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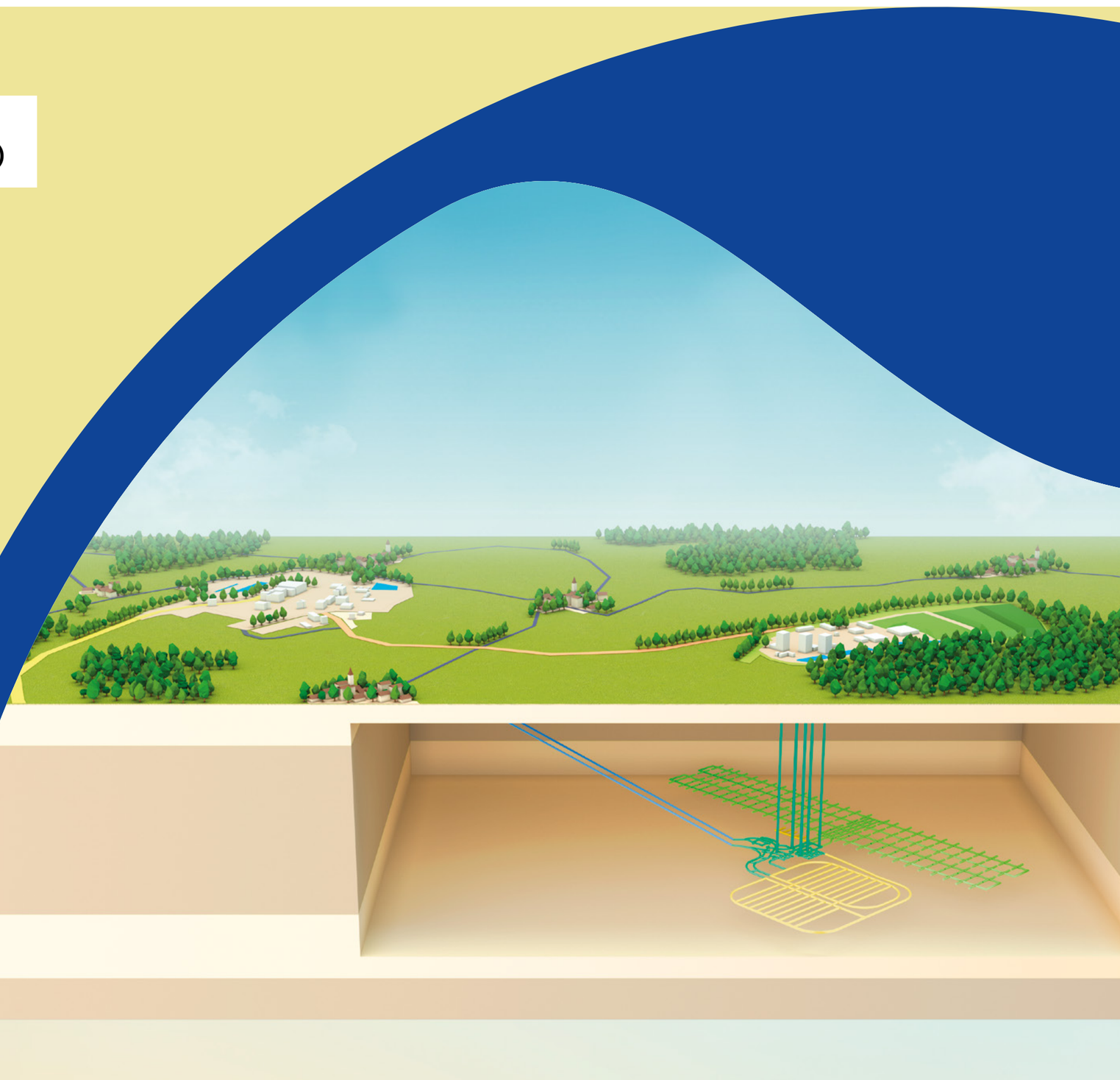
2026

LICENCE APPLICATION FILE FOR THE CREATION OF THE CIGÉO BASIC NUCLEAR INSTALLATION (BNI)

DOCUMENT 6BIS

Environmental Impact Assessment of the Cigéo Overall Project

NON-TECHNICAL SUMMARY



This text is a translation of document No 6bis-RNT of the licence application file for the creation of the Cigéo basic nuclear installation, updated in 2026.

This document has been produced to facilitate access to the creation application file for non-French readers. This translation is for information purposes only; Andra is liable solely on the basis of the original French-language version.

Licence Application File for the Creation of the Cigéo Basic Nuclear Installation (BNI)
Document 6bis: Environmental Impact Assessment of the Cigéo Overall Project
Non-technical summary

CG-TE-D-EDM-AMOA-ESE-0000-22-0005/C

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Preamble

This document constitutes the non-technical summary (NTS) of the environmental impact assessment for the Cigéo overall project.

The environmental impact assessment consists of the following volumes (in French):

	IMPACT ASSESSMENT	
NTS	**Non-Technical Summary of the Environmental Impact Assessment**	
VOLUME I	Introduction and Regulatory Context	
VOLUME II	Justification and description of the Cigéo overall project	
VOLUME III	Current state of the environment and factors likely to be affected by the project	
	Part 1: Chapters 1 - 4	1 - Methodology for analyzing the initial state/2 - Atmosphere/3 - Soil/4 - Subsoil
	Part 2: Chapter 5	5 - Water
	Part 3: Chapter 6	6 - Biodiversity and Natural environment (Part 1)
	Part 4: Chapter 6	6 - Biodiversity and natural Environment (Part 2)
	Part 5: Chapters 7-13	7 - Population, Employment, Economic Activities and Housing/8 - Agricultural and Forestry Activities/9 - Networks/10 - Radioactive and conventional waste/11 - Risks/12 - Transportation infrastructure/13 - Living environment
	Part 6: Chapters 14–17	14 - Landscape, cultural heritage, tourism, and outdoor activities/15 - Land use planning and development/16 - Interactions and cumulative impacts/ 17 - Summary of factors likely to be affected by the Cigéo overall project and prioritisation of issues
	Part 7	Appendices to Volume III (in 3 parts)
VOLUME IV	Impact Assessment and Measures to Avoid, Reduce and Offset these Impacts	
	Part 1: Chapters 1-4	1 - Impact Analysis Methodology/2 - Atmosphere/3 – Soil/4 - Subsoil
	Part 2: Chapter 5	5 - Water
	Part 3: Chapter 6	6 - Biodiversity and the natural environment
	Part 4: Chapters 7—13	7 - Employment, Economic Activities, Population and Housing/8 - Agricultural and Forestry Activities/9 - Networks/10 - Radioactive and conventional waste/11 - Risks/12 - Transportation infrastructure/13 - Living environment
	Part 5: Chapters 14–16	14 - Landscape, cultural heritage, tourism, and outdoor activities/15 - Land use planning and development - Compatibility with spatial planning documents/16 - Interactions and cumulative impacts
	Part 6: Chapters 17 to 22	17 - Best available techniques/18 - Impacts of decommissioning, closure and post-closure operations/19 - Nature and monitoring of follow-up environmental measures /20 - Estimated costs of environmental measures/ 21 - Evolutions of the environment with and without project/ 22 - Summary of the environmental impacts of the Cigéo overall project
	Part 7	Appendices to Volume IV
VOLUME V	Assessment of Impacts on Natura 2000 Sites	
VOLUME VI	Assessment of Impacts on Human Health	
VOLUME VII	Part 1	Presentation of the methods used to conduct the impact assessment (Chapters 1–6)
	Part 2	Presentation of the methods used to conduct the impact assessment (Chapters 7–18)

The non-technical summary consists of three chapters:

- Chapter 1 summarises the context of the project by briefly presenting the project owners involved in the Cigéo overall project, the authors of this study, the regulatory framework, and the planned updates to the impact assessment in line with the sequence of procedures;
- Chapter 2 addresses the essential elements describing and justifying the Cigéo overall project: its objectives, the types of waste to be emplaced, the technical choices, the phased timeline for deployment, the implementation methods, and estimates of resource consumption as well as associated emissions and residues;
- Chapter 3, organised by environmental factor for clarity, provides for each factor a summary of the issues, a summary of the impacts of the Cigéo overall project, the main methods used, and the primary measures planned according to the ARO (“Avoid-Reduce-Offset”) sequence;

In the text, a green border highlights the paragraphs containing details provided to update this non-technical summary compared to the one associated with the declaration of public interest (initial impact assessment/EI-DUP).

The non-technical summary is presented in a separate volume but is part of the environmental impact assessment.

ENVIRONMENTAL IMPACT ASSESSMENT AND CIGÉO OVERALLPROJECT

The initial version of the environmental impact assessment for the Cigéo overall project (EI-DUP) was included in the public inquiry file prior to the declaration of public interest for the Cigéo disposal facility, a declaration issued by Decree No. 2022-993 of July 7, 2022 (1) :

- a first formal update (EI-DAC1) was carried out for the creation licence application (DAC) for the Cigéo basic nuclear installation (BNI), filed on January 16, 2023, and whose admissibility was confirmed on June 22, 2023, by the **French** Nuclear Safety Authority (ASN), thereby initiating the examination of the application;
- a second formal update (EI-DR0) was attached to the environmental authorisation application and to the urban planning authorisation applications (building permits, prior notifications), for requests concerning the first environmental characterisation and monitoring operations—referred to as DR0. These applications were filed on March 6, 2024, and the permits were issued on July 11, 21 and 22, 2025. This second update to the environmental impact assessment is available in French on the Andra website[1].

The environmental impact assessment (EI-DAC3) attached to the version of the licence application file for the Cigéo basic nuclear installation (BNI) and intended for the public inquiry therefore takes into account, in addition to the elements already included in the update prepared for the submission of the DAC application file:

- the formal update carried out in connection with the authorisation applications concerning the first environmental characterisation and monitoring operations—referred to as DR0 and incorporating, in particular, the best available description of the work covered by these applications. Their impacts are integrated into the Cigéo overall project;

[1] https://www.andra.fr/cigeo/les-documents-de-reference (2).

- the EI-DAC2 revision prepared for regulatory consultations, including the referral to the environmental authority (which issued its opinion on December 18, 2025) as part of the review of the creation licence application (DAC) for the Cigéo basic nuclear installation (BNI). This update includes new knowledge regarding certain project components or the environment, regulatory changes, updates to the reserve inventory consistent with the expected evolutions then available for the third Multi-Year Energy Programme (PPE), as well as elements provided during the technical examination (clarifications and commitments with deadlines prior to the end of the technical examination);
- a revision following regulatory consultations to incorporate clarifications regarding commitments made to the French Nuclear Safety and Radiation Protection Authority (ASNR) as part of the technical examination of the DAC application, with deadlines prior to the public inquiry, the third Multi-Year Energy Programme (PPE3) published in February 2026, and the 2026 edition of the National Inventory Essentials. This revision did not require a reappraisal of the environmental impact assessment in light of the Environmental Authority's opinion. The response to this opinion, as well as the follow-up on Andra's commitments, can be found in Document 18 of this file.

The changes between these versions are highlighted for the reader and the reviewing authorities so that they may be aware of the modifications compared to the versions of the environmental impact assessment that were reviewed and made public. In the text, a green border highlights all changes since the initial environmental impact assessment (EI-DUP) related to the two formal updates, EI-DAC1 and EI-DR0, mentioned above. A blue border highlights the updates made after the submission of the DR0 milestone files in preparation for the regulatory consultations of the creation licence procedure (EI-DAC2). A grey highlight indicates changes since the regulatory consultations, constituting the EI-DAC3 revision. Details of these changes are presented in Chapter 3 of Volume I of this environmental impact assessment.

The environmental impact assessment identifies and assesses the environmental impacts of the Cigéo overall project, which includes the Cigéo disposal facility and all operations (activities, facilities, structures, works and developments) necessary for its construction and operation, including the basic nuclear installation (BNI). These operations are carried out by Andra and other project owners.

Due to the nature and scale of the Cigéo disposal facility, its environmental impacts constitute the major portion of the impacts of the Cigéo overall project, even though the operations of the other project owners are also likely to have environmental impacts.

At this stage, the operations of the other project owners related to the operation of the Cigéo disposal facility are not at the same stages of progress in their design and consultation and validation processes. The analysis of their impacts is therefore proportionate to their respective stages of progress.

This environmental impact assessment will be updated later should all or part of the project's environmental impacts not have been fully identified or assessed prior to the granting of another authorisation required under the Cigéo overall project, in accordance with Article L. 122-1-1 of the French Environment Code.

This legally mandated update process ensures the quality of the environmental impact assessment for complex projects such as the Cigéo project, in line with the refinements made to its design and implementation.

1

Introduction and regulatory context

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1.1 The Cigéo overall project, subject of the environmental impact assessment

The project for a French disposal facility for high-level and long-lived intermediate-level radioactive waste (HLW and ILW-LL) is the result of studies and consultations conducted to fulfil the mission entrusted to Andra by the French government.

It is located in the Grand Est region of France, straddling the departments of Meuse and Haute-Marne (see Figure 1-1), which shows the project's study areas.

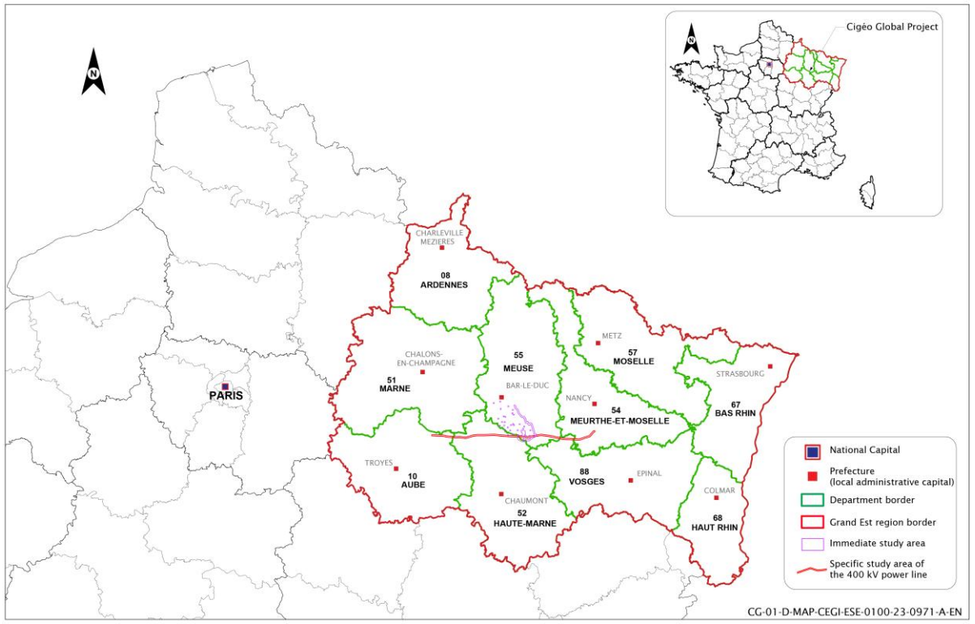


Figure 1-1 Location of the Cigéo overall project

The Cigéo overall project thus comprises:

- the facilities and structures of the Cigéo disposal facility (ramp zone, shaft zone, underground structures zone, inter-site linklink, connected terminal), including those falling within the scope of the basic nuclear installation (BNI) – see Chapter 2 of this non-technical summary, for which Andra is the project owner;
- operations related to the construction and operation of the disposal facility, carried out by other project owners:
  - ✓ the electric power supply, owned by RTE;
  - ✓ the upgrade of railway line 027000, under the project management of SNCF Réseau (modernisation of line 027000);
  - ✓ the water supply, owned by the water utilities syndicates of the Haut Ornain (SIVU) and Échenay (SIAEP);
  - ✓ the deviation of the D60/960 departmental road, under the project management of the Haute-Marne Departmental Council;
  - ✓ the shipping and transport of radioactive waste packages, under the project management of the producers (CEA, EDF, and Orano).
- Environmental characterisation and monitoring operations (including drilling, piezometers, etc.) under the project management of Andra or a third-party project manager.

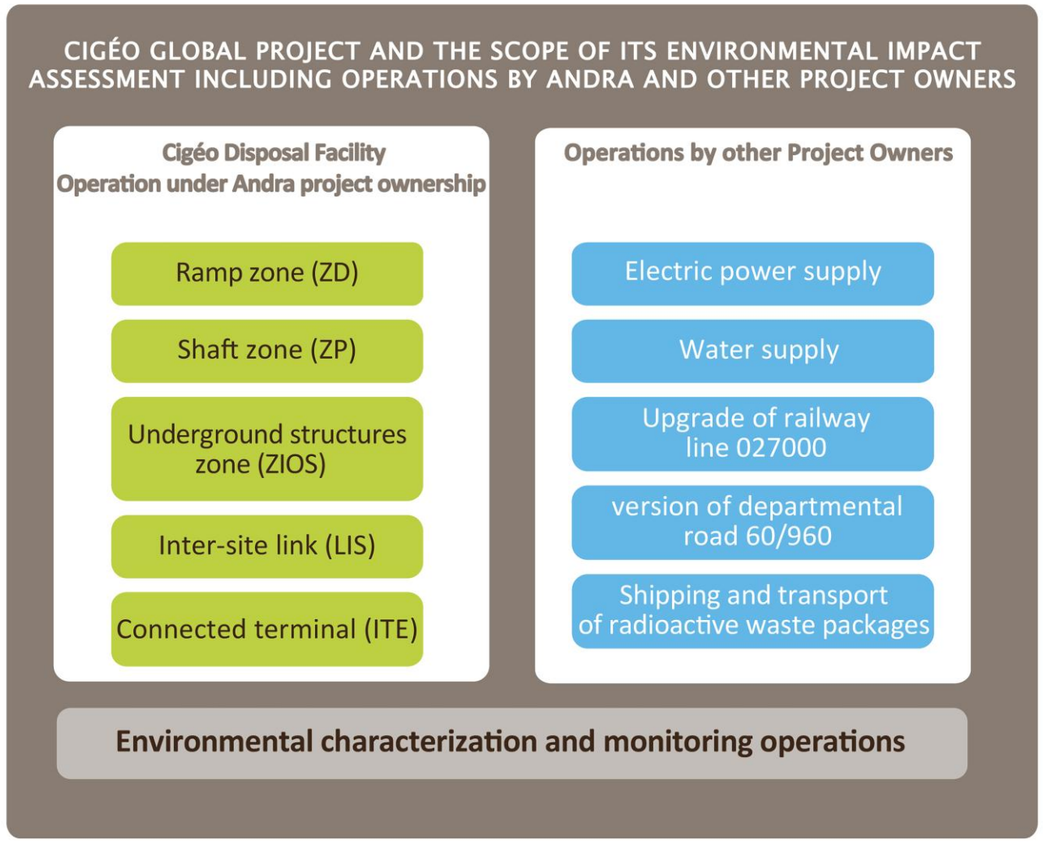


Figure 1-2 Cigéo overall project and the scope of its environmental impact assessment

Figure 1-3 provides a close-up view of the locations of the various operations within the Cigéo overall project.

