EURAD-2 2nd wave Template #2

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<table>
<tr><td>Short Acronym and full Title</td><td colspan="3">StSt WP4: NATural and anthropogenic analogues – STRATegic review of holistic use in radioactive waste disposal (NATSTRAT)</td></tr>
<tr><td>Type of activity</td><td colspan="2">☐R&D
☒Strategic Study</td><td></td></tr>
<tr><td>Budget estimation (total budget in M€, i.e ~ 1.5 M€)</td><td>0.75 M€</td><td>Duration of the WP (in months)</td><td>24</td></tr>
<tr><td>Links with EURAD SRA / Roadmap Themes
(if multiple choices, indicate the primary link in bold – maximum 3)</td><td colspan="3">☒ Programme Management (Theme 1)
☐ Pre-disposal (Theme 2)
☐ Engineered Barrier Systems (Theme 3)
☒ Geoscience (Theme 4)
☐ Disposal facility design and optimisation (Theme 5)
☐ Siting and Licensing (Theme 6)
☒ Safety Case (Theme 7)</td></tr>
<tr><td>Links with EURAD SRA topics
(if multiple choices, indicate the primary link in bold – maximum 3)</td><td colspan="3">Please indicate the corresponding Domains (number) and Description of R&D, StSt or KM needs (second column of SRA):
- 7.1.2 Performance indicators: Shared experience in the use of NA to verify and build confidence in long-term, large-scale processes
- 1.1.3 Public information and participation: Ensure that public information on radioactive waste and spent fuel and a process for public participation are available
- 4.4.1. Geo-datasets and conceptual models</td></tr>
<tr><td rowspan="2">SRA drivers (maximum 3)</td><td>☐Implementation Safety</td><td>☐Tailored Solutions</td><td>☒Scientific Insight</td></tr>
<tr><td>☐Innovation for Optimisation</td><td>☒Societal Engagement</td><td>☒Knowledge Management</td></tr>
<tr><td>Objective (What) – 1 sentence</td><td colspan="3">The strategic study would focus on defining the state of the art and critical gap analysis on natural analogues (NA) (including anthropogenic analogues, both archaeological and industrial) for HLW and L/ILW concepts, as well as providing guidance for currently missing holistic use of NAs in disposal programmes (including safety cases and stakeholder communication).</td></tr>
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Justification: impact / innovation / added-value (Why) – bullet points or short paragraph **(maximum quarter of a page)**	Analogues are relevant to waste disposal programmes, playing a crucial role in understanding many long-term processes, and in validating experimental rates and models against long-term records. Recent reviews on the application of natural analogues (NA), including archaeological and anthropogenic analogues, in safety cases—such as those developed for the KBS-3 spent fuel repository and the near-surface LILW repository at Olkiluoto, as well as analyses across deep and near-surface disposal programmes in Finland, Switzerland, Sweden, Canada, USA, Japan, Germany and UK —have identified several knowledge gaps within the fields of waste forms, engineered barrier systems (EBS), geosphere, biosphere and external processes, that would serve as a starting point for this strategic work. In addition, there is methodological scatter regarding strategies for using NA. The urgency of the topic is reflected in IGD-TP activity, and it is foreseen that any results arising from the IGD-TP NA activities should be used as input for this strategic study. In addition, existing knowledge base from the Natural Analogue Working Group (NAWG) can be utilised in the state-of-the-art definition (note NAWG is a voluntary-based organisation). There are several topical areas, particularly related to the safety strategy for LILW (surface or near surface), where the use of natural analogues remains largely unexplored. These include less-studied engineered barrier systems (e.g. earth covers), external processes (e.g., climate), biosphere, and industrial analogues. Enhancing understanding through the improved application of natural analogues to communicate the robustness of safety cases to civil society groups is seen as an underused asset. In addition, there is a need for EU wide training (expert + young generation) to fully utilise the existing knowledge. Consistency in using NA in safety cases would increase the overall confidence. Added value for future EURAD-3 R&D, well-established research plans for future work are needed to provide data on processes with knowledge gaps at repository relevant timescales. Building on past progress, today's more advanced, refined and innovative methodologies can further reduce uncertainties in safety cases and support future repository designs.
List of planned tasks / subtasks with % of effort per task (5% increments) **(Maximum 10 bullets)**	**Task 1: (5%) Management and coordination of WP** **Task 2: (20%): Knowledge management and training (further instructions for KM task will be taken into account later on the task division)** This task focuses on capturing existing knowledge, transferring results, and providing specialized training. *Sub-task 2.1 (5%): Knowledge capture* - Compiling the initial knowledge and information sources related to Nas - Starting point for Task 3 (Green paper) *Sub-task 2.2 (5%): Knowledge transfer* - Assessing how to best utilize the results of the StSt for EURAD-2 KM initiative - Producing white paper to capture the results of the project (input from Tasks 2 to 5) - Developing guidance for effective stakeholder and public communication of NAs

Sub-task 2.3 (10%): Training, focussing on:

- Train the next generation (involving students) and experts in other disciplines: exploring the practical integration of NAs to safety case via consistent use of NA to build trust and confidence, and to reduce uncertainties and conservatism
- Expert level + next generation training / workshop on stakeholder and civil society engagement: Exploring methods to translate complex NA findings into accessible, transparent and meaningful narratives to support stakeholder engagement and communication.

Task 3 (60%): FEP based gap analysis and state-of-the-art review

This is the central technical task, using Features, Events, and Processes (FEPs) (iFEPs where possible) to systematically review and redefine the use of analogues across various repository components (both from SC perspective and related to communication), through:

- Revisit/redefine the use of analogues to support various stages of geological disposal programmes and components of the safety case;
- Provide a holistic understanding of the current status of NA research and a way forward for different repository concepts (guidance);
- Identify NAs that are crucial for filling knowledge gaps, reducing key uncertainties in the safety cases, and aiding optimization / robustness of repository systems.

