International Review Workshop on JAEA's URL projects

Current Status of Next Phase Plan

- Mizunami Underground Research Laboratory (MIU) -

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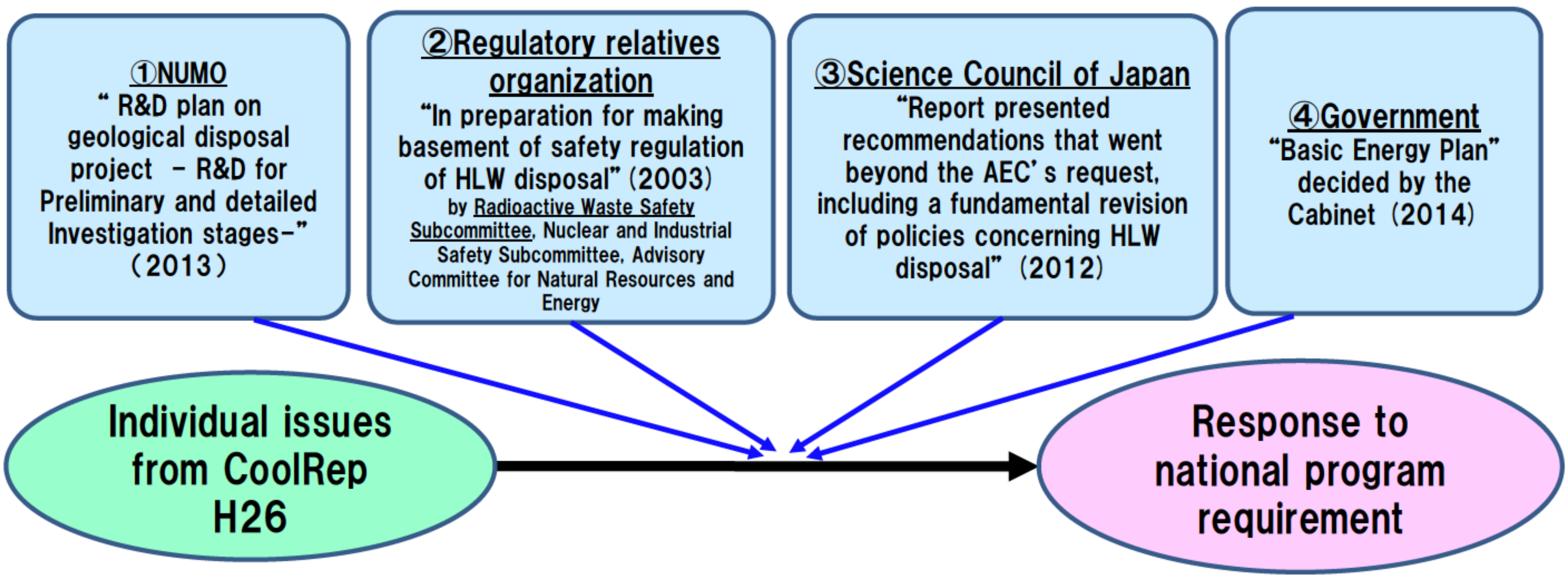
Approach to confirm of importance of response to national program requirements by external needs

Importance of response to the national program requirements were confirmed by assessment of published information (see Slide 3).



External needs considered to confirm importance of response to national program requirements