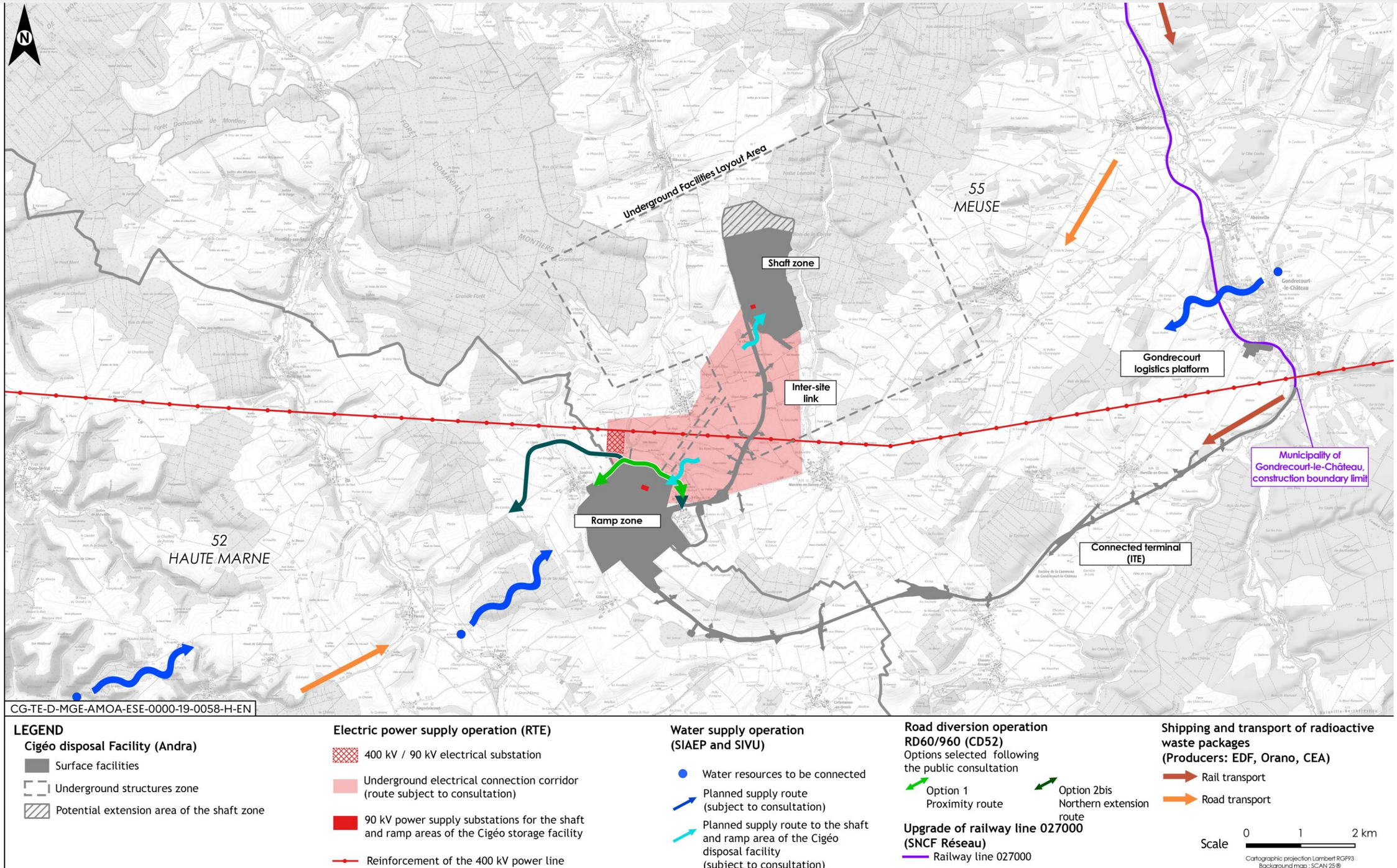


Figure 1-3 *Location of the various operations of the Cigéo overall project (excluding environmental characterisation and monitoring operations) – Close-up view*

1.2 The project owners of the Cigéo overall project

1.2.1 Andra, project owner of the disposal facility

Andra, the National Agency for Radioactive Waste Management, operates under the supervision of the ministries responsible for energy, the environment, and research. Established in 1979, Andra became a public industrial and commercial establishment following Act No. 91-1381 of 30 December 1991 concerning research activities on radioactive waste management (3). Its missions were expanded by Planning Act No. 2006-739 of 28 June 2006 on the sustainable management of radioactive materials and waste (4). Act No. 2016-1015 of 25 July 2016 (5) specifies the terms and conditions for the creation of a reversible deep geological disposal facility for long-lived high and intermediate level radioactive waste and schedules regular meetings with the company regarding project governance.

Article L. 542-12 of the French Environment Code states that *"Andra, a public industrial and commercial institution, is responsible for the long-term management of radioactive waste, and in particular:*

1. *Establishing, updating every five years, and publishing the inventory of radioactive materials and waste present in France, as well as their location within the national territory, with the waste referred to in Article L. 542-2-1 listed by country;*
2. *To conduct or commission, in accordance with the national plan provided for in Article L. 542-2-1, research and studies on interim storage and deep geological disposal, and to ensure their coordination;*
3. *To contribute, under the conditions defined in the penultimate paragraph of this Article, to the assessment of the costs associated with the implementation of long-term management solutions for high-level and long-lived intermediate-level radioactive waste, according to their nature;*
4. *To establish, in compliance with nuclear safety regulations, specifications for the disposal of radioactive waste and to provide the competent administrative authorities with an opinion on the specifications for the conditioning of waste;*
5. *To design, locate, construct, and manage interim storage facilities or disposal facilities for radioactive waste, taking into account the long-term propects for the production and management of such waste, and to conduct all necessary studies for these purposes;*
6. *To ensure the collection, transport, and handling of radioactive waste, as well as the remediation and, where necessary, the management of sites contaminated by radioactive substances, upon request and at the expense of those responsible;*
7. *To make information on the management of radioactive waste available to the public and to contribute to the dissemination of scientific and technological knowledge in this field;*
8. *To share its expertise abroad.*

Thus, Andra is the project owner of the Cigéo disposal facility.

1.2.2 The project owners for the other operations of the Cigéo overall project

The other operations related to the construction and operation of the disposal facility, which are nevertheless carried out outside the Cigéo disposal facility, are under the following project owners:

- RTE: project owner for the electric power supply operation;
- SIVU du Haut Ornain and SIAEP d'Échenay: project owners for the water supply project;
- SNCF Réseau: project owner for the upgrade of railway line 027000 (modernisation of line 027000);
- Haute-Marne Departmental Council: project owner for the deviation project of D60/960 departmental road;
- Producers of radioactive waste (CEA, EDF, and Orano): project owners responsible for the shipping and transport of radioactive waste packages.

1.2.3 Project owners for environmental characterisation and monitoring operations

Environmental characterisation and monitoring operations are carried out under the project management of Andra and under third-party project management, depending on the operations involved.

1.3 The regulatory framework for environmental assessment and the content of the environmental impact assessment

1.3.1 The environmental assessment process

The environmental assessment process is a decision-making tool that takes into account the entire life cycle of a project, from construction until closure. This process allows the project to be adapted, refined and coordinated with the results of public participation conducted prior to decision-making.

The environmental assessment process consists of:

- the preparation of an environmental impact assessment report by the project's owner(s), which corresponds to the environmental impact assessment, the contents of which are specified below;
- the conduct of the required consultations, including consultation with the Environmental Authority, which issues an opinion on the project and the environmental impact assessment, and public consultation;
- the review by the authority authorising the project of the information contained in the assessment report and received during the consultations.

1.3.2 What is the purpose of an environmental impact assessment?

Within the environmental assessment process, the environmental impact assessment is a regulatory document based on scientific and technical analyses. It presents to the public the process for assessing a project's effects on the environment (natural, human, cultural heritage, etc.) and the measures intended to avoid, reduce, or, if necessary, offset them.

Thus, the environmental impact assessment consists of a synthesis of all the environmental studies conducted by the project owners:

- it ensures that the public is properly informed and involved in the project's development;
- it explains how these environmental studies aided in defining the project by enabling the project owners to understand the environmental issues at sites directly or indirectly affected by the project's implementation, and how the project design was adapted to avoid or reduce negative impacts;
- it provides administrative authorities with the necessary information to enable them to rule on the application file submitted to them. This information includes measures to avoid, reduce, and offset the project's impacts, as well as follow-up of their implementation;
- it constitutes a list of commitments by the project owners regarding the environmental integration of the project. This list may be subject to subsequent updates as knowledge of all operations within the overall project evolves, as their design is refined, and as conclusions from ongoing or future public participation procedures are incorporated.

It follows from Article R. 122.5 of the French Environment Code, which defines the content of the environmental impact assessment, that the preparation of the assessment is structured around three main stages:

- assessing the issues by defining the initial state of the environment prior to the implementation of the Cigéo overall project, followed by the evolution of this environment over time. This includes a description of the following factors: population and human health; biodiversity; land, soil, and subsoil; water, air, and climate; physical assets, cultural heritage, and landscape; and the interaction between these factors;
- identify the significant potential impacts that the Cigéo overall project is likely to have on these factors;
- based on the identified effects, propose measures to be implemented by the project owner:
  - ✓ impact avoidance measures;
  - ✓ measures to reduce impacts that cannot be avoided;
  - ✓ for impacts that could not be avoided or sufficiently reduced, offset measures where necessary and possible.

1.3.3 What information is included in the environmental impact assessment and its non-technical summary?

The content of the environmental impact assessment is established by Articles L. 122-1, III and R. 122-5 of the French Environment Code. The following table 1-1 presents the breakdown of the regulatory content within this environmental impact assessment.

For basic nuclear installations and other specific activities, the content is specified and supplemented by Article R. 593-17, as necessary, in accordance with the provisions of Sections VI and IV of Article R. 122-5 of the French Environment Code. Table 1-1 presents this specific content to be included in this impact assessment.

Table 1-1 Breakdown of the regulatory content of the environmental impact assessment related to Articles L. 122-1 and R. 122-5 of the French Environment Code

Articles L. 122-1, III, and R. 122-5 of the French Environment Code		Relationship to the impact assessment (Document 6)	Link to this NTS (Document 6bis)
Article L. 122-1 of the French Environment Code			
III. – The environmental assessment is a process consisting of the preparation, by the project owner, of an environmental impact assessment report, hereinafter referred to as the "environmental impact assessment," the conduct of the consultations provided for in this section, as well as the review, by the authority competent to authorise the project, of all information presented in the impact assessment and received during the consultations conducted by the project owner. The environmental assessment makes it possible to describe and evaluate, in an appropriate manner and on a case-by-case basis, the significant direct and indirect impacts of a project on the following factors: 1. Population and human health; 2° Biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC of May 21, 1992 (6) and Directive 2009/147/EC of November 30, 2009 (7) ; 3° Land, soil, water, air, and climate; 4. Material assets, cultural heritage, and the landscape; 5° The interaction between the factors mentioned in 1° to 4°. The impacts on the factors listed include impacts that may result from the project's vulnerability to major accident hazards and disasters relevant to the project in question. When a project consists of several works, facilities, structures, or other interventions in the natural environment or landscape, it must be considered as a whole, including in cases where it is divided in time and space and where there are multiple project owners, so that its environmental impacts can be assessed comprehensively.		Document 6 – Volume I through VII and Document 6bis - NTS	Chapters 1 through 3
Article R. 122-5 of the French Environment Code			
I. – The content of the environmental impact assessment shall be proportionate to the environmental sensitivity of the area likely to be affected by the project, to the scale and nature of the proposed works, facilities, structures, or other interventions in the natural environment or landscape, and to their foreseeable impacts on the environment or human health. This content takes into account, where applicable, the opinion issued pursuant to Article R. 122-4 and includes the information that may reasonably be required, given existing knowledge and assessment methods.		Document 6 – particularly in Volumes III through VI regarding the initial condition of the area likely to be affected by the project, and the impact assessments	Chapter 3

Articles L. 122-1, III, and R. 122-5 of the French Environment Code		Relationship to the impact assessment (Document 6)	Link to (Docu	Articles L. 122-1, III, and R. 122-5 of the French Environment Code		Relationship to the impact assessment (Document 6)	Link to this NTS (Document 6bis)
II. – Pursuant to Article L. 122-3(II)(2), the environmental impact assessment shall include the following elements, depending on the specific characteristics of the project and the type of environmental impacts it is likely to cause: 1° A non-technical summary of the information provided below. This summary may be included in a separate document;		Document 6bis – Non-technical summary	Documen technic	b) The use of natural resources, in particular land, soil, water, and biodiversity, taking into account, to the extent possible, the sustainable availability of these resources;		Volume IV – Chapters 3, 4, 5, 6 and 8 *Note that this volume includes the conclusions of the preliminary agricultural study (in Chapter 8)*	Chapters 3.3 to 3.6
2° A description of the project, including in particular: – a description of the project's location;		Volume II	Cha	c) The emission of pollutants, noise, vibration, light, heat, and radiation; the creation of nuisances; and the disposal and recovery of waste;		Volume IV – Chapters 2, 10, 11 and 13	Chapters 3.2, 3.10, 3.11 and 3.13
– a description of the physical characteristics of the entire project, including, where applicable, any necessary demolition work, and land use requirements during the construction and operation phases;		Volume II – Chapters 3, 5 and 6	Chapters 2	d) Risks to human health, cultural heritage, or the environment;		Volume IV – Chapter 14 and Volume VI	Chapters 3.13 and 3.14
– a description of the main characteristics of the project's operational phase, relating to the manufacturing process, energy demand and use, and the nature and quantities of materials and natural resources used;		Volume II – Chapters 3 and 6	Chapters	e) The cumulative impacts with other existing or approved projects, taking into account, where applicable, environmental issues related to the use of natural resources and areas of particular environmental importance that may be affected. Existing projects are those that, at the time the application file including the impact assessment was submitted, had already been completed. Approved projects are those for which, at the time the application file including the environmental impact assessment was submitted, a decision had been made allowing them to proceed. Also included are projects which, at the time the application file including the environmental impact assessment was submitted: – were subject to an environmental impact assessment pursuant to Article R. 181-14 and a public inquiry; – were subject to an environmental assessment under this Code, for which an opinion from the environmental authority was made public. Excluded are projects that were the subject of a decree specifying a time limit and have since lapsed, those for which the authorisation decision has lapsed, those for which the public inquiry is no longer valid, as well as those that have been officially abandoned by the project owner;			
– an estimate of the types and quantities of expected residues and emissions, such as water, air, soil, and subsoil pollution, noise, vibration, light, heat, and radiation, as well as the types and quantities of waste generated during the construction and operation phases.		Volume II – Chapter 6 Volume IV	Chapter				
For facilities covered by Title I of Book V of the French Environment Code and basic nuclear installations covered by Title IX of the same book, this description may be supplemented in the permit application file, pursuant to Articles R. 181-13 et seq. and Article R. 593-16.		Volume IV – all chapters (detailed estimates by phase)	Cha			Volume IV – Chapter 16	Chapter 3.16
3° A description of the relevant aspects of the initial state of the environment and their evolution in the event the project is implemented, as well as an overview of the likely evolution of the environment if the project is not implemented, to the extent that natural changes relative to the initial state of the environment can be assessed with reasonable effort based on available environmental information and scientific knowledge;		Volume III (all chapters) and Volume IV, Chapter 21	Cha				
4. A description of the factors mentioned in Section III of Article L. 122-1 that are likely to be significantly affected by the project: population, human health, biodiversity, land, soil, water, air, climate, material assets, cultural heritage, including architectural and archaeological aspects, and the landscape;		Volume III - all chapters	Cha	f) The project's impacts on the climate and the project's vulnerability to climate change;		Volume IV – Chapter 2	Chapter 3.2.1
				g) The technologies and substances used.		Volume IV – all chapters	Chapter 3
(5) A description of the significant environmental impacts the project is likely to have, resulting, among other things, from: a) The construction and operation of the project, including, where applicable, demolition work;		Volume IV - all chapters (detailed impacts at each phase of the project)	Cha	The description of any significant impacts on the factors listed in Section III of Article L. 122-1 covers the direct effects and, where applicable, the indirect secondary, cumulative, transboundary, short-, medium-, and long-term, permanent and temporary, positive and negative effects of the project;		Volume IV – all chapters	Chapter 3