The work will be done under a selection of sub-tasks, that will all review the relevant selections of FEPs and NA (as defined in Objective). The gap analysis methodology will be based on multifactor screening:

- Sub-task 3.0: Defining the criteria for gap analysis and defining outputs of sub-tasks 3.1 to 3.11
- Sub-task 3.1: Analogues for waste forms
- Sub-task 3.2: Analogues for containers (copper, steel, other materials)
- Sub-task 3.3: Analogues for cementitious materials
- Sub-task 3.4: Analogues for buffer and backfill materials (clays and mixture materials)
- Sub-task 3.5: Analogues for geological barriers (host rock analogues and perturbation analysis)
- Sub-task 3.6: Analogues for post-closure processes (e.g., climate change, terrain change, landscape evolution, soil covers, radiolysis, repository interactions EBS-host rock, microbiology, gas generation, organics)
- Sub-task 3.7: Analogues for radionuclide migration and retardation (including NORM)
- Sub-task 3.8 Analogues for other EBS materials (such as bitumen etc.)
- Sub-task 3.9: Biosphere analogues
- Sub-task 3.10: Analogues for operational phase
- Sub-task 3.11: Analogues for toxin migration and retardation (non-radiological)
- Sub-task 3.12: Defining common approach to use NAs in safety cases and public communication (input also from Task 2)

	Task 4 (10%): Feasibility assessment for future NA studies - Based on Task 3 Gap Analysis, topics for future work will be provided including preliminary assessment of the sites / samples (accessibility, field work / sampling feasibility, sample quality if existing samples, etc.) including initial reconnaissance visits to relevant sites (Potential R&D for EURAD-3). **Task 5 (5%): Final report** - Delivering a structured and versatile assessment report for the selection future cutting-edge study topics by accounting for feasibility and scientific gaps for added value (especially NAs for upscaling over long time scales) and development of the EURAD-3 proposal.

List of expected outcomes linked to the identified SRA drivers **(Maximum 6 bullets)**	Outcomes are linked to SRA drivers' Scientific insight, Societal Engagement and Knowledge Management:
	• Scientific insight:
	  ○ (7.1.2) Natural analogues are an inherent part of the multiple lines of reasoning strategy within the safety case. The time period considered is so vast that natural and anthropogenic analogues are the only sources of data at relevant timescales. Collaboratively developed use of natural analogues will reduce uncertainties, e.g., those associated with the extraction and interpretation of data. Sensitivity analyses and information from natural analogues can be used to enhance confidence in the safety case.
	  ▪ Outcome: Increased understanding of the State of the art within EURAD and internationally, holistic and systematic assessment of future R&D needs
	  ○ (4.4.1) Geo-datasets and conceptual models: provide a geoscientific synthesis with key information about long-term safety.
	  ▪ Outcome: Develop understanding of the capacity of host-rock and EBS materials to buffer unexpected and adverse conditions.
	• Societal engagement & knowledge management:
	  ○ (1.1.3) Establish structured interaction between researchers and CS actors in the frame of research programmes and projects
	  ▪ Outcome: guidance and training, inclusion in EURAD-2 KM

Deliverables **(Maximum 6 – including the prescribed deliverables)**	D.1. Green paper D.2. White paper D.3. Training materials D.4. Outcome/impacts report to Member States and End-Users D.5. Final report compiling the results of green paper, Tasks 3 and 4
Critical input requirements & identified risks (Optional - Explain what is out of the scope?)	Research on analogues themselves is out of scope. The WP is intended as a meta-analysis.

List of preliminary interested organisations as partners in the WP contributing effort; **% of effort (person months, by College)**	**Total ppm ~75-100** **RE (50%):** GTK (FI), VTT (FI), CEA (FR), BRGM (FR), BGR (DE), EGIS (FR), FZ-JUELICH (DE), GFZ Helmholtz (DE), KIT (DE), HZDR (DE), UFZ (DE), ENEA (IT), UniBern (CH), EPFL (CH), Remondis (CH), TUDelft (NL), TNO (NL), UDC (ES), SCK CEN (BE), BGS (GB), Uni Manchester (GB), UKNLL (GB), Amphos21 (ES), ÚJV Řež (CZ), RATEN ICN (RO), SIIEG NAS of Ukraine (UA), KAERI (KR), NARI (TW) **TSO (40%):** CIEMAT (ES), Merience (ES), UGR (ES), VTT (FI), EIMV (SI), NTW (FR), CEPN (FR), GRS (DE), LBL (USA), SSTC NRS (UA), SÚRO (CZ) **WMO (10%):** ANDRA (FR), BGE (DE), COVRA (NL), ENRESA (ES), NUMO (JP), SOGIN (IT), Posiva (FI)
If applicable - links with previous projects / work packages	**EURAD-2**: WP2 KM, WP9 InCoManD, WP10 ANCHORS, WP11 CLIMATE, WP12 RAMPEC, WP13 OPTI, WP14 SUDOKU, WP09 INCOMAND, WP18 DITUSC, WP8 SAREC **Previous projects**: FP5-NANET (2003-2004), EURAD-1 (ACED, FUTURE, HITEC, SFC, CONCORD).
WP Preparation Team (1 member per College) contact (**organisation + person**, email)	RE: Heini Reijonen (mailto:heini.reijonen@gtk.fi, +358 50 3488 669) TSO: Ana María Fernández (anamaria.fernandez@ciemat.es, +34 627245016) WMO: Erika Neeft (erika.neeft@covra.nl, +31 1 13616681