DE55226–BALI C35954

IMPLEMENTING AGREEMENT

ON

"Contaminant transport in porous geological media"

BY AND BETWEEN

THE INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH of the Department of Atomic Energy, Government of India located at Kalpakkam – Tamil Nadu – India, duly represented by Dr. Arun Kumar Bhaduri, Director, Indira Gandhi Centre for Atomic Research,

Hereinafter called as "**IGCAR**"

AND

THE COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, a French state-owned research entity with a scientific, technical or industrial activity duly organised under the laws of France and having its registered office located Bâtiment Le Ponant D - 25, rue Leblanc - Paris 15ème (France) - and declared at the Paris, Register of Commerce and Trade ("Registre du Commerce et des Sociétés de Paris") under the following registration number: R.C.S. PARIS B 775 685 019, duly represented by Mr. Philippe STOHR acting as Director of the Energies Division and duly authorised for the purpose hereof,

Hereinafter referred to as "**CEA**",

Hereinafter also referred to as individually as a "Party" or collectively as the "Parties"

WHEREAS the Government of the French Republic and the Government of the Republic of India signed on September 30, 2008 an Agreement on the Development of Peaceful Uses of Nuclear Energy (hereinafter "the Framework Agreement");

WHEREAS the Government of the French Republic and the Government of the Republic of India signed on December 6, 2010 an Agreement concerning intellectual property rights on the development of the peaceful uses of nuclear energy(hereinafter "the Intellectual Property Agreement");

WHEREAS CEA and DAE signed on December 6, 2010 an agreement in the field of nuclear science and technology for peaceful uses of nuclear energy with the aim to establish a general framework for their cooperation (hereinafter "Cooperation Agreement"),

WHEREAS CEA and DAE signed on January 14, 2021 amendment no.1 to the Cooperation Agreement extending the validity of the Cooperation Agreement up to Dec 5th, 2025.

WHEREAS CEA and IGCAR have common interest to co-operate in the field of safety related to the transfer of contaminant into the environment,

WHEREAS CEA and IGCAR have decided, pursuant to articles 4 and 5 of the Cooperation Agreement, to establish an Implementing Agreement to prepare the bilateral cooperation on a joint research project titled " Contaminant transport in porous geological media",

Whereas the Parties consider that no nuclear incident can occur from the cooperation between the Parties subject to the Implementing Agreement within the meaning of the Civil Liability for Nuclear Damage Act, 2010 in force in India or the Paris Convention on Third Party Liability in the Field of Nuclear Energy of 29th July 1960 as implemented by legislation in force in France, and that, as a consequence, the Implementing Agreement is not subject to nuclear civil liability.

Now therefore, in consideration of the foregoing and mutual covenants contained herein, the Parties agree as follows:

ARTICLE 1 - DEFINITIONS

The words defined in Article 1 of the Intellectual Property Agreement, have the same meaning in this Implementing Agreement.

(i)**"Implementing Agreement"** means the present agreement, its annexes and its prospective amendments.

(ii) "**Own Information and Technology**" means without limitation any know-how, data, studies, software, specifications or any information whether patented or not, in any and all medium belonging to one Party prior to the effective date of this Implementing Agreement or acquired or developed thereafter independently of this Joint Research Project of this Implementing Agreement,

(iii) "**Joint Results**" means any and all document and information whether in written form or not including but not limited to manuals, drawing, know-how, trade secrets, trademarks, copyrights, manufacturing process data, studies, software, designs, specifications, technical description and data whether patentable or not generated during the Joint Research Project.

ARTICLE 2 - OBJECTIVES OF THE IMPLEMENTING AGREEMENT

The objectives of this Implementing Agreement is to define the terms and conditions under which the Parties shall cooperate on the following areas in Joint Research Project.

For the safe operation of nuclear facilities, industrial, academic, and government bodies need to estimate the environmental impact of their activities. In particular, they must develop operational methods and tools to measure, control, and predict the potential release and subsequent transport of contaminants from their installations. The estimation of migration of activity through a geological medium requires an understanding of the behaviour of radio-nuclides within the medium. Hence a robust numerical methodology is important to address the reactive transport of radioactivity inside a subsurface medium.