Articles L. 122-1, III, and R. 122-5 of the French Environment Code		Relationship to the impact assessment (Document 6)	Link to (Docu	Articles L. 122-1, III, and R. 122-5 of the French Environment Code		Relationship to the impact assessment (Document 6)	Link to this NTS (Document 6bis)
6° A description of the significant negative environmental impacts expected from the project resulting from the project's vulnerability to risks of major accidents or disasters related to the project in question. This description shall include, where applicable, the measures envisaged to avoid or reduce the significant adverse effects of such events on the environment and details of the preparedness and response envisaged for such emergency situations;		Volume IV – Chapter 11	Chap	focusing in particular on the consumption of agricultural, natural, or forested areas resulting from the project, depending on the scale of the anticipated work and the sensitivity of the affected environments; – an analysis of the societal costs of pollution and nuisances and the benefits to the community. This analysis shall include the main findings, with commentary, of the socioeconomic analysis when required by Article L. 1511-2 of the French Transport Code; – an assessment of energy consumption resulting from the project's operation, particularly due to the travel it generates or helps prevent; – a description of traffic assumptions, traffic conditions, and the calculation methods used to evaluate them and study their consequences. It shall also set forth the principles of noise abatement measures to be implemented in accordance with the provisions of Articles R. 571-44 through R. 571-52.			
7. A description of the reasonable alternatives that have been considered by the project proponent, based on the proposed project and its specific characteristics, and an indication of the main reasons for the choice made, including a comparison of the impacts on the environment and human health;		Volume II – Chapter 2	Chapters				
8. The measures planned by the project proponent to: – avoid significant adverse effects of the project on the environment or human health and reduce those effects that could not be avoided; – offset, where possible, the significant adverse effects of the project on the environment or human health that could not be avoided or sufficiently reduced. If it is not possible to offset these effects, the project owner shall justify this impossibility. The description of these measures must be accompanied by an estimate of the corresponding expenses and a statement of the expected effects of these measures with respect to the project's impacts on the elements mentioned in 5°;		Volume IV – all chapters, Chapters 19, 20, and Volume VI	Cha	IV. – For facilities, structures, works, and developments falling under Title I of Book II or the French Mining Code and subject to an environmental assessment, the impact assessment shall contain the elements mentioned in Section II of Article R. 181-14. For injections of natural gas or liquefied petroleum gas (LPG) into an aquifer containing drinking water or water that can be made potable, or in contact with such water, the impact assessment shall demonstrate, in particular, that the injection is carried out in such a way as to avoid any present or future risk of deterioration in the quality of the groundwater concerned.		*Only the first paragraph of Section IV of Article R. 122-5 of the French Environment Code applies in this case. Indeed, no injection of natural gas or LPG into an aquifer will be carried out. Consequently, the content specific to this type of operation does not need to be included in the impact assessment.* Volumes III and IV *Elements specific to IOTAs outside BNI perimeters will be detailed in the corresponding environmental permit applications (DAE). An update to the environmental impact assessment is therefore planned in this context.*	Chapter 3
9° Where applicable, the procedures for monitoring the proposed avoidance, reduction, and mitigation measures;		Volume IV – all chapters and Chapter 19	Chap				
10. A description of the forecasting methods or evidence used to identify and assess significant environmental impacts;		Volume VII	Cha				
11. The names, titles, and qualifications of the expert(s) who prepared the environmental impact assessment and the studies that contributed to its completion;		Volume I – Chapter 4	Cha				
12. Where certain of the elements required above are included in the risk management assessment for basic nuclear installations or in the hazard assessment for facilities classified for environmental protection, this shall be noted in the impact assessment.		Volume IV – Chapter 11 for the BNI *Elements specific to ICPEs outside the BNI scope will be detailed in the corresponding environmental authorisation applications (DAE). An update of the impact assessment is thus planned in this context.*	Chap	V. – For projects subject to an impact assessment pursuant to the provisions of Chapter IV of Title I of Book IV, the case-by-case review form serves as the Natura 2000 impact assessment when it establishes the absence of impact on any Natura 2000 site. If, following a case-by-case review, it appears that the project is likely to have significant impacts on one or more Natura 2000 sites, or if the project is subject to a systematic impact assessment as provided for in the aforementioned provisions, the project owner shall provide the information required by Article R. 414-23. The impact assessment shall serve as the Natura 2000 impact assessment if it contains the information required by Article R. 414-23.		Volume V	Chapter 3.6.4
III. – For the transportation infrastructure referred to in items 5 through 9 of the table appended to Article R. 122-2, the environmental impact assessment shall also include: – an analysis of the project's foreseeable consequences on potential urban development; – an analysis of the ecological issues and potential risks associated with land use, agricultural, and forestry developments,		Volume IV – Chapter 12 and Volume VII	Chap				

Articles L. 122-1, III, and R. 122-5 of the French Environment Code		Relationship to the impact assessment (Document 6)	Link to this NTS (Document 6bis)
VI. – For facilities classified for environmental protection under Title I of Book V and basic nuclear installations under Title IX of the same book, the content of the impact assessment is specified and supplemented, as necessary, in accordance with the provisions of Section II of Article D. 181-15-2 and Article R. 593-17.		*The elements specific to the BNI are detailed in the following table (Article R. 593-17).* *The elements specific to ICPEs outside BNI perimeters will be detailed in the corresponding environmental authorisation applications (DAE). An update of the impact assessment is thus planned in this context.*	-
VII. - For the development actions or operations referred to in Article L. 300-1-1 of the French Urban Planning Code, the impact assessment shall also include: 1° The conclusions of the feasibility study on the area's potential for renewable energy development, as well as a description of how this is taken into account; 2° The conclusions of the study on optimising building density in the area concerned, as well as a description of how these are taken into account.		*The operations of the Cigéo project, at their current stage of development (prior to public participation for certain operations), are not covered by this feasibility study or this density study.*	-
VIII. – To ensure the comprehensiveness and quality of the environmental impact assessment: a) The project owner shall ensure that the impact assessment is prepared by competent experts; b) The project owner shall take into account, where applicable, the available results of other relevant environmental impact assessments required under other applicable legislation; c) The competent authority shall ensure that it has sufficient expertise to review the impact assessment or, if necessary, shall seek such expertise; d) If necessary, the competent authority shall request from the project developer information supplementary to that provided in the environmental impact assessment, as referred to in II, and directly relevant to the preparation and justification of its decision regarding the significant environmental impacts of the project, as provided for in I of Article L. 122-1-1.		Volume I – Chapter 4 Volume I – Chapter 2 Volume VII	Chapter 1.5

Table 1-2 Breakdown of the regulatory content of the environmental impact assessment relating to Article R. 593-17 of the French Environment Code

Article R. 593-17 of the French Environment Code		Relationship to this NTS (Document 6bis)
II. - The description referred to in paragraph 2 of Section II of Article R. 122-5 sets forth, in particular, the proposed water withdrawals and discharges of liquid or gaseous effluents. It specifies the different types of effluents to be treated and their respective sources, quantities, physical characteristics, and radioactive and chemical compositions, the treatment process used, the conditions under which discharges into the receiving environment will occur, and the composition of the effluents to be discharged. It lists the waste that will be generated by all facilities and equipment located within the facility's perimeter, whether radioactive or not, as well as its volume, nature, hazardousness, and the proposed disposal methods. It describes the measures adopted by the operator to ensure that the management of this waste meets the objectives set forth in Article L. 541-1 and in Section II of Article L. 542-1-2.	Volume II – Chapter 6 Volume IV – Chapters 2, 4, 10 and 11	Chapters 2.3, 3.2, 3.4, 3.10 and 3.11
III. - The description referred to in Article R. 122-5(II)(3) shall also include a radiological assessment of the environment covering the site and its surroundings.	Volume III – Chapters 2, 3, 4, 5 and 6	Chapter 3
IV. - The description of the significant environmental impacts that the project is likely to have, as referred to in Article R. 122-5(II)(5), distinguishes between the various phases of construction and operation of the facility. It takes into account seasonal and climatic variations.	Volume IV Volume VI	Chapter 3
It shall indicate the facility's impacts on water resources, the aquatic environment, water flow, water levels, and water quality—including runoff—as well as on each of the elements mentioned in Article L. 211-1.	Volume IV – Chapters 5 and 6	Chapters 3.5 and 3.6
It also presents the effects of aerosols or dust and their deposition; it indicates the facility's impact on air quality and soil quality.	Volume IV – Chapters 2 and 3	Chapters 3.2 and 3.3
It justifies the optimisation of the management of liquid and gaseous effluents and waste, particularly regarding the overall impact of all these emissions on the environment and human health.	Volume II – Chapter 2.5 Volume IV – Chapters 2, 5, 10, 17 and 18 Volume VI – Chapters 3 and 4	Chapters 2.1.4, 3.2, 3.5, 3.10, 3.13, 3.17, and 3.18

Article R. 593-17 of the French Environment Code		Relationship to this NTS (Document 6bis)
It assesses the public's exposure to ionising radiation resulting from the facility, taking into account, in particular, radiation exposure caused directly by the facility and the transfer of radionuclides via various pathways, including food chains.	Volume VI – Chapter 4	Chapters 3.13 and 3.18
The environmental impacts of the facility are assessed, in particular, with regard to the air protection plans defined in Article L. 222-5, as well as the standards, quality objectives, and limit values defined pursuant to Articles L. 211-2, L. 211-4, and L. 221-2.	Volumes III and IV – Chapter 2 (air quality protection plans) *The Cigéo overall project is not subject to the standards, quality objectives, and limit values defined pursuant to Articles L. 211-2, L. 211-4, and L. 221-2.*	Chapter 3.2
It demonstrates the facility's compliance, with respect to radioactive waste intended to be generated by the facility or temporarily stored or disposed of therein, with the decree establishing the requirements of the French national plan for the management of radioactive materials and waste provided for in Article L. 542-1-2.	Volume IV – Chapter 10	Chapter 3.10
V. - The description of the measures envisaged to meet the requirements of paragraphs 6 and 8 of Section II of Article R. 122-5 specifies, in particular, by justifying the use of the best available techniques: 1° The expected performance, in particular with regard to the protection of groundwater, the treatment, discharge, management, and monitoring of wastewater and gaseous emissions; 2° The conditions for delivering materials to the facility for treatment, for transporting manufactured products, and for the rational use of energy; 3° The measures adopted by the operator to control water withdrawals and discharges from the facility and to monitor the facility's environmental impact; 4° The solutions adopted to minimise the volume of waste produced and its radiological, chemical, and biological toxicity.	Volume IV – Chapter 17	Chapter 3.17

1.4 Developments in the environmental impact assessment of the Cigéo overall project

1.4.1 The environmental impact assessment in the administrative procedures for the Cigéo overall project

The process for updating the environmental impact assessment is provided for in Article L. 122-1-1, III of the French Environment Code: *"The environmental impacts of a project whose implementation is contingent upon the issuance of multiple authorisations shall be assessed at the time the first authorisation is issued.*

Where the project's environmental impacts could not be fully identified or assessed prior to the granting of this authorisation, the project owner shall update the environmental impact assessment by evaluating these impacts *within the scope of the operation for which authorisation was sought and by assessing their consequences at the overall project level. […].*

The authority competent to issue the requested authorisation shall, if necessary, by means of a new decision, determine the measures to be taken by the project owner(s) to avoid significant adverse impacts, reduce those that cannot be avoided, and offset those that cannot be avoided or reduced, as well as the related monitoring measures."

The Cigéo overall project comprises operations that are divided in terms of project management and timing. These operations are not all at the same stage of design; this version of the environmental impact assessment therefore clarifies the identification and assessment of the impacts presented in the first version of the environmental impact assessment (initial 'DUP' version) submitted for public inquiry prior to the declaration of public interest.

The Cigéo overall project involves conducting several successive public consultation and authorisation procedures prior to its implementation. The environmental impact assessment is a document that must be attached to each regulatory application to which the Cigéo overall project is submitted.

Given the numerous authorisations required to carry out the Cigéo overall project, the impact assessment will therefore be updated as part of the review process for each of these authorisation applications. This approach ensures the quality of information and the participation of the public and the reviewing authorities in accordance with applicable regulations[2].

[2] This updating strategy was deemed appropriate by the Environmental Authority during its review of the environmental impact study for the public inquiry preceding the declaration of public interest (8). In its deliberative opinion No. 2020-79 dated January 13, 2021 (9), the Environmental Authority states that *"this initial study is intended to be updated as and when the necessary authorisation requests for the project's implementation are submitted" and that "this approach is the only appropriate one to ensure that the public and the legislature are informed about environmental issues throughout the project. This updating will necessitate successive referrals to the Environmental Authority."*

1.4.2 The reasons for changes to the environmental impact assessment in the context of successive submissions

There are three reasons for updating the environmental impact assessment as part of the successive submissions of regulatory applications:

- clarifications provided by the project owners regarding the characteristics of the operations comprising the overall project, particularly those related to the project's design and/or its changes following public participation procedures;
- changes in the initial state of the environment between successive submissions of the environmental impact assessment;
- regulatory changes.

Another update to the environmental impact assessment results from the incorporation of responses to comments made by the Environmental Authority. It may also be supplemented to take into account any comments from the agencies responsible for reviewing the authorisation application(s) to which the environmental impact assessment is attached.

1.4.3 The environmental impact assessment covered by this file

1.4.3.1 The context for updating the environmental impact assessment

The initial environmental impact assessment is the one provided with the application for a declaration of public interest.

1.4.3.1.1 The formal update associated with the application for authorisation to establish the Cigéo BNI – reminder (initial environmental impact assessment 'EI-DUP'/environmental impact assessment 'EI-DAC')

The establishment of a nuclear facility is subject to an environmental assessment pursuant to the appendix to Article R. 122-2 of the French Environment Code. The environmental impact assessment is one of the documents in the Creation Licence Application (DAC) of the Cigéo basic nuclear installation (BNI) (Article R. 593-16 of the French Environment Code), which is currently under review. It updates the environmental impact assessment that was included in the public inquiry file for the declaration of public interest for the Cigéo disposal facility, a declaration issued in 2022 (1).

The creation licence application for the basic nuclear installation was submitted on January 16, 2023, to the Minister responsible for nuclear safety. The French Nuclear Safety and Radiation Protection Authority (ASNR) is reviewing the application, jointly and at the request of the Ministry responsible for nuclear safety. Consultations are being conducted in parallel with various departments and technical experts, followed by consultations with various bodies and the public, notably *through* a public inquiry.

This environmental impact assessment ('EI-DAC3') is a second revision of the version submitted on 16 January, 2023 ('EI DAC1') as part of the creation licence application for the Cigéo BNI. Attached to first version of the creation licence application, it incorporates the following:

- the 'EI-DR0' formal update, part of the authorisation applications concerning the first environmental characterisation and monitoring operations—referred to as DR0—submitted on 6 March, 2024 (see Chapter 1.4.3.1.2 of this non-technical summary);
- the 'EI-DAC2' revision prepared for regulatory consultations, including the referral to the Authority Environmental as part of the review of the creation licence application (DAC) for the Cigéo basic nuclear installation (BNI);
- a revision following the regulatory consultations to incorporate clarifications, detailed in chapter 1.4.3.2 of this non-technical summary.

1.4.3.1.2 The formal update related to the DR0 work phase concerning the first environmental characterisation and monitoring activities for the Cigéo overall project (environmental impact assessment 'EI-DAC' / environmental impact assessment 'EI-DR0')

The first environmental characterisation and monitoring activities for the DR0 work phase must be subject to:

- an environmental authorisation pursuant to Article L. 181-1 of the French Environment Code;
- prior notifications and building permit applications pursuant to the French Urban Planning Code, depending on the characteristics of the structures (6 building permits, 26 prior notifications).

Document DAE6, "Environmental Impact Assessment of the Cigéo Overall Project" (10), is one of the documents in the application file for the environmental authorisation of the DR0 work phase, also attached to the files for urban planning authorisation applications. The environmental impact assessment attached to these files is the formal updated version of the impact assessment that was attached to the application for a construction permit (DAC) for the Cigéo basic nuclear installation (BNI), filed on January 16, 2023.

The first environmental characterisation and monitoring operations are part of the Cigéo overall project, more specifically the "environmental characterisation and monitoring" operation (see Chapter 2 of this non-technical summary). These operations consist of installing equipment designed to provide additional data on the characterisation and monitoring of the environment for the Cigéo overall project from geological, hydrogeological, and geotechnical perspectives. This equipment includes boreholes, drillings, and piezometers installed directly at, near, or at a distance from the operations comprising the Cigéo overall project, depending on their purpose.

In addition, archaeological excavations—mandated following archaeological surveys conducted in 2015–2016—as well as voluntary supplementary archaeological surveys are also planned. This involves:

- approximately 28 ha of additional voluntary archaeological surveys;
- approximately 100 ha of areas reserved for archaeological excavations.

Preventive archaeology, a regulatory requirement, aims to ensure the detection, conservation, or preservation through scientific study of elements of the archaeological heritage affected or likely to be affected by the works contributing to the development.

Accordingly, the environmental impact assessment for the creation licence application (DAC) has been updated (second update) to specify the characteristics of the first environmental characterisation and monitoring operations and their environmental impacts.

This second formal update was attached to the applications for the DR0 work phase, detailed above and submitted on March 6, 2024, and subsequently to the associated single public inquiry file, which was open for public consultation from February 28 to April 15, 2025. The authorisations were issued on July 11, 21, and 22, 2025. This second update is available on the Andra website[3].

[3] https://www.andra.fr/cigeo/les-documents-de-reference (2).

1.4.3.2 Key changes to the environmental impact assessment since the version 'EI-DUP'

This environmental impact assessment (EI-DAC2) primarily includes the updates made as part of the creation licence application (DAC) to the environmental impact assessment associated with the public inquiry for the declaration of public interest.

As a reminder, the latter presented, in grey boxes, the additions made in response to questions from the environmental authority (11). These additions primarily concerned the justification for choosing deep geological disposal, its design, its location, and the safety of the facility during operation and in the long term. Clarifications were also provided regarding potential impacts and associated measures for water, seismic risk, agriculture, biodiversity, and health.

When the creation licence application was submitted, these grey inserts were incorporated into the text.

The main changes made during the first update of the environmental impact assessment, for the submission of the creation licence application, concerned:

- the process for updating the environmental impact assessment accompanying the regulatory applications required for the Cigéo overall project and its traceability (see Volume I of this environmental impact assessment);
- the restructuring of certain chapters to highlight the Avoid-Reduce-Offset (ARO sequence) and improve public understanding (see General Summary of the Impact Assessment);
- details of the Cigéo BNI (see Volume II of this impact assessment);
- the update of initial state data, confirming the levels of concern identified in the previous impact assessment, for meteorology, water quality and uses, flora and fauna, demographics, road traffic, landscape and heritage, and public utility easements (see Volume III of this impact assessment);
- the update, which confirms the impact levels from the previous version of the environmental impact assessment, including liquid effluent discharges, traffic modelling, acoustic modelling, atmospheric dispersion modelling, health risk assessment, debt calculation, and the management principles for ecological compensation sites, as well as cumulative impacts with other projects (see Volumes IV, VI and VII of this impact assessment);
- detailed analyses related to the risk management assessment on natural and technological risks and best available techniques, under normal and accident conditions, for the environment and human health, from construction through post-closure (see Volumes IV, VI, and VII of this environmental impact assessment).

Second, the version of the environmental impact assessment (EI-DAC2) prepared for the regulatory consultations associated with the review of the creation licence application incorporates the changes to the overall project that were reviewed and made available to the public: these are reflected in the update to the environmental impact assessment associated with the single public inquiry file for the DR0 work phase, relating to the first environmental characterisation and monitoring operations (10).

As a reminder, the second formal update of the environmental impact assessment (EI-DR0) has:

- provided descriptive details on the first environmental characterisation and monitoring operations;
- updated the intial state, confirming the levels of concern identified in the previous environmental impact assessment;
- The traceability of these cumulative changes since the environmental impact assessment associated with the public inquiry for the declaration of public interest (12), which also incorporates the second update of the environmental impact assessment, has been established.

The EI-DAC2 update includes changes compared to the environmental impact assessment associated with the submission of the DR0 construction phase documents on March 6, 2024, concerning the first environmental characterisation and monitoring operations:

- it no longer includes the specific chapters for each topic regarding the impacts of the first environmental characterisation and monitoring operations, which were presented in the second update. Indeed, the purpose of this environmental impact assessment is to support the public consultation on the creation licence application to construct the Cigéo basic nuclear installation. The impacts of the DR0 operations remain available for review in the second update, available on the Andra website;
- it incorporates regulatory and project updates, as well as updated data, the details of which are noted in the text. In particular, it takes into account changes to the reserve inventory in line with the guidelines then available for the third Multi-Year Energy Plan, as well as elements provided during the technical examination (clarifications and commitments with deadlines prior to the end of the technical examination).

