteria will reduce sulfate and produce sulfide; therefore, the knowledge of the SRB sulfide production and canister corrosion mechanisms, and relevant experiments should be developed.

One of the strong restrictions against the microbial activity is the swelling pressure, which is dependent on compacted density of the buffer. The investigation of how well the SRB activity is inhibited by the increasing density of MX-80 bentonite is developed, and related works are done in progress. In addition, the diffusion experiments of sulfate are set up to obtain diffusion coefficients in the saturated MX-80 compacted bentonite.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Adsorption of Uranium(VI) on the MX-80 Bentonite

Ying-Chieh Lin

Sinotech Engineering Consultant, Ltd..
171, Nanking E. Rd., Sec. 5, Taipei 10570, Taiwan

Key words; *Adsorption, Bentonite, HYDROGEOCHEM, Uranium(VI)*

Abstract

In present work, a coupled model of groundwater flow, thermal transport, and geochemical transport through saturated-unsaturated media, HYDROGEOCHEM, has been employing to simulate the uranium adsorption on the MX-80 bentonite. The numerical experiments were performed with different sodium and hydrogen concentrations. Uranium concentrations were kept below 10^{-7} mol/L to avoid precipitation of amorphous uranium-hydroxide. Adsorption of uranium on the bentonite shows significant dependency on sodium concentration, because of the competition between uranium and sodium ions. The numerical simulations of uranium transport in the MX-80 bentonite had also been proposed with fresh groundwater and salt water conditions. These simulations show that the composition of groundwater could influence the retarded capacity of bentonite and also affect the balance of mineralogy

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Am(III)/Nd(III) INTERACTIONS WITH BORATE: EXPERIMENTAL INVESTIGATIONS OF $Nd(OH)_3$(micro cr) SOLUBILITY IN NaCl SOLUTIONS IN EQUILIBRIUM WITH BORAX

Yongliang Xiong[1)*], Leslie Kirkes[1)], Cassie Marrs[1)] and Jandi Knox[1)]

[1)]*Sandia National Laboratories (SNL), Carlsbad Programs Group, 4100 National Parks Highway, Carlsbad, NM 88220, USA*

***Key words**; Nuclear Waste Management, Waste Isolation Pilot Plant (WIPP), Salt Formation, Rare Earth Elements*

Abstract

In previous studies on Am(III)/Nd(III) interactions with borate, the borate concentrations were kept at a relatively low level, up to ~0.16 mol•kg^{-1} as the highest. Such concentrations of borate are not saturated, in terms of borate, with borate-bearing phases such as borax ($Na_2B_4O_7$•$10H_2O$) and tincalconite ($Na_2B_4O_7$•$5H_2O$) that could be present in geological repositories. For instance, tincalconite has been observed as a corrosion product for boroslicate glass for HLW under the repository conditions in China.

In this study, we examine the Nd(III) interactions with borate in equilibrium with borax in a wide range of NaCl solutions at 25°C. In our experiments, the solubility-controlling phase for Nd(III) is $Nd(OH)_3$(micro cr). In synthesis of $Nd(OH)_3$(micro cr), we followed the procedure from literature. First, high purity Nd_2O_3 was loaded into Paar® reaction vessels with deaerated DI water, and then the reaction vessels were sealed in a glovebox under a positive pressure of an inert gas. The reaction vessels were removed from the glovebox and placed into a muffle furnace. $Nd(OH)_3$(micro cr) formed when the high purity Nd_2O_3 reacted with the deaerated DI water at 200°C in Paar® reaction vessels for a period of two weeks. Second, following the synthesis step, the reaction vessels were then transferred back into the glovebox, and were opened for drying in an atmosphere of inert gas. This synthesis method assures the complete conversion of Nd_2O_3 to $Nd(OH)_3$(micro cr), as demonstrated by XRD and SEM-EDS characterizations. Note, the deaerated DI water used in the synthesis was prepared by vigorously bubbling high purity Ar or N_2 gas through the DI water for a minimum of 30 minutes in the glovebox. This deaeration process was intended to remove any dissolved CO_2 and therefore ensure the synthesis process was not contaminated by carbonate.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Microbial DNA; A brand-new tracer of groundwater flow

[1]Ayumi Sugiyama, [2]Kenji Kato, [2]Kazuyo Nagaosa, [1]Tetsuo Ibara, [1]Kazuyoshi Takenobu, and [3]Atsunao Marui

[1]Asano Taiseikiso Engineering Co., Ltd., 2-8-7, Kitaueno, Taitou-ku, 110-0014, Tokyo, Japan,
[2]Department of Geoscience, Faculty of Sciences, Shizuoka University
[3]Geological Survey of Japan,
National Institute of Advanced Industrial Science and Technology (AIST)