The objective of this Implementing Agreement is to co-operate on a balanced basis on the development and share of scientific knowledge related to the numerical modelling of migration of radioactivity within a subsurface medium (homogeneous, mixed and rock).

The Parties agree to cooperate pursuant to the terms of this Implementing Agreement according to the provisions of the Cooperation Agreement unless otherwise specified herein. The present implementing agreement could be later amended or completed by other implementing agreement(s) or to update the planning of actions of this Implementing Agreement.

ARTICLE 3 – SCOPE OF THE COOPERATIVE ACTIVITY

The main objective of the study for both the centres is to develop a state of art methodology to estimate subsurface migration of activity through different porous media. Contaminant migration is governed by the geological nature of the site as well as the chemical properties

of the contaminant. A series of simulations will be conducted with increasing complexity. The study will start with simplified cases and subsequently address realistic, site-based cases including migration through different porous media (soil, fractured rocks etc.).

The Joint Research Project is divided into three main tasks (see Appendix):

ARTICLE 4 – MILESTONES - DELIVERABLES

Milestones and deliverables	Time
Inter-comparison of results of modeling of flow for CEA region-simple case	T0* + 5 months
Inter-comparison of results of modeling of tracer migration for CEA region-simple case	T0 + 7 months
Inter-comparison of results of modeling of flow for IGCAR region-simple case	T0 + 8 months
Inter-comparison of results of modeling of tracer migration for IGCAR region-simple case	T0 + 10 months
Data selection for transport calculations.	T0 + 12 months
Inter-comparison of results of modeling of flow and radionuclide transport for CEA region.	T0 + 18 months
Inter-comparison of results of modeling of flow and radionuclide transport for IGCAR region.	T0 + 24 months
Detailed modeling of flow and transport of radionuclide for CEA region.	T0 + 28 months
Detailed modelling of flow and transport of radionuclide for IGCAR region.	T0 + 32 months
Detailed modelling of complex flow and transport of radionuclide for CEA region.	T0 + 36 months
Detailed modelling of complex flow and transport of radionuclide for IGCAR region.	T0 + 40 months
Preparation of Joint report	T0 + 42 months

**T0: date of entry into an Implementing Agreement*

ARTICLE 5 – NOMINATED CORRESPONDENTS:

IGCAR	CEA
Dr. Soubhadra Sen RIAS/RESD/RESG IGCAR Kalpakkam Tamil Nadu, India PIN-603102 Phone (office): +91-044-27480500-23572 E-Mail: ssen@igcar.gov.in	Dr. O. BILDSTEIN DEN/DTN CEA Cadarache F-13108 Saint Paul les Durance, France Tel: +33 4 42 25 37 24 e-mail:olivier.bildstein@cea.fr

The technical correspondents have to report the cooperation activities to the Joint Research Project to the Franco-Indian Joint Committee as stated in article 6 the Cooperation Agreement.

ARTICLE 6 –FINANCIAL PROVISIONS

Both Parties agree that all activities done in the framework of this Implementing Agreement are to be done on a self-financing basis and equally reciprocating manner.

CEA will bear the cost of internal travel, allowance and accommodation of one IGCAR scientific officer for up to 2 weeks/year (or equivalent time cumulated on the whole IA duration: 6 weeks maximum) in France. IGCAR will bear the cost of internal travel, allowance and accommodation of one CEA scientific officer/trainee for up to 2 weeks/year (or equivalent time cumulated on the whole IA duration: 6 weeks maximum) in India.

Visits or meetings may be organised if necessary according to provisions of article 8.1 of Cooperation Agreement.

ARTICLE 7 – CONFIDENTIALITY

7.1. "Confidential Information" means:

i. Own Information and Technology and/or any type of written information and in whatever form or medium that one Party discloses, whether directly or indirectly, to the other Party and relating to the Implementing Agreement.
ii. The Results arising from the Joint Research Project.

7.2. Each Party undertakes

i. to disclose only Confidential Information it has the right to dispose of, according to the following;
ii. to keep strictly confidential and not to disclose nor to communicate to any third party, by any means whatsoever, any Confidential Information received from the other Party, unless the communicating Party has explicitly notified to the receiving Party that such proprietary information was not subject to secrecy, and
iii. to use such Confidential Information solely for the purpose of the Implementing Agreement.