A separate record of these changes since the submission of the authorisation applications for the DR0 works has been maintained (see Chapter 1.4.4 of this non-technical summary).

Third, this environmental impact assessment (EI-DAC3), prepared following the completion of regulatory consultations associated with the review of the creation licence application for the Cigéo BNI, is a revision of the EI-DAC2 incorporating:

- regulatory changes resulting from the third Multi-Year Energy Plan (PPE3) published in February 2026 (13) ;
- updated data resulting from the 2026 edition of the National Inventory Essentials, the publication of the summary of the consultation conducted by Andra on reversibility reviews, the publication of the report on the consultation conducted by the water authority, as well as the holding of the public debate on the 6th PNGMDR the update of data resulting from the 2026 edition of the essentials of the National Inventory ;
- clarifications regarding the IRSN report "Assessment of the Radiological Status of the French Environment from 2018 to 2020" in the initial radiological status section of Volumes III and VII, as well as the PM2.5 and PM10 values in table 3-5 of Volume IV.

This revision did not require a modification of the environmental impact assessment in connection with the opinion of the Environmental Authority, issued on 18 December 2025. The response to this opinion, as well as the follow-up on Andra's commitments, can be found in Document 18 of this file.

A separate traceability of these changes since the EI-DAC2 revision has been carried out (see Chapter 1.4.4 of this non-technical summary).

1.4.4 Traceability of the environmental impact assessment update within the framework of successive environmental assessment processes

Each new version of the environmental impact assessment is attached to one or more authorisation applications. The objective is to track the changes made between two successive versions of the environmental impact assessment, i.e., between versions N (previous version) and N+1 (updated version) of the environmental impact assessment.

»SPECIAL CASE OF GRAPHICAL REPRESENTATION IN THIS 'EI-DAC'

The graphical elements allow for the tracking of:

- using green bars in the margin of the text, all modifications or additions made to the environmental impact assessment of the public inquiry file prior to the declaration of public interest for the Cigéo disposal facility, with the exception of minor corrections to form and consistency that are not highlighted (initial impact assessment/'EI-DUP' (12)). These updates combine the modifications made to the environmental impact assessment as part of the first ('EI-DAC1') and second formal updates ('EI-DR0'), as presented in the environmental impact assessment associated with the single public inquiry file concerning the first environmental characterisation and monitoring operations;
- with blue bars in the margin of the text, the modifications or additions made to the environmental impact assessment associated with the DR0 work phase filed on March 6, 2024 concerning the first environmental characterisation and monitoring operations (first update/EI-DAC2 revision);
- gray highlighting of text, modifications, or additions made to the environmental impact assessment since the regulatory consultations conducted as part of the review of the creation licence application (first update/EI-DAC3 revision).

Several indicators help track modifications made to the environmental impact assessment as part of the updates:

- in the text, colored borders highlight the chapters corresponding to clarifications made to update the environmental impact assessment; minor corrections regarding formatting, rewording, and consistency have not been marked;
- a table of the environmental impact assessment's structure is available in the general table of contents of the environmental impact assessment; it specifically outlines changes to the document's structure: creation, relocation, grouping, or deletion of chapters or paragraphs. It allows for easy comparison between the previous version of the environmental impact assessment and the updated environmental impact assessment. These restructuring and changes to the table of contents are not highlighted in the text with a green border so as not to make the document more cumbersome to read;
- a table tracking the main changes to the environmental impact assessment's content is available at the end of each volume to summarise the modifications made to the updated environmental impact assessment. It lists, according to the structure of the updated environmental impact assessment, the substantive changes highlighted in the text with a green border as mentioned in the first point.

Regarding figures and tables, in the event of changes, a border appears only in the legend referencing these figures and tables.

1.5 Experts involved in the preparation and execution of the environmental impact assessment

The preparation of the environmental impact assessment for the Cigéo overall project is led by Andra, based on the environmental and technical studies and impact assessments conducted by the various project owners and contractors for each phase of the overall project.

To produce this environmental impact assessment, Andra relied on:

- its key in-house experts (notably the Directorate of Safety, Environment, and Waste Management Strategy, and the Legal Department);
- project management consultants (PMCs):
  - ✓ *Egis Structures et Environnement*, for updating the impact assessment of the Cigéo overall project;
  - ✓ *SI LEX et Associés*, for regulatory expertise;
- its generalist or specialised external service providers, for the technical and environmental studies of the Cigéo disposal facility;
- with other project owners of the Cigéo overall project and their service providers.

An internal and external validation process has been established for the validation of the environmental impact assessment.

2

Justification and description of the Cigéo overall project

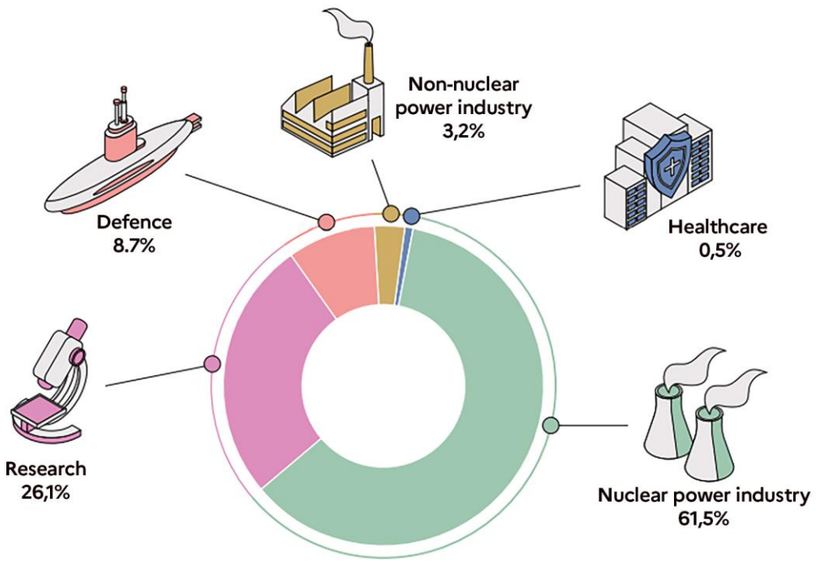
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2.1 Justification of the project and the main technical and environmental choices

2.1.1 Justification of the need for sustainable management of high-level (HLW) and long-lived intermediate-level (ILW-LL) radioactive waste

Radioactivity is a physical phenomenon that can be of natural origin (cosmic radiation or radiation from radioactive elements naturally present in food or soil) or of artificial origin (various economic sectors utilise the properties of radioactivity and, as a result, produce radioactive waste intended to be managed by Andra (see Figure 2-1).

DISTRIBUTION BY ECONOMIC SECTOR OF WASTE VOLUMES OF WASTE VOLUMES (in conditioned equivalent) ALREADY DISPOSED OF OR PLANNED TO BE MANAGED BY ANDRA BY THE END OF 2024



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Figure 2-1 *Breakdown by economic sector of the volume of waste (in conditionned equivalent) already disposed of or intended to be managed by Andra by the end of 2024 (14)*

RADIOACTIVITY, RADIOACTIVE HALF-LIFE

Radioactivity is a natural phenomenon that has existed since the origin of the universe, when atoms first formed. It is the phenomenon whereby certain unstable atoms—radionuclides—tend to become stable. To do so, they decay and release energy in the form of radiation and/or particles. Radioactivity can also be created artificially through human activities. This involves creating or recreating radioactive nuclei using a particle accelerator or a nuclear reactor.

The half-life refers to the time it takes for the amount of a given radionuclide to be reduced by half as a result of its decays. It varies greatly depending on the radionuclide (from a few seconds to several thousand years).

Radioactive waste consists of substances that contain radioactive elements and emit radiation, which makes them hazardous depending on their nature and level of radioactivity.

The French classification of radioactive waste management streams is based on two parameters used to determine the appropriate management method (see Figure 2-2):

- the level of radioactivity (very low, low, intermediate, high);
- the radioactive half-life of the elements (very short, short, long).

Radioactive waste is thus classified into six categories, namely:

- very short-lived waste (VSLW). Its activity level decreases very rapidly due to radioactive decay;
- very low-level waste (VLLW), waste resulting from the operation, maintenance and decommissioning of nuclear facilities (concrete, rubble, scrap metal, soil, etc.). Its activity level is generally less than 100 becquerels per gram;
- short-lived low- and intermediate-level waste (LILW-SL), waste resulting from the operation, maintenance and decommissioning of nuclear facilities (gloves, clothing, tools, fibers, sludge, etc.). Its activity level ranges from a few hundred to approximately one million becquerels per gram;
- low-level long-lived waste (LLW-LL), graphite waste from the first nuclear power plants, and radium-bearing waste (such as that resulting from extraction of rare earths). Its activity varies depending on its nature (graphite waste, radium-bearing waste, etc.). It can reach up to approximately 100,000 becquerels per gram;
- long-lived intermediate-level waste (ILW-LL), waste from metal structures surrounding spent fuel, and technological waste related to the maintenance of nuclear facilities. Its activity ranges from one million to one billion becquerels per gram;
- High-level waste (HLW), waste resulting mainly from the reprocessing of spent fuel. Its activity level is in the range of several billion becquerels per gram.

Long-term management pathways, tailored to the radioactivity level and half-life of radioactive waste, have been developed and are currently in place for the final disposal of VSLW, VLLW, and LILW-SL (see Figure 2-2):

- VSLW, for which radioactivity decreases significantly within a few months, or even a few days or hours, is stored at its location of use until its radioactive decay is complete, before disposal via the conventional waste management pathway suited to its physical, chemical or biological characteristics;
- two centers located in the Aube department and operated by Andra enable the above-ground disposal of VLLW and LILW-SL (see Figure 2-3 and figure 2-5), with the latter accounting for 90% of the volume of produced waste packages. It should be noted that the Manche disposal facility, which operated from 1969 to 1994, also allowed for this type of disposal and is currently in the process of being decommissioned (see Figure 2-4).

Andra is also conducting studies to design technical solutions that will eventually enable permanent disposal of (see Figure 2-2):

- LLW-LL (shallow-depth disposal);
- HLW and ILW-LL (deep geological disposal); **this is the purpose of the Cigéo overall project**.

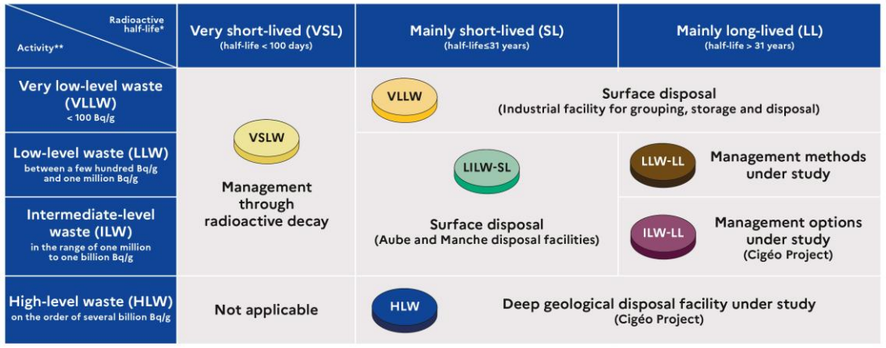


Figure 2-2 *Waste management pathways developed or planned for the various categories of radioactive waste (14)*

Table 2-1 *Existing radioactive waste disposal facilities in France*

Very low-level waste (VLLW)	 *Figure 2-3* *Industrial facility for Grouping, Storage, and Disposal (Cires) in the Aube department - currently in operation*
Short-lived low- and intermediate-level waste (LILW-SL)	 *Figure 2-4* *Manche Disposal facility (CSM) – operated from 1969 to 1994 – currently in the process of decommissioning and closure*

[4] A waste preparation stage may precede the placement of waste into a container (pre-packaging)



Figure 2-5 *Aube Disposal facility (CSA) – in operation*

High-level (HLW) and intermediate-level long-lived (ILW-LL) waste account for approximately 3% of the total volume of all radioactive waste but more than 99% of the radioactivity.

Their level of radioactivity makes them highly radiologically hazardous. An individual standing in the immediate vicinity of high-level waste (HLW) without protection would have a life expectancy of only a few minutes due to the intensity of the radiation. Due to their nature and significantly lower concentrations of radionuclides, intermediate-level long-lived) waste (ILW-LL) are generally less radioactive. HLW and ILW-LL are also dangerous if dust emitted near the packages is ingested or inhaled in the event of an accident resulting in a loss of containment of the package. Ingestion or inhalation of HLW and ILW-LL particles could lead to internal contamination or irradiation of the body, which could be very serious for health.

Even though the radioactivity of HLW and ILW-LL decreases, the timescales associated with its hazardous nature are very long. It is only after several hundred thousand years that the vast majority of radionuclides contained in the waste pose a low risk to people and the environment.

HLW and ILW-LL therefore cannot be stored permanently on or near the surface in a passive manner, given its high level of hazard and the very long duration for which this hazard persists. Facilities for managing high-level (HLW) and intermediate-level long-lived (ILW-LL) radioactive waste packages are therefore designed to be robust and with the sole objective of ensuring their safety, so that, despite the waste's intrinsic hazard, they result in minimal exposure to the public and the environment under both normal and degraded conditions.

This hazardous nature also requires the implementation, at each step of their management, of appropriate measures to protect people and the environment.

First and foremost, the waste is conditioned by the waste producers. This conditioning encompasses all operations involving the placement of waste into a container[4] , where it may or may not be incorporated into a coating material. Conditioning operations include, for example, compaction, vitrification, cementation, bituminisation, and placement into a container. These operations enable the creation of "waste packages", in which radioactive waste is in a form suitable for transport, storage and disposal (see Figure 2-6).



Figure 2-6 *Examples of waste packages—vitrified high-level (HLW) waste on the left and cemented long-lived intermediate-level (ILW-LL) waste on the right*

Furthermore, appropriate measures to protect people and the environment are also implemented at existing surface storage facilities, where HLW and ILW-LL already produced is currently stored by waste producers on a temporary basis. Despite the intrinsic hazard of radioactive waste, current facilities for managing HLW and ILW-LL packages, thanks to their robust design and given their sole objective of securing this waste, result in low exposure to the public and the environment under both normal and degraded conditions.

However, this stage of storing HLW and ILW-LL in surface or subsurface facilities is not sustainable in the very long term, considering, on the one hand, the very long duration for which the waste remains hazardous and, on the other hand, the limited lifespan of these storage facilities, which must be periodically renewed to maintain their safety level.

The Cigéo overall project ensures the definitive and very long-term passive containment of HLW and ILW-LL packages currently stored at the producers' sites pending sustainable management. The disposal of waste packages adds, to their conditioning, the possibility of passive containment of radioactive waste over long time scales, adapted to their radiological and physicochemical characteristics.

The sustainable management of high-level (HLW) and intermediate-level long-lived (ILW-LL) waste—that is, ensuring their permanent and very long-term safe disposal to prevent or limit the burden on future generations—is an ethical requirement established by the French Environment Code. Indeed, it is the responsibility of current generations, who have engaged in and benefited from nuclear activities, to implement the technical solutions necessary to ensure the long-term and safe management of the produced HLW and ILW-LL, without indefinitely passing the burden from one generation to the next. **The Cigéo overall project ensures this sustainable and responsible management of HLW and ILW-LL.**

2.1.2 The choice of deep geological disposal in the Callovian-Oxfordian clay formation

Research and studies into sustainable management options for high-level (HLW) and intermediate-level long-lived (ILW-LL) radioactive waste have long been underway in most countries that have developed nuclear or nuclear-power programs, taking into account the nature and properties of the resulting waste. Long-term storage of waste, either above or below ground; reducing its hazard through transmutation; sending it into space; disposal on the seabed (immersion in the oceans, burial on the seabed, or utilising plate tectonics); disposal in the polar ice caps; disposal in the continental geological environment in very deep boreholes (several thousand metres) or in facilities excavated in deep geological layers using mining techniques—all of these management options have been the subject of evaluation programmes[5].

A comparison of geological disposal with other options considered for the management of HLW and ILW-LL justifies the choice of geological disposal and serves as the starting point for the study, siting, design, and impact analysis phases of the Cigéo disposal facility.

Sending waste into space, disposing of it on the seabed or in the polar ice caps has been ruled out for technical, regulatory, or ethical reasons.

The remaining alternatives, to be compared to decide on the method for managing high-level and intermediate-level waste, are as follows:

- long-term storage of waste, either above or below ground;
- reducing the hazardousness of the waste through transmutation;
- disposal of waste in the continental geological environment:
  - ✓ in very deep boreholes;
  - ✓ in facilities excavated in deep geological layers using mining techniques.

A comparative analysis of these four plausible options considered for the sustainable management of HLW and ILW-LL, presented in Volume II of this impact assessment and summarised briefly below (see Chapter 2.2 of this non-technical summary), shows a significant advantage for disposal in the continental geological environment, in facilities excavated in deep geological layers using mining techniques. This advantage stems primarily from its capacity to manage all HLW and ILW-LL sustainably and over the very long term, its safety performance, its reversibility and its very low long-term impact.

Furthermore, among all the options considered for the sustainable management of HLW and ILW-LL, disposal in the continental geological environment in facilities excavated in deep geological layers using mining techniques constitutes the reference approach that has achieved international consensus for the sustainable and very long-term management of HLW and ILW-LL. This is the management approach adopted by France in the French Environment Code (Article L. 542-1-2, II, 3) and implemented by Andra through the Cigéo overall project. Research on storage and transmutation, as complementary solutions to geological disposal, is ongoing.

[5] For more information: International Overview of Research on Alternatives to Geological Disposal of Long-Lived High- and Intermediate-Level Waste (IRSN Report No. 2019-00318) (15). Excerpt from Article L. 542-1-2 of the French Environment Code: *"After storage, final radioactive waste that cannot, for reasons of nuclear safety or radiation protection, be stored at the surface or at shallow depth shall be emplaced in deep geological formations."*

2.1.2.1 The principle of deep geological disposal

Deep geological disposal involves placing radioactive waste packages in structures built in the continental subsoil, at a depth that isolates the waste from people and the environment, to take advantage of the natural properties of the rock over long time scales.

The implementation of such passive systems is provided for by European Council Directive 2011/70/Euratom of July 19, 2011(16), which is itself based on the nuclear safety recommendations of the International Atomic Energy Agency (IAEA). Considering that *"radioactive waste (...) requires containment and isolation from humans and the living environment over the long term"* (Whereas N° 21), the directive stipulates that member states' national policies on the management of spent fuel and radioactive waste must be based, in particular, on the following principle: *"spent fuel and radioactive waste shall be safely managed, including in the long term with passive safety features*" (Article 4(3)(c)).