Key words; *Microbial DNA, groundwater flow path, Brand-new tracer*

Abstract

To understanding better how the groundwater flow passes and its influence on the water chemistry we employ a brand-new method to analyze microbes with abundance and community constituents in groundwater. In the previous studies, estimation of transit time and groundwater flow path by groundwater flow analysis, estimation of averaged residence time of groundwater by chemical analysis such as various radioactive elements and stable isotopes have been widely used in the study of hydrology. These methods show an averaged value of chemistry of the examined water which was blended by various water with different sources and flow passes in subsurface environment. In order to improve the reliability of these results, we focus on Microbial DNA. Particles represent the place from which they transported. Microbes which are living organisms, express the environment appropriate for their growth. Interaction among rocks - groundwater - microorganisms is studied to evaluate biogeochemical influences on natural barrier of geological disposal facility for high-level-radioactive wastes. This study shows the possibility to reveal the groundwater history such as groundwater flow and the environment from which groundwater flow through analyzing the density of prokaryotes and microbial community structure analysis.

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

Seismic Analysis for the Deposition Tunnel in Fractured Rock by 3DEC

Meng-Hsiu Hsieh and Yuan-Chieh Wu

Institute of Nuclear Energy Research, Atomic Energy Council
No.1000 Wenhua Rd, Jiaan Village, Longtan District, Taoyuan City 32546, Taiwan

Key words*; fracture rock, seismic analysis, 3DEC*

Abstract

In this study, the seismic stability analysis of the deposition tunnel was carried out during the operation of the nuclear fountains in the outlying island crystalline rock test area. Even in the deep intact granite rock mass, there still are some fractures, and these fractures might be the key to the instability of the tunnel during the earthquake. The existed cracks in the deep integrity of the granite body and rock cracks occurred in the tunnel during the earthquake may be the key of instability. In order to ensure the safety of the deposition tunnel, the seismic analysis of fractured rock tunnel should be carried out. In this study, the 3DEC was used to analyze the stability after the excavation of tunnel and the intact rock and fractured rock during the earthquake. The results show that the safety factor after tunnel excavation is directly affected by the fractures, while the safety factor is higher in the intact rock. The results of the seismic analysis show that the impact of the earthquake on the safety factor is relatively small. But the existence of the location of the fractures may still have an impact on stability, and still need to do further study in the future.

Session 6C-3

6th East Asia Forum on Radwaste Management Conference
November 27-29, 2017, Osaka, Japan

GROUNDWATER FLOW ANALYSIS FOR EVALUATING FACTORS ON WATER INFLOW TO THE FACILITY DURING THE OPERATION PERIOD

Masataka IMAI[*1], Minoru EMORI[*1], Tomoko ISHII[*1], Masahiro KAWAKUBO[*1], Kazuhiro TSUBONO[*1], Masayoshi YAMAURA[*2], Tsuneyuki MAEMURA[*2] and Eiko SUGIMOTO[*2]

*1 Radioactive Waste Management Funding and Research Center
Nichirei Akashicho Bldg. 12F, 6-4, Akashicho, Chuo-Ku, Tokyo, 104-0044, Japan
*2 Dia Consultants Co., Ltd.
2-272-3 Yoshino-cho, Kita-ku, Saitama-shi, Saitama 331-0811, Japan

Key words; *Geological disposal, Disposal system, Groundwater flow analysis, Density-dependent flow*

Abstract

In order to ensure the long-term safety of geological disposal system of high level radioactive waste, it is necessary that each component of the disposal system should be maintained its initial performance required from the long-term safety assessment taking into consideration of disturbances caused by construction and operation of the underground facility.

This research is aiming to develop an evaluation method to predict evolution of its state and/or performance of each component focusing on the disturbances during construction and operation. For this evaluation, unsteady groundwater analysis is necessary to consider the hydraulic characteristics of the site and the staged shape transition of its underground facility during construction and operation. For this developing purpose, the coastal site was examined as a test case.

First, numerical simulations of density-dependent groundwater flow were performed by using a simple two-dimensional vertical model taking into consideration of the operation process, and major factors that may affect the underground hydraulic environment were summerized. Then, we conducted three-dimensional groundwater analysis on different regional size to evaluate the influence of the operation procedure on water inflow to the facility.

As a result, it's confirmed that the hydrostatic pressure of sea water was a dominant factor on water inflow to the facility. It was also possible to understand the trend of changes in water inflow to the disposal tunnel according to the operation process.
This research is under a grant from the Japanese Ministry of Economy, Trade and Industry (METI).