	Codes
① ***Basic R&D expected for the latter half of detailed investigation stage***, described in " R&D plan on geological disposal project – R&D for Preliminary and detailed Investigation stages– (2013) ***<u>NUMO</u>***" (see the Slide 4 in the presentation material of "Brief reviews on requirements of Japanese implementer and regulator")	
a) Geological environment	①a
b) Design and construction of engineered barrier*	①b
c) Design of underground facility*	①c
d) Safety assessment*	①d
e) Monitoring technology*	①e
② ***Research issues encouraged by regulatory relatives organization***, described in the report of "In preparation for making basement of safety regulation of HLW disposal (2003)" by ***Radioactive Waste Safety Subcommittee***, Nuclear and Industrial Safety Subcommittee, Advisory Committee for Natural Resources and Energy	
• Natural phenomena	②a
• Radionuclide migration through groundwater flow system etc.	②b
③ Urgent issues, such as <u>long-term stability of geological environment</u>, suggested by ***Science Council of Japan*** (2012) from the experience of the Great East Japan Earthquake	③
④ ***Basic Energy Plan*** (2014.4) , decided by the Cabinet described as following, ✓ With effort on the premise of waste disposal, it should be possible for future generation to choose the best disposal method if other better option will be put to practical use, by allowing reversibility and retrievability of radioactive waste. ✓ <u>The investigation and research regarding influence of such a case of maintaining retrievability by keeping repository open should progress</u> in order to bring how to manage HLW into shape until closure of repository	④

*: Partial needs only related to geological environment is targeted in these technical fields.

These codes are used to indicate the relationship with response to national program requirements in Slide 4.

Summarized response to national program requirements

Main individual issues
A1) Identify the initial condition (for siting): ➢ Complete R&D on surface-based investigation by feedback of knowledge on facility closure
A2) Estimate the short-term change/recovery behavior of environmental conditions: ➢ R&D on monitoring and demonstration of the recovery process after closure • R&D on long-term monitoring technology of recovery process to the baseline (or stable) condition • Simulation on environmental changes e.g. GW replacement in facility scale (EdZ) and rock mechanical-hydraulic-chemical process in drift scale (EDZ) • Proposal of appropriate drift/facility closure methods and procedures based on the observations in drift closure ➢ R&D on Mass transport • Development of methodology to understand geological structure, hydraulic characteristics and mass transport property ➢ R&D on grouting technology • Development of water-tight tunnel technology (including post-excavation grouting) • Estimation of influence of artificial materials (cement etc.) to rock mass and groundwater.
A3) Estimate the long-term change/recovery behavior of environmental conditions (for isolation and additional countermeasures): ➢ Developing the possible long-term scenarios by integration of FEPs on post facility closure and on geological environment in more longer time scale ➢ Implication and confirmation of the disturbance of geological environment by earthquake

Response to national program requirements

- ①b ①d ①e ④ → Development of long-term monitoring technology ↔ Development of drift backfilling technology
- ①a ①c ①d ②b → Development of modelling methodology for heterogeneous fracture networks
- ①b ①c ④ → Development of technology to control GW inflow (water-tight grouting technology)
- ①d ②a ③ → Development of technology and methodology for analysis and evaluation of long-term changes in geological environment

Relationship with external needs is represented by codes in Slide 3.

Characteristic geological environment in Japan to make overall design for R&D MIU project

● Located in mobile belt・Young age (High-temperature) rock mass
● Humid warm-temperate climate (high amount of precipitation)

- Active natural phenomena (Earthquake/fault movement, uplift/erosion and volcanism)
- Many fractures with hydrothermally alternated minerals
- Complicated geological structure
- Fast GW circulation