Deep geological disposal meets the objectives of sustainable management of the most hazardous waste as defined in the French Environment Code (Articles L. 542-1 et seq. of the French Environment Code):

- to avoid burdening future generations with the management of this waste, thanks to the passive nature of the protective measures;
- to provide long-term protection for people and the environment by isolating the waste and durably confining the hazardous substances it contains.

In deep geological disposal:

- radiation from the waste cannot reach living organisms given the thickness of the rock separating them from the ground surface;
- the depth and stability of geological formations protect the waste from disturbances of natural origin (severe weather, erosion, flooding, desertification, etc.) and human origin (construction sites, destruction, looting, vandalism, etc.) occurring on the surface. The selected rocks have often been stable for tens of millions of years, and forecasts indicate that this geological stability will be maintained for millions of years to come (phenomena such as erosion, uplift, and volcanism linked to tectonic movements). Furthermore, on the continent, the properties of the rocks can be studied in depth through surface investigations and *in situ* testing in dedicated laboratories;
- the properties and thickness of the geological formation in which the waste is placed ensure containment over long time scales, in addition to waste packaging and the design of disposal facilities. In practice, the radioactive and toxic substances contained in the radioactive materials present in the waste are retained within the rock and/or their migration is significantly slowed down over time. At the same time, the hazard posed by radioactive waste decreases over time due to the natural decay of radioactivity. Thus, most radioactive elements will never reach the surface, and some will reach it only after several hundred thousand years and in very small quantities, such that this poses no danger to people or the environment.;
- the depth of the disposal facility and the selection of a site lacking exceptional or specific resources reduce the likelihood of inadvertent human intrusion (in the event that the disposal facility is forgotten). Excavation at this depth is relatively costly and is undertaken only for specific geological investigation purposes. Even if restrictions on surface land use, or even the memory of the disposal facility's existence, fade over time, the probability of inadvertent human intrusion into a deep geological repository is very low. Given the design of the disposal facility, even if drilling were to inadvertently penetrate it, the long-term consequences would remain limited;
- the areas selected for geological repositories have no exceptional or particular interest in terms of natural resources in their subsurface. The choice of this type of resource-poor area aims to further reduce the risk that deep drilling will be carried out in their vicinity.

[6] BRGM, the French geological survey, is France's leading public institution for Earth Science applications for the management of surface and subsurface resources with a view to sustainable development.

The principle of deep geological disposal is to isolate HLW and ILW-LL from people and the environment over very long timescales. This is what distinguishes it from the principle of storage, which is necessarily temporary. Once filled, the deep geological repository is "closed." Closure involves dismantling the operational equipment and constructing specific structures—complementary to the geological barrier (drift backfills, walls, sealings, etc.)—to ensure the proper containment of the waste over very long timescales.

The geological formation is selected and the disposal facility is designed such that, after the facility's permanent closure, safety is ensured passively by the geological formation—that is, people and the environment are protected from the radioactive substances and toxic chemicals contained in the radioactive waste, without requiring human intervention (ventilation, maintenance, etc.).

2.1.2.2 France's choice of disposal in the Callovian-Oxfordian clay formation

In France, Act No. 91-1381 of December 30, 1991 (3), for which Deputy Christian Bataille served as rapporteur, established the broad guidelines for research activities on the management of high-level (HLW) and intermediate-level long-lived (ILW-LL) waste. It provided for the study of options for reversible or irreversible disposal in deep geological formations, notably through the establishment of underground laboratories. This law was the first French law concerning research on radioactive waste management.

The selection of the Bure site for the establishment of a deep geological repository was based on a process involving studies, assessments (including international ones), consultations, and local and national decisions beginning in 1991.

Prior to 1991, an initial phase consisted of conducting "*the national inventory and the preselection of areas deemed favourable a priori*." This phase was *"conducted by ANDRA with the support of the French Geological Survey (Bureau de recherches géologiques et minières* - BRGM)[6]." It *"consisted of a review of available geological data on the French subsurface (bibliographies, drilling carried out as part of oil or mining exploration, etc.) in order to select four zones whose subsurface exhibits favourable characteristics."*

Since 1991, the process of identifying a site for an underground research laboratory—with the aim of studying the deep geological formation where radioactive waste could potentially be emplaced and assessing the feasibility of a disposal facility to be excavated there using mining techniques—has been carried out in successive stages, under the oversight of Parliament. It has systematically considered two criteria, treated with equal importance:

- the technical compatibility of the subsurface with the requirements of deep geological disposal and with the objectives of protecting human health and the environment from the hazards of the waste. This criterion of technical compatibility was assessed based on existing geological knowledge;
- dialogue and consultation with the host region. Only departments that responded to a call for volunteers to host an underground research laboratory were selected.

As part of a mediation mission entrusted by the government to MP Christian Bataille (17), three geologically suitable zones located in volunteer departments (the three zones extending over four departments) were selected in 1993:

- a clay zone in the Gard;
- a clay zone extending across Haute-Marne and Meuse;
- a granitic zone in Vienne[7].

A second phase then consisted in *"selecting a site for the establishment of an underground laboratory*." This involved assessing the preselected zones *"through geophysical studies conducted from the surface (gravimetry, seismic surveys), shallow drilling and deep drilling*."

These three zones were then subject to preliminary geological surveys by Andra from the surface and an analysis of available data to better assess the technical suitability of their subsurface. Preliminary studies for possible designs of underground laboratories were initiated to prepare for their potential construction.

In 1996, Andra submitted applications for authorisation, installation and operation of underground laboratories for each of the three zones.

[7] During the site search led by Mr. Christian Bataille mentioned above, no region with rock salt (halite) in its subsoil expressed interest in potentially hosting an underground research laboratory.

In December 1998 (18), following the review of these applications, the government decided:

- the abandonment of the Gard and Vienne sites for technical reasons;
- the establishment of an underground laboratory at the Meuse/Haute-Marne site to study the feasibility of a reversible deep geological disposal facility in the Callovian-Oxfordian clay formation; this site appears to have a very favourable geological context based on the preliminary investigations and with strong local support;
- the continuation of research on the granitic environment.

The site in the granitic zone in Vienne was ultimately ruled out after initial investigations because there was no consensus within the scientific community regarding the properties of the granitic massif.

In August 1999, Andra obtained authorisation by decree to construct the underground laboratory known as the "Meuse/Haute-Marne Underground Research Laboratory" in Bure (19), *"intended to study deep geological formations where radioactive waste could be emplaced*." Construction of the Underground Research Laboratory began in 2000. In 2004, the drilling of the laboratory's shafts reached the Callovian-Oxfordian clay layer to be studied. This underground research laboratory is not designed to receive radioactive waste itself and does not have authorisation to do so.

CLAY

Clay is a very fine-grained sedimentary rock. It is most often formed from particles transported and deposited millions of years ago by wind, rivers, or ocean currents in the form of alluvium. Over time, these deposits settled, dehydrated, and compacted to form a rock[8].

Clay is a rock with properties that make it suitable for radioactive waste disposal:

- a layer of clay acts as a natural impermeable barrier[9]. This property can be observed in nature, where it is responsible for the distinctive landscape of regions with clay subsoil: since water cannot seep into the ground, ponds, lakes and marshes form naturally. In a disposal facility, a layer of clay protects the waste and prevents significant water movement in contact with it;
- almost all radioactive and toxic substances are retained in the clay. Only a few specific substances can pass through the clay very slowly and might eventually reach the biosphere. These substances, known as "mobile" substances—such as iodine or chlorine—move through the clay, however, only via an extremely slow diffusion process[10]. This retention property of clay, which can be measured in the laboratory, has also been observed in nature at Oklo (Gabon);
- clay has mechanical and physical characteristics that allow it to close up over time and regain hydraulic properties close to its initial ones, for example when it has been fractured or dried out. It is said to "heal" hydraulically.

ARGILLITE

Argillite is a rock composed mainly of clay minerals. By extension, it refers to the Callovian-Oxfordian formation in which the Cigéo disposal facility is located.

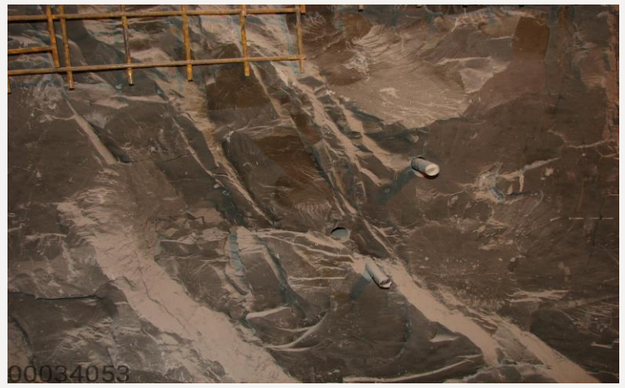


Figure 2-7 *Close-up of a tunnel wall at the Meuse/Haute-Marne Underground Research Laboratory showing Callovian-Oxfordian argillite*

Under the Act of December 30, 1991 (3), and based on all relevant research (geological reconnaissance campaigns, Underground Research Laboratory...), the "2005 Report" (20) concluded that the geological environment—and the Callovo-Oxfordian in particular—possesses favourable characteristics and that the disposal of HLW and ILW-LL in the Callovo-Oxfordian within the 250 km² "transposition zone" surrounding the Underground Research Laboratory is feasible in principle. This report was reviewed by the National Assessment Board (*Commission nationale d'évaluation* - CNE) established by Parliament and by the French Nuclear Safety Authority (ASN). It was examined by the Institute for Radiation Protection and Nuclear Safety (IRSN) and was the subject of an opinion by the standing group of experts responsible for radioactive waste (21).

At the government's request, Andra's work was reviewed by an international group of experts. This review confirmed Andra's findings regarding the technical feasibility and safety of deep disposal of HLW and ILW-LL in the Callovian-Oxfordian clay layer, within a 250 km² area known as the "transposition zone."

Following a review of Andra's work and a public debate on waste management held in 2005, the government and parliament passed legislation (4) to continue studies and research on geological disposal with the aim of establishing a disposal facility for this waste.

Construction of the Meuse/Haute-Marne Underground Research Laboratory began in 2000 with the successive excavation of two vertical shafts. The excavation of these shafts, in addition to reconnaissance campaigns carried out from the surface (deep drilling, seismic refraction surveys, field investigations), has confirmed that the encountered geological layers are indeed uniform and have not been altered by natural phenomena, such as earthquakes or glaciation, thereby confirming the suitability of the site for the establishment of a disposal facility for HLW and ILW-LL radioactive waste.

Lessons learnt from accidents that occurred at the Meuse/Haute-Marne Underground Research Laboratory are taken into account to improve current construction sites and future construction projects, even though the characteristics may be quite different. In all cases, the accidents and incidents that have occurred relate to construction site issues and do not call into question the characteristics of the geological environment or the fundamentals of the disposal facility.

[8] Diagenesis
[9] In scientific terms, a clay layer has very low water permeability
[10] So-called "sorption" capacity of potentially solubilized radionuclides

The Act of July 25, 2016 (5) reflects the conclusions of the 2013 public debate and specifies the procedures for establishing a reversible deep geological repository for high-level (HLW) and intermediate-level long-lived (ILW-LL) waste. Furthermore, its provisions regarding reversibility address and supplement the provisions of the Act of June 28, 2006.

REVERSIBLE DISPOSAL

Given the expected operational lifespan of the Cigéo disposal facility—on the order of a century—approximately five successive generations are likely to operate it. The current generation, which is planning to build this facility, therefore has a duty not to lock future generations into design choices made at the project's inception. It is in this spirit that Andra is developing a reversible disposal project (see Chapter 2.4.2 of this non-technical summary), as required by law.

The act of July 25, 2016 defined reversibility as *"the ability for future generations, either to continue the construction and subsequent operation of successive stages of a disposal facility, or to reassess previously defined choices and adapt management* solutions" (5).

The reversibility of the disposal facility is based on:

- the gradual nature of construction of the underground facilities, which primarily offers the possibility of accelerating, delaying, or modifying the order of construction of the disposal facility, for example to incorporate technical improvements;
- the ability to retrieve waste packages already emplaced and redirect them towards a management pathway (yet unknown) that would offer an advantage over disposal;
- the adaptability of the design, which allows the disposal facility to be modified in the event of changes in national waste management policy;
- the flexibility of the repository's operation, which allows for adaptation to changes in its industrial programme (packages delivery schedule, changes in waste packaging, and the anticipation or postponement of closure operations).

2.1.3 The selection of the site for the Cigéo disposal facility and other associated operations

The location of the project's facilities is the result of a gradual process that took into account the geological criteria critical to disposal safety, as well as environmental, social, and economic criteria identified in consultation with local stakeholders.

The Cigéo disposal facility project is being developed under the supervision of the authorities and their evaluators and in dialogue with the community and the region to address public concerns and prepare for its integration (see Chapter 2.1.4 of this non-technical summary). Since the 2013 public debate (22), conducted under the auspices of guarantors appointed by the French National Public Debate Commission (*Commission Nationale du Débat Public* - CNDP), Andra has strengthened its consultation process to consolidate its project and reinforce its environmental assessment.

2.1.3.1 The site selection for the Cigéo disposal facility

2.1.3.1.1 The site selection for the underground facilities of the Cigéo disposal facility

Andra ensured that the key characteristics of the Callovian-Oxfordian formation, observed at the Meuse/Haute-Marne Underground Research Laboratory, could be extrapolated to a larger area, known as the "transposition zone," spanning approximately 250 km² defined around the Underground Research Laboratory and verified by various means (drilling, seismic surveys, etc.). This transferability ensures that the results obtained are not dependent on the specific characteristics of a small area.

Several sites within the Callovian-Oxfordian geological formation were proposed for the construction of disposal facilities. Their comparative evaluation led, by the end of 2009, to the selection of the Zone of Interest for detailed reconnaissance (*Zone d'intérêt pour la reconnaissance approfondie* - ZIRA), optimised with regard to criteria for the protection of human health and the environment, particularly over the very long term: to avoid locating the disposal facility beneath urbanised village areas, to favour a location beneath forests, to prioritise rail access to the disposal facility. This zone, which is large enough to accommodate underground disposal, was the subject of further investigations. These confirmed its capacity to accommodate the disposal facilities (see Figure 2-8).

Andra has decided to include within the Underground Structures Zone (ZIOS) of the Cigéo disposal facility the entire Callovian-Oxfordian block defined by the Zone of Interest for detailed reconnaissance (ZIRA), within which the disposal facilities are located, as well as the volume of overlying rock housing the shafts and ramps for access from the surface facilities.

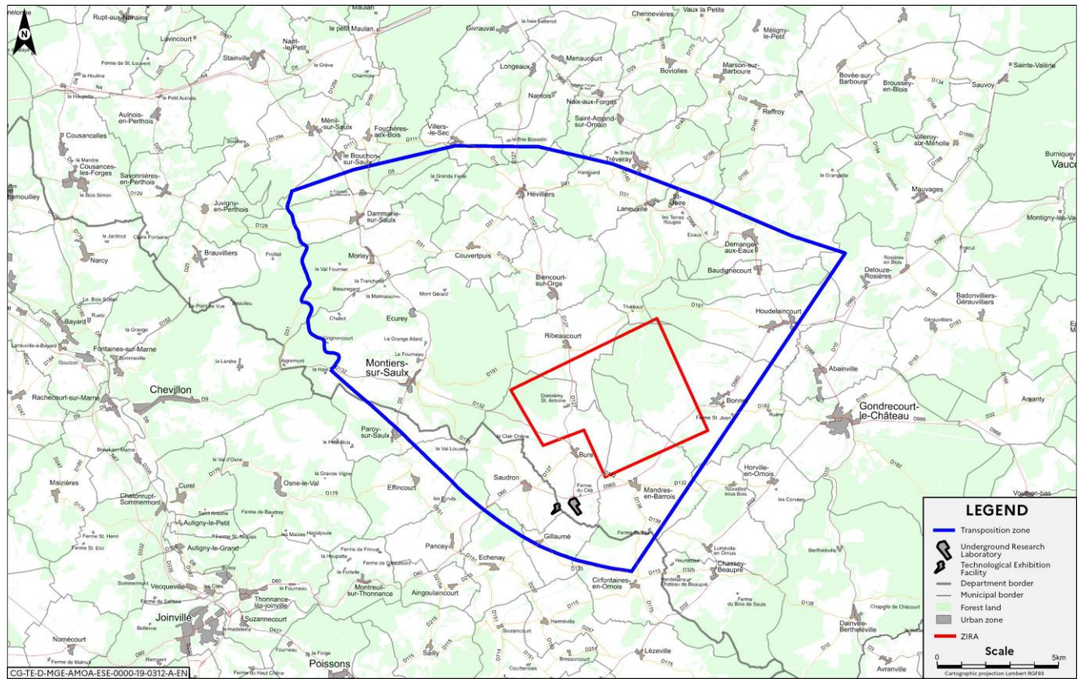


Figure 2-8 *The ZIRA within the transposition zone*

2.1.3.1.2 The site selection for the surface facilities of the Cigéo disposal facility

Starting from the underground zone, Andra sought the best locations for the surface facilities. The criteria defined in collaboration with local stakeholders were primarily aimed at minimising impacts on human health and the environment by reducing drawbacks and risks, while respecting land-use planning considerations and ensuring industrial efficiency.

The surface facilities are grouped into two main areas:

- an area, known as the "shaft zone," located directly above the Callovian-Oxfordian block where the underground disposal facilities are located. In fact, the underground sections of the disposal facility must be connected to the surface via vertical shafts. This type of structure provides the shortest and most efficient route for ventilation and for transporting materials and personnel to the underground sections, or for evacuating them, particularly in emergency situations. Since vertical shafts are essential for the safety of this type of facility, Andra also identified zones capable of accommodating all excavated material near the shafts while meeting all regulatory requirements;
- an area, known as the "ramp zone," located a few kilometres from the shafts, where the entrance to an inclined tunnel (ramp) is situated, used to lower radioactive waste packages to the disposal zones. Indeed, transporting them via a ramp transfer system in a straight tunnel with a gentle gradient (approximately 12%) is the safest method for this operation. Furthermore, to avoid the long-term risk of water flow through the disposal facility, the points where the shafts and the ramps intersect the Callovian-Oxfordian clay layer must be as close together as possible. These safety requirements therefore imply locating the entrance to the ramps away from the shaft area.

To protect human health and the environment, Andra has identified urbanised areas, sites of remarkable landscape, listed and classified historic monuments, water catchment areas, and sites of biodiversity significance, Natura 2000 sites, sensitive natural areas, and French ecological, faunal and floristic interest natural zones (ZNIEFF) located within the broader area. It should be noted that initially, the Lejuc forest was not designated as a ZNIEFF site.

To mitigate external risks to the facility itself, Andra conducted an inventory of flood-prone areas, airfields and the strips along their runways, steep-slope areas, and existing industrial facilities, gas pipelines, and wind farms. It should be noted that the analysis of risks related to lightning strikes, extreme temperatures, earthquakes, or forest fires was not deemed significant at the scale of the expanded transposition zone.