7.3. Each Party shall use at least the same degree of care in protecting Confidential Information against disclosure to any third party as it exercises in protecting its own Confidential Information.

7.4. Each Party undertakes to disseminate Confidential Information only to its employees on "a need to know" basis to use it within the scope of the performance of the Implementing Agreement, and the receiving Party shall take appropriate measures with such employees to ensure that the latter should be bound by equivalent confidentiality provisions as those stipulated herein.

Notwithstanding the above provisions, each of the Parties has the right to communicate Confidential Information received from the other Party to its government authorities and its national safety authorities subject to appropriate protection of the Confidential Information by the receiving government authorities.

7.5. However, the provisions of this article shall not apply to Confidential Information for which the receiving Party can prove in writing that:

- Such Confidential Information is or has become publicly known through no wrongful act on its part;
- Such Confidential Information is available to the public and already known, at the time of disclosure by the disclosing Party;
- Such Confidential Information was rightfully received by the receiving Party from a third party without breach of any confidentiality obligation;
- Such Confidential Information was independently developed or discovered by the receiving Party without use of any Information received under the Implementing Agreement;
- Such Confidential Information is disclosed pursuant to a judicial order, a lawful requirement of government agency; or by operation of law, but then only to the extent so ordered; in such case the receiving Party will make its best efforts to timely advice the disclosing Party prior to disclosure.

7.6. The provisions of this article shall remain in force during the term of this Implementing Agreement, and for ten (10) years after the expiration or termination of the Implementing Agreement.

7.7 Any scientific publication, presentation or release paper relating to all or part of the Confidential Information, all or part of the work carried out under the Implementing Agreement shall be submitted to the prior approval of the other Party, as the case may be through the Joint Committee. The other Party shall examine it promptly and notify the submitting Party of (i) its consent to the content of the paper or (ii) its request to amend and/or remove certain parts of the paper or (iii) to delay the paper publication, presentation or release as long as necessary to ensure adequate industrial and intellectual protection, provided that such period shall not exceed eighteen (18) months from the date of the receipt of the paper by the notified Party.

Any failure of the notified Party to communicate its decision to the submitting Party within thirty (30) calendar days shall be deemed as its consent and a waiver of any objection to the contents thereof.

Unless otherwise agreed between the Parties, any scientific publication, presentation or release paper by the submitting Party shall clearly mention the collaboration with the other Party.

ARTICLE 8 – CLAIMS RESULTING FROM INFORMATION TRANSFERRED

8.1. While the information (including Confidential Information as defined in article 7.1) given by one Party to the other under this Implementing Agreement is accurate, in the opinion and to the best of the communicating Party's knowledge, the communicating Party does not warranty the pertinence of such information to any use which may be made by the receiving Party or by a third party. The use of such information by the receiving Party (including the communication to a third party) shall be entirely at the receiving Party's risk.

8.2. No claim shall be made against a Party for any direct or consequential damages to its property, its personnel or to third parties, which might result from the use of information given to the other Party.

ARTICLE 9 – INDUSTRIAL PROPERTY AND RIGHTS OF USE

9.1 Ownership

9.1.1 Ownership of Own Information and Technology

Each Party shall remain the exclusive owner of its Own Information and Technology. As such, each Party shall be free to transfer to a third party its Own Information and Technology.

9.1.2 Ownership of Results

9.1.2.1 General principles
The Parties shall ensure adequate and effective protection of the Joint Results.

The Parties shall inform each other of any Joint Result which is likely to be protected and shall engage in a timely manner on ensuring protection for the Joint Results.
To this end, the Parties undertake not to oppose the seeking, by a Party, of protection of Results in countries authorising such protection.
Each Party shall on the basis of its respective domestic legislation grant the other Party non-discriminatory treatment regarding the property, allocation and exploitation of Joint Results.

9.1.2.2 Co-ownership instrument
Before any exploitation for industrial and/or commercial purposes by one Party, the Parties shall draw up a co-ownership instrument determining the rights of use of the said Joint Results, according to the following principles:
- The co-ownership instrument shall take into account the respective material, human, financial and intellectual contributions to the acquisition of the Intellectual Property of each Party, the benefits of exclusive and non-exclusive licences in each territory or field of use, the conditions required by the respective national legislation of the Parties or other factors deemed appropriate.
- If the Parties cannot reach agreement on instrument of co-ownership within a maximum of six (6) months from the date of expiry of the Implementing Agreement, each Party may directly or indirectly exploit Joint Results throughout the world subject to remuneration for the other co-owner. Each Party should notify the other Party of its intention to invoke this clause before beginning exploitation with industrial and commercial purposes with prior notice of at least two (2) months.