Elements	Japan:MIU URL	Sweden :HRL	References
Rock Uplift rate Geothermal gradient	・Granite: ca. 70 Ma ・Average uplift rate for the last 70milion years: Approx.0.15mm/year ・Geothermal gradient:1.7℃/100m (Average in Japan:3℃/100m)	・Granite: ca.1,800 Ma ・Average uplift rate for the last 2 hundred million: Approx.0.02mm/year ・Geothermal gradient:1.5℃/100m	Yamazski et al. (2012) Soderlund (2008) Stanfors et al. (1999)
Fault/Fracture frequency	Approx.11/m (-300 m Access/Research Gallery)	2.5 -6.5 /m	Result of investigation in drifts
Hydraulic conductivity of fractured rock mass	10^{-6}-10^{-8}m/sec	10^{-8}-10^{-10}m/sec	Mazurek (2001)
Alternation	Approx. 30% of the whole rock mass	Approx. 10% of the whole rock mass	Yoshida et al. (2009)
Fracture filling material	About 30% of fractures are filled with clay material (unconsolidated material)	Very few clay materials are observed as fracture filling material of fractures	
Ease of understanding based on surface investigation	・Existence of over layer (thicknes:100-200m) ・Difference of fault width in over layer and basement of granite	・No existence of over layer ・Possibility of understanding by outcrop and trench investigations etc.	
Groundwater flow Hydrochemical properties	・Annual amount of precipitation:1,500mm ・Average yearly temperature :13℃ ・Salinity concentration:Low (200-400mg/L)	・Annual amount of precipitation:675mm ・Average yearly temperature :6.5℃ ・Salinity concentration: High (800-14,300mg/L)	Mahara et al. (1999) SKB (1999) Iwatsuki et al. (2005) Stanfors et al. (1999)

Goal, phenomena and testing for each response to national program requirements

Response to national program requirements	Goals	Phenomena	Testing	Related Research
Development of long-term monitoring technology	✓ To develop optimal equipment and methodology to monitor GW pressure, chemistry, and mechanical behavior (e.g. monitoring layout considering the hydrogeology, installation and maintenance of monitoring equipment, remote monitoring techniques, observation frequency, long-term durability of equipment) ✓ To demonstrate mechanical, hydraulic and chemical changes in EDZ/EdZ after drift/whole facility closure and to develop its simulation techniques ✓ To demonstrate the tunnel stability and long-term mechanical behavior of rock	✓ Damage and disturbance processes during facility construction operation, and recovery process after facility closure • EDZ: Fracturing in rock, sealing of fractures and alkalization of GW by cement and backfill material • EdZ: Drawdown of GW, shallow water infiltration, deep GW upconing, heterogeneous GW recovery after closure, and redox buffering	✓ Long-term Monitoring in Drift and Facility Scale (EDZ/EdZ)	-MoDeRn (Monitoring Development for safe Repository operation and staged closure) (European Atomic Energy Community) -Enhanced Sealing Projects (ESP) (AECL Manitoba) etc. ●Wireless monitoring technique, etc. used in MoDeRn will be applied in MIU. ●Considered characteristic geological environment in Japan such as complicated network structure of fractures and heterogeneous replacement of GW
Development of drift backfilling technology	✓ To develop investigation techniques for geological condition around drift and appropriate techniques (procedures) for drift closure in Japanese crystalline rock environment ✓ To understand characteristics of backfill material buried in practical underground environment	✓ Saturation or heterogeneous unsaturation of backfill material ✓ Hydraulic and chemical changes caused by backfill materials	✓ Drift Closure Experiment with Backfilling	-DOPAS (Full Scale Development of Plugs and Seals) (EC) -TSX project (AECL/ANDRA/JAEA) -Prototype Repository (SKB) etc. ●Design of plug

EDZ: Excavation Damaged Zone, EdZ: Excavation disturbed Zone (Chin-Fu et al., 2005)

JAEA has participated in the task shown in blue type.