These potential sites for surface facilities were discussed with local stakeholders in 2009. They expressed strong demands regarding the reduction of nuisances and economic and social development, notably conveyed by the Local Information and Monitoring Committee (*Comité Local d'Information et de suivi* - CLIS) of the Meuse/Haute-Marne Underground Research Laboratory:

- maximise the potential of existing transportation infrastructure;
- preserve the living environment and ensure environmental integration;
- minimising impacts on local communities and promoting the development of rail and river transport;
- protect surface and groundwater;
- ensure the proper disposal of excavated materials deposits (Callovo-Oxfordian excavated material produced by the construction of disposal facilities);
- strive for a balance between the use of agricultural land and forested land.

The choice of location for the ramp zone (package reception and preparation for disposal) is primarily based on:

- the implementation of the ramp transfer system;
- the protection of aquifers. For the ramp zone, Andra sought a location that would avoid crossing the Gondrecourt-le-Château ditch and the diffuse fracture zone through which groundwater flows;
- the will, expressed during consultations with local stakeholders, to seek a site on the border between the departments of Meuse and Haute-Marne.

In the search for the best site for the shafts, Andra took into account the environmental constraints established for identifying potential sites for surface facilities (avoiding urbanised areas, sites of remarkable landscape, proximity to historic monuments, water catchment areas, sites of biodiversity significance, flood-prone areas, areas with heavy air traffic, and areas with steep slopes).

Three siting scenarios were selected for the shafts and presented during the 2013 public debate on the Cigéo overall project. All favour locating the shafts in a forested area. Indeed, siting in a forest environment offers the dual advantage of facilitating the landscape integration of the structures—particularly the shaft heads, which are the tallest structures in the facility (up to about 40 metres)—while balancing land use between agricultural and forested areas.

Among the three scenarios for siting the shafts, the Montiers-sur-Saulx national forest was ruled out for environmental and technical reasons. Andra continued its design studies for the disposal facility in the Lejuc woods and the Caisse woods. Based on environmental protection criteria, in 2014 it selected a location for the shafts and the excavated materials deposits zone in the Lejuc forest. This choice notably allows for maximum distance from the Demange forest's Natura 2000 site and better landscape integration, taking advantage of the terrain's slope towards the east. Above all, it avoids the need to cross the Ormançon, a sensitive natural area, for transport and connections between the ramp zone and the shaft zone. In terms of biodiversity, there was no notable difference in species richness between the two forested areas in 2014. In-depth studies conducted by Andra on this point showed near equivalence, particularly regarding bats. The quality of the woodlands in the Lejuc forest was considered inferior, as it had been severely damaged by the 1999 storm.

The selection of the Callovo-Oxfordian excavated materials deposits zone, of the shaft zone, stems from objectives to protect human health and the environment while adhering to environmental constraints such as avoiding urbanised areas, sites of remarkable landscape, historic monuments, water catchment areas, sites of biodiversity significance, and flood-prone zones. Andra's additional objectives are to keep the Callovo-Oxfordian excavated materials, with a view to the eventual closure of the facilities (backfilling with material corresponding to, or similar to, that of the host environment to limit physicochemical disturbances of the subsurface), at an Andra facility to monitor and control its quality, and within a reasonable distance from the shafts to limit material transport and associated impacts. Identifying the optimal site for depositing Callovo-Oxfordian excavated materials is an integral part of the analysis for siting surface facilities. Site selection options were analysed based on environmental criteria. As with the shafts, locating the Callovo-Oxfordian excavated materials depositswithin a forested environment offers the dual advantage of facilitating the landscape integration of the deposits, which are quite high (nearly 20 metres), while balancing land use between agricultural and forested areas.

The grouping of surface activities, structures, and buildings in the ramp zone and the shaft zone necessarily involves transfers and movements between these two areas. To reduce the impacts and risks to human health and the environment associated with these operations, Andra has studied the creation of a dedicated link, known as the "inter-site link" (LIS). The establishment of the LIS also responds to a desire for integration into the local landscape and to environmental concerns. To minimise the disruption caused by the transfer of materials between the zones, Andra opted to create a specific infrastructure—a semi-underground conveyor belt—rather than using lorries. For this infrastructure, a route away from residential areas was sought, halfway between the villages of Bure and Mandres-en-Barrois. Road safety was taken into account by creating a private road dedicated to heavy-duty vehicle traffic between the two zones, running parallel to the road for light vehicles and the conveyor belt. The elevation profile and final route were defined to avoid ecologically sensitive areas and minimise visual impact as much as possible.

The desire to reduce the nuisances caused by lorry transport and to respect the region's commitment to promoting rail transport led Andra to study rail service to the Cigéo disposal facility, particularly for the transport and delivery of radioactive waste packages. This rail facility, which connects the Cigéo disposal facility to the national rail network, is called the "connected terminal" (*Installation terminale embranchée* - ITE). The establishment of the ITE also addresses the goal of integrating the facility into the local landscape and environmental concerns. To minimise the use of agricultural land and avoid the impacts associated with building a new line, Andra sought to reuse as much as possible the former railway line connecting Joinville to Gondrecourt-le-Château. This allows for a connection at Gondrecourt-le-Château to the 027000 railway line managed by SNCF Réseau. Studies have made it possible to repurpose 10 km of the old track bed. Only 4 km of new track need to be built at the end of the route. The route for these final kilometres is heavily constrained by the elevation profiles of the old track and the ramp zone to be served. Ultimately, Andra selected a location along the route of the old line and within open agricultural land. It also includes a logistics hub owned by Andra that repurposes a former industrial brownfield site in Gondrecourt-le-Château.

2.1.3.2 The selection of sites for other projects

The siting decisions for other facilities associated with the creation of the Cigéo disposal facility are closely linked to the siting decisions for the Cigéo disposal facility itself, as the latter requires:

- a power supply;
- a drinking water supply;
- road and rail access.

The selection of the precise locations for the other components of the Cigéo overall project, which fall under the responsibility of other project owners, is currently underway and will continue in the future based on the same criteria as those used for the Cigéo disposal facility (see Chapters 2.1.3.1 and 2.4.1.1 of this non-technical summary).

The choice of location for the other components of the Cigéo overall project is more constrained:

- for the shipping and transport of radioactive waste, consideration must be given to:
  - ✓ existing shipping units at radioactive waste production sites;
  - ✓ existing transport infrastructure.
- for the environmental characterisation and monitoring operations, the location within the various study areas, with siting guided by the objective sought (characterisation and/or monitoring).

In addition to the review of reasonable alternative solutions for the disposal facility, variant studies have been initiated or will be for the operations of the other project owners within the overall project. These variant studies include a comparative analysis of their environmental impacts based on criteria identical to those used for the Cigéo disposal facility (including biodiversity considerations).

More specifically, and in line with Andra's oversight of all environmental impact assessments for all operations of the Cigéo overall project, the development of site selection alternatives for the operations of the other project owners is based on a gradual and appropriate approach. It begins with a literature review of the baseline conditions within a broad search area for site selection alternatives. This is then supplemented by more detailed field analyses (including inventories by species groups, locations of wetlands and confirmed ecological corridors, etc.) within the potential route corridors. Finally, the baseline assessment is further refined in the area likely to be affected by the solution selected following public participation.

2.1.3.2.1 Power supply

The scenario selected for the power supply to the Cigéo disposal facility includes a substation at the foot of the 400/90 kV line. Underground 90 kV power lines connect this substation to the ramp zone and the shaft zone.

The technical constraints for siting the 400/90 kV substation are as follows:

- the substation must be located adjacent to the 400 kV transmission line to minimise the length of overhead lines to be built. This reduces the impact on the landscape and the investment costs;
- it occupies an area of approximately 400 m x 300 m (with the shorter side of the site parallel to the 400 kV transmission line). This area accounts for the substation's dimensions (approximately 300 m x 250 m), landscaping, and the installation of connection towers outside the substation, set back approximately 50 m from the 400 kV transmission line.

The "Fontaine consultation" (French administrative procedure) conducted on the electrical infrastructure projects for connecting the Cigéo disposal facility helped identify preferred locations for the substation and the corridor for the underground power lines. The stakeholders involved in this consultation included local elected officials, associations (environmental, fishing, hunting, etc.), chambers of agriculture, the Architects of France, departmental councils, departmental directorates for territorial development (*Direction Départementale des Territoires* - DDT), chambers of industry and commerce, the Regional Directorate for Environment, Planning and Housing (*Direction régionale de l'Environnement, de l'Aménagement et du Logement* - DREAL), RTE, network operators and concessionaires, the National Gendarmerie, the Meuse Prefecture, and Andra.

Based on the scenario analysis produced for the so-called "Fontaine Circular" consultation and the progress of other projects—specifically the inter-site link led by Andra—RTE selected several sites subject to this preliminary consultation. Five locations (3S, 5S, 6S, 7S, 8N, and 10S, shown in red on figure 2-9) were chosen from among the initial 24.

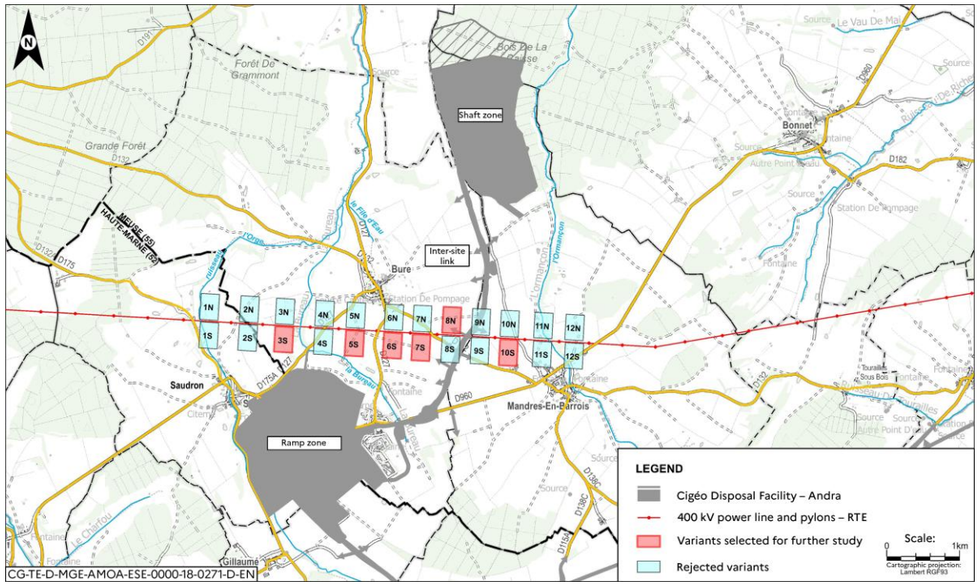


Figure 2-9 *Location of the 24 sites proposed by RTE for the construction of the 400/90 kV substation*

The CNDP facilitator submitted his report on March 13, 2020 (23). He notes in particular that the choice of location for the electrical substation was the topic most frequently raised by participants and that *"a unanimous preference for the 3S location emerged among those who spoke*." The facilitator also invites RTE to present its decision following the preliminary consultation to the public and to continue providing public information throughout all phases of the upcoming project.

In May 2020, RTE outlined the follow-up actions taken following the preliminary consultation regarding the connection of facilities and structures for the Cigéo overall project (24). RTE proposes to select the 3S location favoured by participants in the preliminary consultation. This choice was ratified by the Prefect of Meuse on February 24, 2022 (location of the 3S substation visible on figure 2-27).

RTE is also committed to continuing public consultation and information on various topics: the substation's integration into the landscape, agricultural land management, electromagnetic fields, and the scope and duration of the work. In addition to maintaining the project's dedicated website, RTE is also organising two public engagement sessions, one prior to the public inquiry and another prior to the start of construction.

The decision to use 90-kV underground power lines rather than overhead lines to connect the 400/90-kV substation to the Cigéo disposal facility represents a significant environmental measure aimed at avoiding impacts. Indeed, underground lines eliminate the visual impact on the landscape caused by overhead lines. Only the construction phase will have a temporary impact on the landscape and agricultural activities. Furthermore, compared to overhead lines, they reduce the impact on land and agricultural practices since they do not require pylons. Farming above the underground lines is possible.

The process of establishing the substation is therefore continuing with further development of the final technical solution. The route of the power lines will be the subject of a consultation led by RTE. The selected solution will be the subject of further studies and an update to the environmental impact assessment of the Cigéo overall project.

2.1.3.2.2 Water supply

The Échenay and Haut-Ornain water utilities syndicates are responsible for overseeing the studies and construction work for the "water supply" project, which involves connecting the Cigéo disposal facility to the existing drinking water supply network.

The preferred technical solution for water supply is to draw water from the Thonnance-lès-Joinville, Échenay, and Gondrecourt-le-Château catchments, given their productivity and protected status (see Chapter 2.3.2.2 of this non-technical summary).

The main technical, environmental, and regulatory constraints for installing the structures necessary for water supply (pipelines, pumping stations, reservoirs, etc.) are as follows:

- avoid sensitive natural areas (wetlands, wooded areas, etc.);
- minimising disturbances to the population caused by construction and easements;
- take into account the topography, elevation changes, and waterways to be crossed.

Based on the needs expressed by Andra, the water utilities syndicates have initiated a study for a project to restructure and expand the drinking water networks between Haute-Marne and Meuse. More broadly, this project addresses the challenges of securing the region's water supply, improving public service, and supporting economic development.

The public was consulted during a dedicated preliminary consultation organised at the end of 2025. Following this process, the concept of an interconnected network was adopted to secure the resources of three water districts and meet current and future needs, including those of the Cigéo disposal facility project. Studies are continuing in the preliminary design phase.

2.1.3.2.3 Upgrade of the 027000 railway line

SNCF Réseau is the project owner for the "upgrade of railway line 027000" project, also referred to during the consultation process as the "modernisation of railway line 027000," which involves upgrading railway line 027000 of the national rail network to subsequently connect it to the connected terminal (ITE) of the Cigéo disposal facility.

Prior to the 2013 public debate on the Cigéo overall project, an exploratory study of rail service to the Cigéo disposal facility was conducted under the auspices of waste producers. This study identified and analysed scenarios for the delivery of waste packages from producers' storage facilities to the Cigéo disposal facility.

Two types of scenarios were analysed: either "all-rail," without transshipment, to a connected Cigéo disposal facility; or "mixed road/rail," with transshipment, to a non-connected Cigéo disposal facility.

The analysis of this exploratory study, which incorporated safety, environmental, land use, cost, operational, and infrastructure impact considerations, led to the scenario involving the creation of a connected terminal (ITE) with 14-kilometre-long railway line connected to the Nançois-Tronville/Gondrecourt-le-Château line. This scenario is the most favourable option as it relies on an existing railway line exclusively dedicated to freight, which allows for an easy connection to the Cigéo disposal facility. During the 2013 public debate, the public clearly expressed its preference for this scenario.

SNCF Réseau organised a preliminary consultation on the upgrade of railway line 027000 of the national rail network (freight line between Nançois-Tronville and Gondrecourt-le-Château) from May 3 to June 28, 2021 (25).

The main concern for participants is safety and security. The removal of a large number of level crossings—*at least* 22 out of 59—does not raise any fundamental opposition.

Following this preliminary consultation, in its summary (26), SNCF Réseau commits to:

- **maintain dialogue with the local community:**
  By keeping active the Cigéo project's general contact email address—used during the consultation—, organising technical and informational meetings with local stakeholders, and establishing a project monitoring committee;
- **optimising the line's design to improve its integration into the local landscape:**
  Approximately 30 specific points have been reviewed regarding safety, environment, and mobility, and about ten of them have been the subject of additional studies, particularly concerning the procedures for removing level crossings, reconstructing engineering structures, providing access, and opening up land parcels. Some studies can only proceed after conducting further investigations (particularly regarding hydraulic issues). Some studies also follow up on recommendations requested from CEREMA (Centre for Studies and Expertise on Risks, the Environment, Mobility and Urban Planning[11]) to improve the safety of level crossings along the entire line.

Since the preliminary consultation, SNCF Réseau has conducted additional studies to address the development requests made by elected officials and residents and has proposed the creation of a project monitoring committee. This committee facilitates the sharing of study results and the continuation of dialogue with local elected officials. The first meeting of the monitoring committee took place on Thursday, September 29, 2022, in Tréveray. SNCF Réseau presented the progress of the additional studies underway regarding the modernisation of the Nançois-Tronville–Gondrecourt-le-Château freight line and outlined proposed improvements to level crossings, engineering structures, and other elements.

Following the first meeting of the project's monitoring committee, SNCF Réseau organised two public information sessions in December 2022 to share updates on the progress of the rail project with all interested parties, provide as much detail as possible on the ongoing studies, and answer questions.

Since then, SNCF Réseau has held four additional monitoring committee meetings, the most recent of which took place on June 17, 2025. These annual meetings are intended to continue, and additional public meetings may be scheduled depending on the progress of the studies.

2.1.3.2.4 deviation of the D60/960 departmental road

The Haute-Marne Departmental Council is the project owner for the D60/960 departmental road deviation project, which involves rerouting the D60/960 departmental road to bypass the ramp zone of the Cigéo disposal facility.

Given the criteria established for the protection of the environment, the public, and the facilities, the urban planning studies for the Cigéo disposal facility demonstrate the need to partially reroute the D60/960 departmental road in order to deploy the facilities of the ramp zone, particularly the utilities area north of the EP1 nuclear building.

Three possible bypass options have been identified.

A preliminary consultation on the route options was conducted by the Haute-Marne Departmental Council from January 31 to March 11, 2022 (27).

The result of the preliminary consultation was published by the Haute-Marne Departmental Council on May 20, 2022. The department considers that the consultation's objectives have been met, despite the difficulties encountered when two meetings were disrupted and interrupted. In this context, the department made efforts to encourage public participation through other means and was committed to maintaining in-person participation options.

Following the consultation, the Haute-Marne Departmental Council has abandoned the idea of a southern bypass (option 3) and is committed to continuing studies on the northern options. Two route options have been selected for the next phase of the study:

- Option 1, the "proximity route," which runs along the north of the ramp zone of the Cigéo disposal facility and reuses portions of Departmental Roads D175A (in Haute-Marne) and 127 (in Meuse);
- Option 2bis, the "northern extension route," which modifies the option 2 initially presented;
  - ✓ study of the possibility of connecting the bypass to Departmental Road D175 to directly serve the future Parc'Innov business park;
  - ✓ adoption of the same route north of the ramp zone as for option 1;
  - ✓ removal of the connector between Departmental Road D227 and Departmental Road D960 to facilitate through traffic in front of the Bure commercial zone.