9.2 Rights of use

9.2.1 Rights of use of Own Information and Technology
Each Party undertakes to grant to the other Party a non-exclusive licence without the right to sublicense on its Own Information and Technology within the scope of this Implementing Agreement for the Joint Research Project. This licence shall be granted royalty-free.

Each Party undertakes to grant to the other Party a non-exclusive licence without the right to sublicense on its Own Information and Technology if needed for industrial and/or commercial exploitation of its Joint Results. This licence shall be granted with fair and reasonable conditions as agreed by the Parties in a specific agreement.

9.2.2 Rights of use of Results

Each Party shall have the right of free use of the Joint Results for research and development purposes.
The Parties shall facilitate the effective exploitation of the Joint Results. To this end, the Parties agree to conclude a co-ownership instrument before any industrial and/or commercial exploitation of Joint Results, as mentioned above in article 9.1.2.2.

ARTICLE 10 – LIABILITY

10.1. Personal damages to the staff of each Party:
Each Party on its own account, is fully liable for the damages to its own staff, e.g. for the insurance coverage of its own staff for workmen's compensation and professional diseases,

in accordance with the appropriate local regulatory and legal requirements. Consequently, each Party proceeds to the appropriate formalities, and sustains if any, all the costs associated to the insurances underwritten in order to cover its own staff against the risks.

Each Party shall inform the other Party of any claim or damage that has occurred during or consequent to any work, by the staff of other Party, employed by it, in order to proceed to the various regulatory and legal requirements.

Notwithstanding the above provisions, each Party is liable in compliance with the applicable law to damages caused by its staff to the staff of the other Party in case such damages were caused by or contributed to by the gross negligence or wilful misconduct of that staff.

10.2. Damages to the other Party's properties

Each Party keeps on its own account, without any right of recoveries against the other Party, the damages caused to its own property by the staff of the other Party when the staff thereof put to its disposal, unless such damages were caused by or contributed to by the gross negligence or wilful misconduct of that staff.

10.3. Third party liability

In accordance with the appropriate local regulations, each Party remains liable for damages to third parties caused by its own staff, except if this staff is under the management and/or the control of the other Party, unless such damages were caused by or contributed to by the gross negligence or wilful misconduct of that staff.

ARTICLE 11 – DURATION

11.1 Subject to the entry into force of the Cooperation Agreement according to article 16.1 of the said Cooperation Agreement and Amendment No.1 to Cooperation Agreement signed on Jan 14, 2021, this Implementing Agreement shall come into force upon signature by both Parties and shall remain valid for 42 (forty two) Months.

11.2 Three months before the date of termination, the Parties shall consult each other in order to decide whether this Implementing Agreement shall be extended or not.

11.3 Termination of this Implementing Agreement for any reason whatsoever shall be without prejudice to the rights which may have occurred under this Implementing Agreement to either Party up to the date of termination.

11.4 This Agreement shall remain in force for 42 (forty two) Months from the date of signature by both Parties unless terminated by the either party by giving a 3 (three) months written notice in advance to the other party of its intention to terminate this agreement through diplomatic channels.

ARTICLE 12 - SETTLEMENT OF DISPUTES

The Parties agree that any dispute arising out of this Implementing Agreement will be settled amicably if possible with assistance of one or more independent experts.

All disputes which cannot be settled between the Parties will be finally settled under the Rules of conciliation and arbitration of the International Chamber of Commerce by one or more arbitrators appointed in accordance with the said Rules. Procedures of arbitration shall be conducted in English. The place of arbitration shall be in Geneva (Switzerland).

ARTICLE 13 - AMENDMENT

The Implementing Agreement may be amended by mutual consent in writing of the Parties.

ARTICLE 14 - LANGUAGE

This Agreement is drawn up and executed in two copies each in the English and Hindi languages.

The language of the Joint Research Project and of all correspondence and other communication between the Parties shall be English.