Goal, phenomena and testing for each response to national program requirements

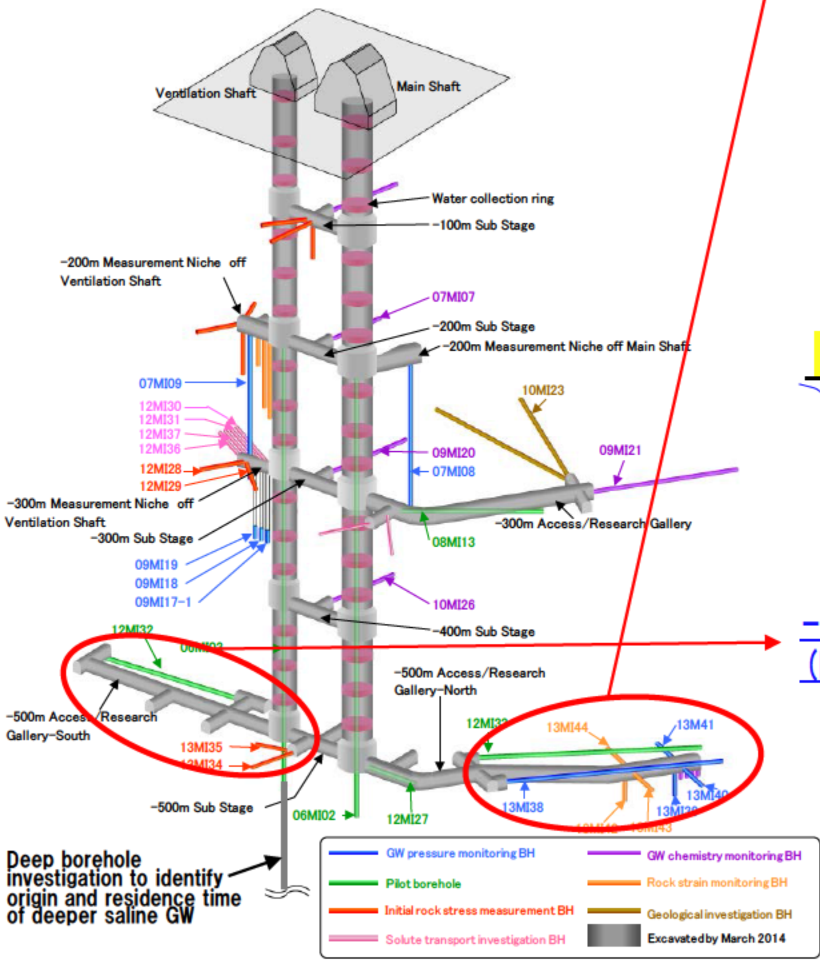
Response to national program requirements	Goals	Phenomena	Testing	Related Research
Development of technology to control GW inflow into excavations (Water-tight grout technique)	✓ To demonstrate the feasibility of water-tight grouting technology, employing pre- and post-excavation grouting methods, to control GW inflow in Japanese crystalline rock ✓ To evaluate influence on geological environment and long-term stability of grouting ✓ To evaluate EDZ around plug with post-excavation grouting	✓ Decrease of GW inflow by grouting ✓ Dissolution of cement materials ✓ Leakage through EDZ around plug	✓ Grouting Experiment	-TASS-tunnel, KHB-3H tunnel grouting (SKB) etc. ●Considered characteristic geological environment in Japan such as complicated network structure of fractures.
Development of modeling methodology for heterogeneous fracture networks	✓ To develop the modelling methodology of fracture network based on the actual fractured rock mass with heterogeneous characteristics due to fractures and discontinuous structures with large-scale. ✓ To develop the investigation technique to evaluate characteristics of the mass transport and retardation (eg. investigation technique for data acquisition of fracture with a wide range of hydraulic characteristics in a continuous manner) ✓ To understand the influence of mineral filling fracture/fracture alteration on characteristics of mass transport and retardation ✓ To evaluate effective factors of colloid/organics and microbes on mass transport	✓ Mass transport in large-scale discontinuous structures such as faults and compartment structure ✓ Mass transport in networked fractures ✓ Mass transport and retardation in single fractures with fillings and/or alteration ✓ Sorption of elements on colloid ✓ Formation of complex with organics ✓ Microbially catalyzed geochemical reaction ✓ Matrix diffusion through intact rock	✓ Mass Transport Experiment, including -hydrogeological characterization -colloid/organics/microbe characterization in groundwater	-Aspo HRL ✓Long-term sorption and diffusion experiment ✓Colloid transport project ✓Microbe project ✓Aspo Task Force on modelling of groundwater flow and transport of solutes -Grimsel test site ✓Long term diffusion experiment ✓Colloid formation and migration experiment -ONKALO ✓Host rock classification project ✓Rock suitability criteria program etc. ●Considered characteristic geological environment in Japan such as complicated network structure of fractures and filling materials