[11] Cerema is the major French public agency for developing public expertise in the fields of urban planning, regional cohesion and ecological and energy transition for resilient and climate-neutral cities and regions

In 2023, the Departmental Council decided to present the project's progress and gather public feedback:

- to elected officials and farmers potentially impacted by the project during a dedicated meeting on April 20, 2023;
- to the general public via an online platform on a dedicated webpage, from May 15 to June 16, 2023.

Following an assessment of the feedback received (28), the Departmental Councils of Haute-Marne (29) and Meuse deliberated (30) and selected Option 1, known as the "proximity" option. Project development is now focused on this route, and additional studies will be conducted to refine its design.

2.1.3.2.5 Environmental characterisation and monitoring operations

Throughout all phases of the Cigéo disposal facility's deployment (preliminary works, initial construction, operation, decommissioning and closure, monitoring and surveillance), Andra and the other project owners are required to carry out environmental characterisation, monitoring, and follow-up of prescribed environmental measures. All of these operations, along with the associated structures and equipment, are grouped and identified within the Cigéo overall project under the heading of environmental characterisation and monitoring.

The locations of these activities and the installation of the associated monitoring systems are defined progressively, in parallel with the progress of the design studies. Indeed, characterisation, environmental monitoring, and the follow-up of environmental measures are subject to several implementation phases and dedicated regulatory authorisation applications, tailored to their nature, their location (within or outside the perimeter of the basic nuclear installation), and their potential environmental impacts.

The location of these activities and facilities is determined, within the framework of preventive archaeology operations, by the locations of the structures of the Cigéo overall project and guided by the objectives of the surveys and monitoring to be conducted.

The first environmental characterisation and monitoring operations—referred to as DR0—constitute the first phase of work for this project (the complete file is available in French on the Andra website[12]).

2.1.3.3 The design choices for the Cigéo disposal facility

The major design decisions for the ramp and shaft zones are based primarily on:

- environmental principles:
  - ✓ limit changes to the natural topography while seeking a balance between excavated and backfilled material;
  - ✓ reduce the impact on surrounding environments given their ecological significance, by preserving them or maintaining buffer zones, particularly with regard to the Orge and Ormançon valleys and the edges of the Lejuc woods;
  - ✓ reduce the impact on the landscape, particularly as seen from the nearest villages, namely Saudron and Gillaumé, notably by physically distancing the buildings and by creating a perimeter wooded strip and landscaped earthworks to the southeast of the ramp zone.
- urban planning principles:
  - ✓ take into account existing facilities and buildings near the ramp zone and potential interfaces with them. The fact that the ramp zone adjoins the existing facilities of Andra's Meuse/Haute-Marne Centre allows for the sharing of infrastructure and road access to reduce the project's overall impact;
  - ✓ define structural axes as the basis for the spatial development of surface areas, as these provide flexibility and clarity for the gradual development of an industrial or urban zone over the long term, notably: retaining the route of the current D60/960 departmental road as the main distribution axis for the facilities in theramp zone, and developing the shaft zone from south to north in line with the operation and development of the Callovo-Oxfordian excavated material management zone;
  - ✓ position and organise the infrastructure (buildings, utilities, ponds, etc.) according to topographic contours and road networks, and structure the zones through appropriate landscaping, with the aim in particular of concealing or highlighting certain elements and areas, creating a sense of rhythm in the perception of the developments, and avoiding sharp transitions between the boundaries of the redeveloped zones and their surroundings.
- risk mitigation principles:
  - ✓ define rules for positioning structures in relation to one another to protect them, including from risks they might pose to one another, and to allow for maintenance and renovation work on these structures;
  - ✓ define rules for the positioning of structures to protect the public outside the zone from the consequences of a potential accident affecting a building within the zone. To maintain a physical distance from the nearest villages of Saudron and Gillaumé, the industrial facilities in the ramp zone, including the nuclear facilities, have been located more than 500 metres from the buildings in these villages;
  - ✓ organise the placement of fences according to the topography and the layout of the structures and roadways, primarily for safety reasons and to maintain buffer zones between the fences and the structures and buildings to be protected.

To limit risks, reduce nuisances, and optimise industrial activity in the ramp zone, Andra has grouped all nuclear activities there. This decision allows, in particular, for better control of access, better protection of sensitive activities, optimisation of environmental protection measures, and prevention of the transfer of radioactive substances between zones. Due to its size and function, the EP1 surface nuclear building is the central element of the area's layout. Its location, operation, and prospects for potential development determine the organisation of the buildings and the spatial layout around it. Furthermore, as a precautionary measure, open spaces are preserved in its vicinity to allow for the potential construction of extensions that may be decided upon, if necessary, as part of the implementation of reversibility (new package shipping plant, flow management storage areas, new functionalities). To reduce the overall footprint, Andra has also included the buildings dedicated to public reception, memory, the issuance of access permits, and the main administrative services for the entire Cigéo disposal facility within the ramp zone.

To optimise the capacity of the excavated materials deposits zone of the shaft zone for receiving excavated Callovo-Oxfordian material, a dyke is installed along its southern, western and northern peripheries. This dyke reduces the area required while ensuring landscape integration and stormwater management. This optimisation reduces the use of forested land. The excavated Callovo-Oxfordian is transported to the storage area via conveyor belts. This handling method is suitable for transporting large quantities of heavy materials. From an environmental perspective, this avoids the need for lorry transport and the associated nuisances and risks. The maximum height planned for the excavated materials deposits is approximately 20 metres, primarily for reasons of mechanical stability. To protect them from the elements, they are gradually covered with vegetation using soil from the shaft zone. This measure also facilitates their integration into the landscape and reduces their impacts, particularly on air quality (dust), water quality and biodiversity. Finally, the excavated materials deposits zone spreads in several phases to minimise the impacts of associated land clearing operations.

The deployment of storage for the excavated materials deposits consisting of Callovo-Oxfordian clay excavated during the gradual construction of the underground facility will thus take place progressively across three zones. With the specific aim of avoiding the use of the third zone, Andra has launched a series of studies aimed at utilising the excavated materials not required for the closure of the underground facility in technical applications.

The major design choices for the inter-site linklink (LIS) and the connected terminal are based primarily on the following principles:

- minimising disruption to the landscape, primarily in terms of land use and, as much as possible, from a scenic perspective, while ensuring the continuity of the green corridor and the restoration of water flow;
- preserving existing land uses (particularly agricultural) and existing landscape features (units, landmarks, woodlands, etc.) and minimise visual impact from inhabited areas;
- integrating with the local road network (for the LIS) and restoring routes interrupted by road and rail infrastructure to reduce the impact on local traffic and agricultural activities (so that no plot of land remains isolated).

[12] https://www.andra.fr/cigeo/les-documents-de-reference (2)

2.1.3.4 Design choices related to plant safety and the gradual accumulation of scientific and technological knowledge

Safety-related design choices are based on a foundation of scientific and technological knowledge acquired over more than thirty years and on safety/design/scientific and technological knowledge feedback loops conducted since the 1990s. These iterative cycles, which are crucial to the progressive development of storage, enable decisions to be made to ensure the safety of facilities and structures during operation, as well as after closure and in the long term.

Safety iterations related to the progress in developing the deep geological disposal solution for HLW and ILW-LL, as well as the studies and research conducted notably at the Meuse/Haute-Marne Underground Research Laboratory, were carried out with a specific objective in mind.

In line with the gradual development over a timescale of more than a century, Andra will conduct iterative cycles involving safety, design, and knowledge as part of periodic safety reviews and based on feedback from the construction and operation of the BNI (31).

THE IMPORTANCE OF ITERATIONS BETWEEN SAFETY, DESIGN, AND KNOWLEDGE IN THE PROGRESSIVE DEVELOPMENT OF DEEP GEOLOGICAL DISPOSAL OF HLW AND ILW-LL

Several safety iteration cycles have been carried out since the 1990s, each addressing a specific objective linked to a key stage in the progressive development of the disposal project: initial design options, authorisation for the construction and operation of the Underground Laboratory, feasibility preparation, feasibility, initial design and safety options, site selection, conceptual design, safety options, and risk management assessment.

Each iteration led to an assessment of safety, both during operation and in the long term, based on the state of scientific and technological knowledge, the repository design, and the description of its behaviour over time. For each iteration, Andra focused on verifying, in particular, compliance with the safety and protection objectives set by the fundamental safety rules for BNIs defined by the French Nuclear Safety Authority (RFS No. III.2.f of 1991 (32)) and subsequently the French Nuclear Safety Authority (ASN) guide on the final disposal of radioactive waste in deep geological formations from 2008 (33).

Each iteration resulted in the preparation of a report issued by Andra, which was subject to a systematic review conducted by the ASN.

Three reports were also reviewed by internationally recognised experts (under the auspices of the OECD/NEA and subsequently the IAEA).

The successive safety/design/knowledge iterations helped to identify safety challenges very early on and progressively, and to integrate them into the design at each key stage of the repository's development as well as into the research and development programme. The iterative nature of the design and scientific and technological knowledge acquisition approach implemented by Andra made it possible to ensure, in a progressive, structured, evaluated and traceable manner, the feasibility of the project and then its development in light of applicable safety requirements.

As part of these iterations, Andra submitted a safety options report to the ASN in 2016, who reviewed it and requested an international review by the IAEA. The ASN's opinion and the IAEA report (as well as previous opinions) are available on the ASN website (34–37).

The ASN's opinion on the *"Cigéo safety options report*," published on January 11, 2018 (38), which is generally positive, represents a significant step forward for the project: *"The ASN considers that the project has generally reached a satisfactory level of technological maturity at the safety options report* stage" and that *"the safety options report is well-documented and substantiated and represents a significant step forward compared to the '2005 clay' (39) and '2009 milestone' files*." Considering that certain topics in the safety options report require additional information for the creation license application, in its follow-up letter dated January 12, 2018, the ASN also presented *"the supplementary studies and justifications necessary for the creation license application*."

Thus, in line with the safety options, Andra continued the studies to consolidate knowledge, design and safety assessments during operation and long-term post-closure in the preliminary design phase in order to provide the additional elements announced in the safety options and the responses to the requests for additional information made by the ASN following their review (37). The preliminary design studies for the Cigéo disposal facility, which form the basis for the creation licence application for the BNI, have been adapted in recent years to incorporate periodic technical and economic optimisation exercises, while ensuring optimal safety of the facilities. The technical and economic optimisations of the Cigéo disposal facility are part of a standard process for the design of industrial projects. They are carried out without calling into question the project's fundamental requirements or compromising its safety level. In addition to these optimisations, design updates for the Cigéo disposal facility project also incorporate feedback from the reviewing agencies.

The creation licence application, submitted in accordance with Article R. 593-16 of the French Environment Code, includes a preliminary version of the safety report resulting from this iterative process, which replaces or supplements the safety options report. This application also includes a risk management assessment in accordance with the aforementioned article of the French Environment Code. It summarises the key elements of the preliminary safety report. It is written to be as accessible as possible to the general public, particularly during local consultations or the future public inquiry planned at the conclusion of the review of the licence application. This document, which also contains a non-technical summary, replaces/supplements the summary of safety options presented in the response to the Environmental Authority's opinion, Appendix 1 of "Document 8 – Opinion on the Cigéo Disposal Facility Project" in the public inquiry file preceding the declaration of public interest for the Cigéo disposal facility (40).

2.1.3.5 Environmental design choices

The environmental design of the Cigéo disposal facility has resulted in:

- the decision to use electricity as the primary source of operational power, necessitating a connection to the 400-kV Houdreville-Méry extra-high-voltage line, and the creation of a heating network adaptable to the development of green energy;
- the decision to supply the centre with water from local catchments, hence the necessary connection to the existing drinking water network, while allowing for the reinforcement of the municipalities' current networks, and to recycle water as much as possible at the Cigéo disposal facility, in order to minimise consumption as much as possible;
- the decision to discharge treated conventional liquid effluents into local waterways, consistent with the criteria for good chemical and ecological status of surface waters as defined by the Water Framework Directive, without increasing the risk of flooding to people and property;
- the possibility of reusing Callovo-Oxfordian excavated material that will not be used for closure;
- prioritising rail transport for the delivery of radioactive waste packages and construction materials. To this end, the upgrade of the 027000 railway line is being carried out by SNCF Réseau (modernisation of the 027000 line) to connect the Cigéo disposal facility to the national rail network;
- the retention of waste packages at waste producers' sites until they can be accepted and disposed of at the Cigéo disposal facility and it has been demonstrated that they meet the facility's acceptance specifications.

2.1.4 The project developed in dialogue with society

The Cigéo repository project is based on nearly 30 years of discussions, studies and political decisions that have mutually fuelled one another. The growing emphasis on environmental dialogue within society and in regulatory texts has also been reflected in the way the government and Andra have managed public participation, particularly the consultation process regarding the Cigéo repository project.

Following the difficulties encountered during the initial feasibility studies conducted in the 1980s, the selection of the Meuse/Haute-Marne site was gradually defined through a process of engagement with the local community initiated by the 1991 Act (3). Similarly, the criteria formulated by participants in the 2009 local consultation were taken into account by Andra in proposing several scenarios for the location of the ZIRA (Zone of Interest for detailed Reconnaissance) and surface facilities(41). The proposed location for the ZIRA was approved in 2010 (42) by the Government, and the selection of the ZIIS (Zones for the Installation of Underground Facilities) was officially ratified on February 4, 2013, by the High-Level Committee chaired by the Minister of the Environment (43).

All these years of dialogue and consultation have made it possible to discuss the feasibility of deep geological disposal of nuclear waste, while research on radioactive waste management options has progressed, and to hear the various public opinions on the matter. Following the submission of the *2005 Clay file*, in which Andra concluded that deep disposal is feasible within a 250 km² area around the Underground Laboratory, this file being specifically evaluated and validated by the ASN (20), and the 2005 public debate on radioactive waste management (44), the deep geological disposal solution was adopted by Parliament in 2006 as the reference solution for high-level (HLW) and intermediate-level long-lived (ILW-LL) radioactive waste (4). It nevertheless remains the main topic of discussion in the 2013 public debate on the Cigéo disposal facility project. The follow-up actions taken by Andra (45) demonstrate the Agency's commitment to providing every possible opportunity for society to engage in dialogue and debate the choices to be made. The 2016 Act (21) regarding the procedures for establishing the Cigéo disposal facility project updates several provisions of the 2006 law and clarifies certain aspects of the project (reversibility, industrial pilot phase, timeline) highlighted by the outcomes of the 2013 public debate.

Regarding the safety of the Cigéo disposal facility, Andra has provided answers with full transparency, particularly during the 2013 public debate and, more broadly, in all its information and communication efforts. The Agency has thus contributed to raising public awareness of issues related to waste generated by nuclear activities in France, in response to public expectations as well as to adopted laws, such as the 2006 Act on transparency and safety in nuclear matters (46).



Figure 2-10 Online debate as part of the 2013 public consultation

As a continuation of the dialogue and information initiatives with local communities, the roadmap for post-2013 public consultation was defined and implemented under the auspices of guarantors appointed by the French National Public Debate Commission (CNDP), following a voluntary request by Andra in 2017. This roadmap (47) aims to ensure a more sustainable and transparent organisation of the consultation process leading up to the public inquiry preceding the declaration of public interest for the Cigéo disposal facility, followed by the inquiry regarding the creation licence application, and beyond. The first consultation phase (2017–2022) made it possible to propose new consultation methods that encourage the widest possible participation, both nationally and locally, in the project. The various lessons learnt at its conclusion have enabled the project to evolve in terms of its implementation, governance and integration into the local community.

In addition to legislation, public debates and regular exchanges with the CLIS, public consultations organised by Andra and the other project owners of the Cigéo overall project enable the concerns of the local community to be addressed and the project's integration to be prepared. The integration of the Cigéo overall project is a major challenge for Andra and the local community, as well as an opportunity for local economic development.

In collaboration with the guarantors, Andra has developed a local programme of conferences, meetings, and workshops on four key topics to feed its reports and environmental impact assessment:

- the "water cycle";
- the "transport infrastructure";
- "energy";
- "land use planning and living environment.".

In 2018, Andra organised 10 meetings, on the topics "water cycle" (48) and "transport infrastructure" (49, 50).

In 2019, Andra launched two topics for dialogue with the local community, while ensuring proper coordination with the PNGMDR public debate:

- the "energy" topic, focusing on the energy supply for the Cigéo disposal facility. A consultation series comprising four conferences and collaborative workshops (51) was conducted by Andra in the first half of 2019;
- the "land use planning and living environment" topic. Discussions began in the fall of 2019 and will continue over several years, extending throughout the initial construction phase of the Cigéo repository, should it be authorised.

Within the framework of this topic, "construction site" issues were the focus of a dedicated meeting on Tuesday, October 27, 2020, in Gondrecourt-le-Château. Following this meeting, Andra committed to establishing a construction site supervision group, specifically to work on the organisation of future construction sites (52).

In 2023, building on previous discussions, Andra launched a consultation process focused on construction sites, initially centred on the first works of the Cigéo project (DR0 operations for environmental characterisation and monitoring). A construction site supervision group was formed, and the dialogue is intended to continue over the long term. Between 2020 and 2025, the consultation also covered operations of the Cigéo overall project not under Andra's project management (see Chapter 2.1.3.2 of this non-technical summary).

In 2021 and 2022, at the local and national levels, two public consultation processes were organised on topics related to the development and deployment of the Cigéo disposal facility project:

- the industrial pilot phase, which has a twofold objective:
  - ✓ to validate, *in situ* and under the actual environmental, construction and industrial operating conditions of the repository, the data used for its design and safety demonstration;
  - ✓ to gradually take over the operation of the industrial facility.
- the governance of the Cigéo disposal facility, which refers to how decisions—within Andra's purview—regarding the deployment and operation of the Cigéo disposal facility are prepared, made and monitored.

From a governance perspective, the industrial pilot phase constitutes, for public and stakeholder participation, a phase of establishment, fine-tuning and knowledge acquisition, just as the tests within the facility do for technical aspects. Provided that the Cigéo disposal facility's nuclear installation is authorised following the review of its licence application (DAC), its deployment will therefore be gradual. The project will be punctuated by decisions, governance meetings and authorisations that will allow for a reassessment of the validity of previous decisions and for the project to evolve. Expectations regarding public participation on these two topics are therefore similar, which justified holding the two public consultations concurrently with some joint procedures.