Done in two originals, each in Hindi and English languages, all texts being equally authentic. In case of divergence in the interpretation, the English text shall prevail.

For the Indira Gandhi Centre for Atomic Research

Full Name: Dr. Arun Kumar Bhaduri
Title: Director, Indira Gandhi Centre for Atomic Research

Place and date: KALPAKKAM, 04.08.2021

(Signature)

Indira Gandhi Centre for Atomic Research Kalpakkam 603 102

For the Commissariat à l'Energie Atomique et aux Energies Alternatives:

Full Name: Mr Philippe STOHR
Title : Director, Energies Division,

Place and date: - 1 SEP. 2021

(Signature)

Philippe STOHR
Directeur des énergies

COMMISSARIAT A L'ENERGIE ATOMIQUE DIRECTION DES ENERGIES CEA Bât. 121 91191 Gif-sur-Yvette Cedex

APPENDIX

Contaminant transport in porous geological media

1. Introduction

Nuclear power is one of the decarbonized sources of energy that can help meeting the increasing demand of power particularly in the context of decreasing use of fossil fuel resources. One of the major concerns about nuclear facilities is the possibility of any transfer of activity to the environment and subsequently to the public. Environmental safety assessments even for such low probability events require an analysis of all possible transport mechanisms and an estimation of corresponding radiological dose. For instance, during an earthquake, the fuel storage facility may develop cracks opening a route for the radio-nuclides to enter the surrounding porous geological medium. Later, if the leaked activity comes in the contact of underground flow of water, the same would start migrating. Eventually, if this process carries the activity to the public domain (for example, radio-nuclides may reach any lake or a stream of water), it would become a serious issue related to public health and so a thorough study is important.

Experimental verification of simulation results (concentration as a function of space and time within a porous medium) is quite difficult due to the slow migration of a contaminant. The application of a Geotechnical Centrifuge to accelerate the process is a common technique for this purpose. In our case, instead of experimental validation, an inter-comparison of results of different codes for a few common problems can provide an estimation of accuracies of the approaches. The centres (IGCAR and CEA) have access to a number of codes of international standard. Moreover, both of them have developed in-house codes for this purpose. For a list of input data sets, they can be independently used to simulate a few test cases. If the results are found to be similar, it will validate the approaches.

2. Objectives of the collaboration

The objective of this collaboration is to develop and share scientific knowledge related to the numerical modelling of migration of radioactivity within a subsurface medium (homogeneous, mixed and rock). The impact calculations require an understanding of the behaviour of radio-nuclides within a natural environment. Hence a robust numerical methodology is important to address reactive transport of contaminants inside a subsurface medium.

3. Scope of the collaboration

The main objective of the study for both the centres is to develop a state of art methodology to estimate subsurface migration of activity through different porous media. Contaminant migration is governed by the geological nature of the site as well as the chemical properties of the contaminant. A series of simulations will be conducted with increasing complexity. The study will start with simplified cases and subsequently address realistic, site-based cases including migration through different porous media (soil, fractured rocks etc.).

A classification of different porous medium and associated migration with increasing complexity is given below. This will serve as a guide for the calculations:

1. Migration through a homogeneous (sand/soil) medium:

A common near earth surface geological medium is sand/soil which is a homogeneous medium. It is relatively easy to model any transport through this type (single porous) of medium. Here, a simple transport equation will suffice to estimate the concentration of a leaked activity as a function of space and time.

2. Migration through a mixed medium (a medium which is a mixture of sand/soil and gravel):

The second class of geological medium is of mixed nature. This type of medium is a mixture of sand or soil and small stones. As the transport through sand/soil is much faster than the same through a rock, the migration can be assumed to be occurring only through the sand/soil medium. Moreover, in general the locations of the stones are purely random. So in this case, one needs to adopt a probabilistic approach for an accurate estimation of concentration of a leaked radionuclide as a function of space and time. As this approach is computationally demanding, in general estimations are carried out for small distances only. If it is required to simulate migrations at large distances, one may consider the medium to be homogeneous and estimate concentrations with net transport parameters at large scales.

3. Migration through a fractured rock medium:

The third type of medium is fractured rock which is a dual porous medium. Basically a rock is a combination of a network of tiny fractures and porous blocks of arbitrary sizes. Predominant transport takes places through the fractures due to the flow of water. The diffusion of a contaminant through the porous blocks confines the activity and thus reduces the overall transport. There are several models (both deterministic and probabilistic) to address a migration in a rock medium.