Goal, phenomena and testing for each response to national program requirements

Response to national program requirements	Goals	Phenomena	Testing	Related Research
Development of technology and methodology for analysis and evaluation of long-term changes of geological environment	✓ To identify changes in GW flow and chemistry induced by earthquakes ✓ To identify origin and residence time of deeper saline groundwater estimating long-term isolation of GW ✓ To estimate the range of influence of natural phenomena such as faulting, uplift/erosion, etc. on geological environment ✓ To develop methodology to infer future changes of geological environment based on the historical record ✓ To develop synthetic methodology to simulate short- to long-term changes of geological environment due to the construction, operation and closure of facility, and the long-term natural phenomena	✓ Temporal change of geological environment by earthquake ✓ Presence of stagnant groundwater in deeper rock mass ✓ Long-term change by slow or periodical geologic events such as uplift/erosion	✓ <u>Deep borehole investigation</u> ✓ <u>Investigation on mobility of analog elements</u> ✓ <u>Scenario analysis on long-term changes of geological environment</u>	Japanese topics

Other JAEA's project
- Neotectonics research
- Project of developing confidence in geosphere stability for long-term isolation of radioactive waste (under a contract with METI)

An illustration of summarized overall design for R&D in MIU facility
(regarding response to national program requirements shown in Slide 6-7)



Existing research galleries and boreholes

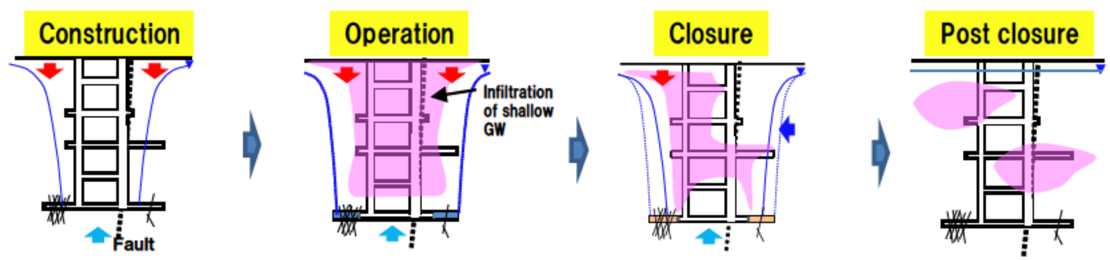
-500m Access/Research Gallery-North (sparsely fracture, slightly inflow condition)

Long-term Monitoring in Drift and Facility Scale (EDZ/EdZ)

- Check and practice of monitoring techniques (water pressure, moisture/chemistry, rock stress, wireless transmission etc.)
- Characterizing and monitoring of EDZ/EdZ in drift and facility scale
- Hydrogeoliogical characterization of compartment structures
- Plug performance test under in-situ water pressure
- Confirming borehole breakout

Mass Transport Experiment

- Tracer test using less-sorptive tracer in sparsely fracture under diffusive condition



-500m Access/Research Gallery-South (highly fractured rock, larger inflow condition)

Mass Transport Experiment

- Tracer test using sorptive tracer in highly fractured rock under advective condition

Grouting Experiment

- Post-excavation grouting test
- Monitoring of the influence of grout material on chemistry and long-term durability of grouting
- Monitoring of GW leakage through EDZ around plug with grouting, using tracers

Drift Closure Experiment with Backfilling

- Installation of monitoring equipment
- Backfilling of drift and/or pit
- Monitoring hydraulic and chemical changes caused by backfill material in and around drift
- Characterization of retrieved backfilling material