Execution of the co-operation:

Task 1 – Inter-comparison of results of different codes for a simplified case

For this first benchmarking exercise, a case with simple geometry is proposed starting from data collected on a CEA site. This task will involve calculations of flow and transport through a homogeneous (sand/soil) medium. For the first calculations, geometry and flow parameters will be provided by CEA who will run the calculation with the MARTHE code. The data will be used by IGCAR in order to run the case with MODFLOW. An important part of the exercise is the exchange between the two parties to achieve consistent data input for the two different codes.

This exercise will be repeated on a site chosen by IGCAR following the same procedure.

Task 1.1 Inter-comparison of results of modeling of flow for CEA region-simple case.

Task 1.2 Inter-comparison of results of modeling of tracer migration for CEA region-simple case. Comparison with field data if available.

Task 1.3 Inter-comparison of results of modeling of flow for IGCAR region-simple case.

Task 1.4 Inter-comparison of results of modeling of tracer migration for IGCAR region-simple case. Comparison with field data if available.

Task 2 – Estimation of migration with site specific data and properties of important radio-nuclides: In the next step, in addition to tracer migration, a list of radio-nuclides of common interest will be made. The important chemical properties (solubility in water, chemical reaction rate with geological medium, etc.) of these species which are relevant for modelling are to be tabulated for exchange between the two parties. Similarly, data concerning the geological medium(diffusivity, porosity, retardation coefficient, etc) through which transport occurs also plays a significant role. For calculations, site specific data sets will be provided by CEA.

This exercise will be repeated on a site chosen by IGCAR following the same procedure.

Task 2.1 Data selection for transport calculations.

Task 2.2 Inter-comparison of results of modeling of flow and radio-nuclide transport for CEA region. Comparison with field data if available.

Task 2.3 Inter-comparison of results of modeling of flow and radio-nuclide transport for IGCAR region. Comparison with field data if available.

Task 3 - Detailed modelling of subsurface migration: Using the properties of a geological medium and radio-nuclides of common interest of the previous task, a detailed numerical simulation of activity migration in a sub-surface porous medium (with heterogeneous distribution of parameters including a potentially fractured medium) will be carried out jointly by CEA and IGCAR. In this phase, the codes developed/used by both the institutions may be used. Finally, the methodology will be applied to a large domain with different zones of different geological characteristics. This involves detailed modelling of complex flow and associated transport.

Task 3.1 Detailed modeling of flow and transport of radionuclide for CEA region.

Task 3.2 Detailed modelling of flow and transport of radionuclide for IGCAR region.

Task 3.3 Detailed modelling of complex flow and transport of radionuclide for CEA region.

Task 3.4 Detailed modelling of complex flow and transport of radionuclide for IGCAR region.

Milestones and deliverables:

Milestones and deliverables	Time
Task 1.1: Inter-comparison of results of modeling of flow for CEA region-simple case	T0* + 5 months
Task 1.2: Inter-comparison of results of modeling of tracer migration for CEA region-simple case	T0 + 7 months
Task 1.3: Inter-comparison of results of modeling of flow for IGCAR region-simple case	T0 + 8 months
Task 1.4: Inter-comparison of results of modeling of tracer migration for IGCAR region-simple case	T0 + 10 months
Task 2.1: Data selection for transport calculations.	T0 + 12 months
Task 2:2: Inter-comparison of results of modeling of flow and radionuclide transport for CEA region.	T0 + 18 months
Task 2.3: Inter-comparison of results of modeling of flow and radionuclide transport for IGCAR region.	T0 + 24 months
Task 3.1: Detailed modeling of flow and transport of radionuclide for CEA region.	T0 + 28 months
Task 3.2: Detailed modelling of flow and transport of radionuclide for IGCAR region.	T0 + 32 months
Task 3.3: Detailed modelling of complex flow and transport of radionuclide for CEA region.	T0 + 36 months
Task 3.4: Detailed modelling of complex flow and transport of radionuclide for IGCAR region.	T0 + 40 months
Task 4: Preparation of Joint report	T0 + 42 months

**T0: date of entry into an Implementing Agreement*