The public consultations that were held provided an opportunity to scrutinise Andra's initial proposals on these two topics. The public's feedback and the commitments made following the consultations (53) also address other issues that drew the interest of participants (protection of workers and local residents, benefits for the region, public information and participation, reversibility, inventory of emplaced waste, economic prospects of the project and memory). Several proposed modifications to the project resulting from this consultation phase have already been incorporated into the first edition of the "Master Plan for Operations" associated with the licence application file (DAC) (54). In 2024, Andra conducted a new consultation on this phase of the project. Indeed, the 5th edition of the PNGMDR (French National Radioactive Materials and Waste Management Plan) stipulated that Andra would propose *"the objectives and success criteria for the industrial pilot phase and define, in particular, the nature of the waste to be emplaced during this phase and the planned tests"*[13]. This proposal drew on the opinions and recommendations of the public and stakeholders, as part of a dedicated consultation process. It also builds on the lessons learnt from the first consultation phase on Cigéo's industrial pilot phase, which have been either confirmed or refined. Following this process, Andra published two reports on the objectives and success criteria for Cigéo's industrial pilot phase, covering its technical aspects (56) and its governance aspects (57), as well as a summary outlining the process and lessons learnt from this consultation (58).

Consultation and dialogue with stakeholders and the public will continue throughout the lifetime of the Cigéo disposal facility, in conjunction with the facility's governance in compliance with the requirements of the French Environment Code (Article L. 542-10-1), which provides for periodic meetings to update the Disposal Facility's Master Plan for Operations (PDE) and periodic reviews of the implementation of the reversibility principle. In 2025, Andra conducted a consultation to better define their role, their deliverables, and their relationship with decisions regarding radioactive waste management. The summary of this consultation was published in February 2026 (59).

Dialogue with society is now fully integrated into Andra's governance and operations, into the project's governance, and more broadly into the practices of all local and national stakeholders involved in the Cigéo overall project.

DIALOGUE ON ETHICAL AND GOVERNANCE ISSUES

The consultation also provided an opportunity to discuss ethical and governance issues. In response to these challenges, following the 2013 public debate, Andra established the Ethics and Society Committee, which provides insight, drives progress, offers advice, and evaluates Andra on topics such as the project's integration into the local community, public participation and engagement in Andra's activities and projects, the governance of its projects, and the ethical and political issues raised by radioactive waste management.

[13] Article 36 of the Order of December 9, 2022, issued pursuant to Decree No. 2022-1547 of December 9, 2022, as provided for in Article L. 542-1-2 of the French Environment Code, establishing the requirements of the French National Plan for the Management of Radioactive Materials and Waste(55).

2.1.5 Why proceed with the Cigéo disposal facility now?

The extreme hazardousness of HLW and ILW-LL and their very long half-life give the generations that benefit from the nuclear industry an ethical responsibility to find and implement management methods that ensure the long-term protection of people and the environment against the dangers of these substances they helped produce.

2.1.5.1 A project that has reached maturity

The scientific and technological work conducted by Andra from the surface (drilling, seismic surveys) and for nearly 20 years in the Meuse/Haute-Marne Underground Laboratory, as well as the design studies, confirm the feasibility and safety of the Cigéo disposal facility for securing high-level (HLW) and long-lived intermediate-level (ILW-LL) waste. The project has undergone numerous evaluations that have confirmed its quality and feasibility. Andra has relied on project reviews at every stage of its design.

The Cigéo disposal facility is, to date, the only reversible and sustainable method for managing high-level (HLW) and intermediate-level long-lived (ILW-LL) waste whose feasibility has been demonstrated and which has a designated site, a financing plan, and design studies that have progressed to the preliminary design stage. The progress report of the Expert and Dialogue Committee on Alternatives to Deep Geological Repository (60), established by the PNGMDR governing bodies and presented on January 13, 2025, presents the following conclusions*: "After one year of work, the committee considers that there is currently no viable alternative to deep geological repository. There is research underway that, in the long term, could pave the way for complementary management methods. This includes R&D on transmutation as well as work aimed at improving conditioning or making the eventual recycling of certain materials possible in the future. Based on current knowledge, it is not currently possible to move away from deep geological disposal for the management of high-level and* intermediate-level long-lived *waste."*

In June 2022, the National Commission for the Evaluation of Research and Studies on the Management of Radioactive Materials and Waste reaffirmed in its Report No. 16 that (61) : *"Andra has acquired sufficient knowledge to enable the launch of the Cigéo project. In particular, it considers that the qualities of the Meuse/Haute-Marne site have been demonstrated and that the technical options considered at this stage are robust.* ".

Additionally, a socio-economic assessment of the Cigéo project (62) was conducted as part of the application file for a declaration of public interest (2). This assessment, published in 2021, highlights the societal benefits of launching the Cigéo project immediately.

Other technical solutions have been conceived and studied for the sustainable management of HLW and ILW-LL (e.g., transmutation and disposal in very deep boreholes). None of these other management approaches is currently capable of providing very long-term safety for all existing types of waste and for waste yet to be produced. All other management approaches still require research, very significant investments, and timelines that are difficult to predict, in the hope—which is by no means guaranteed—of overcoming technological barriers that currently prevent their implementation. Even if these alternatives to disposal were to one day reach technological maturity, they would require time for the development and implementation of industrial processes. All would require the creation of new nuclear facilities. Since none can manage all the waste already produced, they would not allow us to completely do without a deep geological disposal facility, of the same type as the Cigéo disposal facility.

The Cigéo disposal facility is the only sustainable management method capable of handling all the waste produced and yet to be produced by current nuclear facilities. It enables the final disposal of this waste after a little over a century of operation[14].

[14] The technical elements comparing the various options considered for the management of HLW and ILW-LL and justifying the choice of geological disposal are presented in the Environmental Impact Assessment for the overall Cigéo project, which constitutes Document 6 of this licence application file to create the Cigéo disposal facility (see Chapter 2.2.8 of Volume II of this Environmental Impact Assessment).

2.1.5.2 A project enabling gradual and cautious progress towards the final disposal of HLW and ILW-LL

An industrial pilot phase is planned for the Cigéo disposal facility. Andra proposes that this phase cover the initial construction phase of the Cigéo disposal facility and its first years of operation (see Chapter 2.4.2 of this non-technical summary).

The objective of the industrial pilot phase (Phipil) is to "*confirm the reversibility and demonstrate the safety of the facility*," in accordance with the provisions of the French Environment Code (Article L. 542-10-1). From a technical standpoint, it gradually allows for the consolidation of knowledge acquired at the Underground Laboratory, the testing of equipment, and the gathering of feedback on the operation and monitoring of the disposal facility. In terms of interactions with the public and stakeholders, it offers the opportunity to test and refine the governance framework established for the Cigéo disposal facility.

Based on the results of the industrial pilot phase, Parliament will decide on the conditions for continuing disposal and the procedures for doing so, if such a decision is made. Parliament's deliberations will notably be informed by a review of a summary report on the industrial pilot phase, to be produced by Andra.

The industrial pilot phase constitutes a concrete application of the principle of disposal reversibility, defined by the French Environment Code as *"the ability for successive generations, either to continue the construction and subsequent operation of successive stages of a disposal facility, or to reassess previously defined choices and adapt management* solutions" (Article L. 542-10-1).

Following the industrial pilot phase, if disposal operations continue, the project will be punctuated by key decisions and governance milestones (periodic safety reviews, decisions to construct progressive extensions of the ILW-LL disposal complex, decisions on the integration of technological developments, the decision to accept high-level waste packages by 2080, and the decision on decommissioning and closure). Each milestone will be subject to a specific, tailored authorisation. These decision-making milestones will allow for a reassessment of the validity of previous decisions and, if necessary, their adjustment in accordance with the principle of reversibility. Between these milestones, each phase of the project—including the Phipil phase—thus enables the gradual preparation of decisions to be made during subsequent phases.

2.1.5.3 A project launched at a time that allows to profit from available capabilities and expertise

Continuing to develop the deep geological disposal pathway allows us to benefit from current achievements, know-how, and expertise, and to mobilise the nuclear industry's resources—both technical and human—which have been developed and guided by national policies over several decades.

Conversely, delaying the creation of the Cigéo disposal facility, or abandoning it altogether, would risk the loss of expertise and a shortage of resources and skills should an alternative programme for the sustainable management of HLW and ILW-LL ever need to be restarted.

The nuclear industry is one option among many in France's energy mix. If the nuclear sector were to have a diminished future—or no future at all—it would be risky to assume that society would be able to sustain the resources and highly specialised expertise needed to develop a comprehensive radioactive waste management programme. In the event of nuclear phase-out, it is unlikely that research would be sustained over the long term or that massive investments would be made for the sole purpose of managing waste left behind by previous generations. Prudence therefore dictates that we should not rely solely on the future and uncertain developments in nuclear research, industry and science to provide, in a necessarily distant future, the expertise and resources for a hypothetical complete disposal of current waste using techniques not yet mastered scientifically or industrially, or through a pathway not yet conceived today.

Furthermore, the monitoring and renewal of the temporary storage facilities necessary for the conservation of radioactive waste in the meantime also require the maintenance of highly specialised resources and expertise.

Consequently, it would be unwise to halt the development of disposal, a sustainable management method whose feasibility and capacity for implementation are the most advanced.

2.1.5.4 A project that does not conflict with other complementary management approaches

Today, HLW and ILW-LL are mainly stored at the producers' sites. This temporary storage phase is necessary pending the availability of a sustainable management method.

However, the creation of the Cigéo disposal facility, if authorised, does not eliminate the need for temporary storage throughout its long-term operational lifespan. Indeed, temporary storage allows for the preparation, organisation, and regulation of shipment flows of packages from producers' facilities to the Cigéo disposal facility. Packages are shipped only after it has been demonstrated that they meet the Cigéo disposal facility's acceptance specifications and only when Andra has the capacity to emplace them.

For ILW-LL packages, their transfer from producer sites to the Cigéo disposal facility will gradually, starting in the first half of the century, reduce the burden of their surface storage. While ILW-LL accounts for a relatively small portion of the total radioactivity of HLW and ILW-LL, it represents the largest volume (the volume of ILW-LL is about seven times that of HLW).

For HLW packages, the heat emitted by most of them requires a waiting period before they can be emplaced. They must remain in temporary storage for several decades to decay and cool down until their residual heat generation is compatible with disposal conditions. The industrial pilot phase will enable the disposal of the first HLW0 waste (that which emits the least heat) in a pilot zone to verify *in situ*, on a full-scale basis, its behaviour and the changes associated with the transient heating of the rock and structures. This data will help reinforce the demonstration of the safety of high-level waste disposal once the waste has cooled sufficiently to be emplaced, i.e., by 2080. Only by that time will the transfer of high-level waste from temporary storage facilities to the final repository reduce the burden of above-ground storage.

Waste storage facilities will therefore remain in operation for at least another century, and the decision on whether or not to proceed with the Cigéo overall project is therefore not a matter of an immediate choice between disposal, storage, or the search for other management options. All potential management methods for high-level (HLW) and intermediate -level long-lived (ILW-LL) waste, including the Cigéo disposal facility, span unusually long periods, exceeding a century. Over such timeframes, new knowledge and data will inevitably expand the range of available techniques. If new techniques emerge that offer a decisive advantage over disposal, they will naturally be used for the management of the most hazardous radioactive waste. Retrievability offers future generations the possibility of removing all or part of the packages emplaced in the Cigéo repository should another, more advantageous management method—including in terms of long-term safety—be discovered and implemented.

Thus, the commitment to the Cigéo disposal facility project does not constitute a "blank cheque" for the choice of this management method. Numerous governance milestones will mark the project's progress, during which it may be continued, delayed, reoriented or even halted.

The long-term management of HLW and ILW-LL aims to limit the burdens and risks passed on to future generations. Implementing the comprehensive Cigéo project today ensures this intergenerational responsibility by cautiously moving towards a sustainable waste management option. The timeframe for the implementation of this project, spanning more than a century, and its reversibility—as mandated by law—preserve the rights and free will of future generations.

2.2 Waste destined for the Cigéo disposal facility

The waste destined for the Cigéo disposal facility consists of high-level (HLW) and long-lived intermediate-level (ILW-LL) radioactive waste, whose radioactivity levels and half-lives make it impossible to store them safely at or near the surface.

This waste comes mainly from the nuclear power industry, but also from research and national defence:

- HLW consists mainly of residues extracted from spent nuclear fuel during reprocessing (fission products and minor actinides), which are then vitrified;
- ILW-LL consists mainly of waste from the metal structures surrounding the fuel (shells and ends), resulting from the reprocessing of spent fuel and, to a lesser extent, from technological waste related to operation and maintenance of nuclear facilities, waste from the treatment of liquid effluents, and activated waste that has been in nuclear reactors.

The reference inventory for which Cigéo is designed includes the high-level (HLW) and intermediate-level long-lived (ILW-LL) waste already produced, as well as that which will be produced in the future by existing nuclear facilities and by those whose construction was authorised by the end of 2016 (Flamanville EPR, ITER, and the Jules Horowitz experimental reactor), through the foreseeable end of their operation and subsequent decommissioning. Today, approximately 50% of this high-level (HLW) and intermediate-level long-lived (ILW-LL) waste has already been produced.

The volume of radioactive waste in the reference inventory is approximately 83,000 m³ (see Figure 2-11). This corresponds to approximately 225,000 packages to be disposed of.

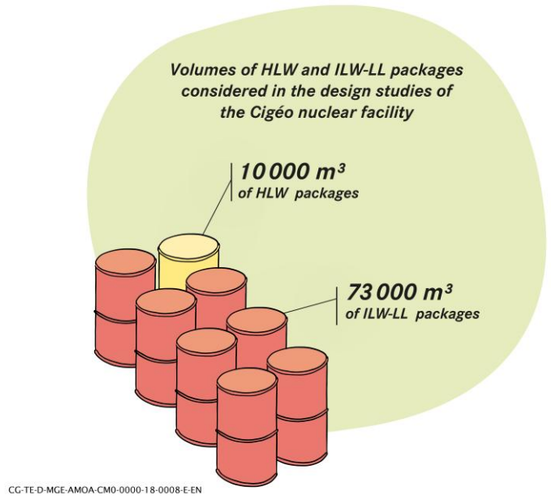


Figure 2-11 *Volumes of HLW and ILW-LL packages considered in the design studies for the Cigéo BNI*

Andra is designing the Cigéo disposal facility so that it can evolve as construction progresses in successive phases to account for potential changes in the inventory of waste to be disposed of, particularly in relation to national industrial and energy strategies, or the implementation of new waste management methods. At this stage, these changes are being studied through a reserve inventory and adaptability studies to ensure that the Cigéo basic nuclear installation can evolve and adapt to energy policy decisions.

2.3 Description of the facilities of the Cigéo overall project

The Cigéo overall project comprises the Cigéo disposal facility and all operations (facilities, infrastructure, construction of structures and activities) necessary for its construction, operation, decommissioning, closure, monitoring and surveillance, carried out by Andra and other project owners (see Chapter "2.3.2 of this non-technical summary). The facilities and structures related to these operations are presented below.

2.3.1 The Cigéo disposal facility, managed by Andra, in operation

Article L. 542-12 of the French Environment Code provides that *"the National Radioactive Waste Management Agency , a public industrial and commercial institution, is responsible for the long-term management of radioactive waste, and in particular: [...] designing, establishing, constructing, and managing radioactive waste temporary storage facilities or disposal facilities, taking into account the long-term outlook for the production and management of such waste, as well as conducting all necessary studies for these purposes*."

The Cigéo disposal facility is the result of collaborative design efforts led by Andra since the 1990s with the aim of creating a basic nuclear installation for the reversible disposal of French high-level (HLW) and long-lived intermediate-level (ILW-LL) radioactive waste.

The HLW and ILW-LL for which the Cigéo disposal facility is designed cannot be disposed of permanently on or near the surface in a sustainable and passive manner, given their high level of hazard and the very long period during which this hazard persists. Cigéo is a deep geological repository designed to provide long-term protection for human health and the environment from the risks posed by this type of radioactive waste. Its objective is to isolate radioactive waste from people and the environment and to slow the migration of radionuclides through a stable geological layer over very long timescales.

Following a construction phase (known as the initial construction phase), the Cigéo disposal facility will operate for more than a century, during which operations to receive and emplace radioactive waste packages will take place. At the same time, work to expand the disposal areas is carried out in successive stages. This gradual deployment allows for potential changes in the delivery schedules of the packages and maximises the benefits of scientific and technological advances, as well as the experience gained during the facility's operation.

This method of managing high-level (HLW) and intermediate-level long-lived (ILW-LL) waste limits the burden that will be borne by future generations in accordance with the requirements of the French Environment Code: *"The sustainable management of radioactive materials and waste of any kind, resulting in particular from the operation or decommissioning of facilities using radioactive sources or materials, shall be ensured in accordance with the protection of human health, safety, and the environment. Research and the implementation of the means necessary for the permanent disposal of radioactive waste are undertaken to prevent or limit the burden that will be borne by future generations"* (Article L. 542-1 of the French Environment Code).

The design, construction and operation of the Cigéo disposal facility also ensure its reversibility, that is, *"the ability for future generations, either to continue the construction and subsequent operation of successive stages of a disposal facility, or to reassess previously defined choices and adapt management solutions "* (Article L. 542-10-1 of the French Environment Code).

2.3.1.1 Overview of the Cigéo disposal facility

2.3.1.1.1 Its location

The Cigéo disposal facility is located in the Grand Est region, within the departments of Meuse and Haute-Marne (see Chapter 2.1.3 of this non-technical summary). The facilities of the Cigéo disposal facility are located in the Meuse municipalities of Bonnet, Bure, Gondrecourt-le-Château, Houdelaincourt, Horville-en-Ornois, Mandres-en-Barrois, Ribeaucourt, Saint-Joire, and the Haute-Marne municipalities of Cirfontaines-en-Ornois, Gillaumé and Saudron (see Table 2-2, table 2-3 and table 2-4).

2.3.1.1.2 Its organisation

The Cigéo disposal facility comprises both surface and underground facilities (see Figure 2-12):

- a surface ramp zone (*zone descenderie* - ZD), primarily dedicated to the reception of radioactive waste packages sent by the producers, their inspection and preparation for disposal prior to their transfer to the underground facility for disposal;
- a surface shaft zone (*zone puits* - ZP), dedicated to support facilities for the activities carried out in the underground facility, particularly the excavation of underground structures;
- an underground structures zone (*zone d'implantation des ouvrages souterrains* - ZIOS), comprising disposal areas for radioactive waste packages, logistics support zones (*zones de soutien logistique* - ZSL), and their access routes from the surface;
- a surface inter-site link (*liaison intersites* - LIS), connecting the shaft zone to the ramp zone, comprising a conveyor, a private road dedicated to heavy-duty vehicle traffic, and a road for light-duty vehicle traffic;
- a surface connected terminal (*installation terminale embranchée* - ITE), a railway line connecting the ramp zone to the national rail network (*Réseau ferré national* - RFN) at Gondrecourt-le-Château and including a logistics platform located in that municipality.



Figure 2-12 Illustration of the layout of the Cigéo disposal facility

2.3.1.1.3 How it works

Once authorised to begin operations, the nuclear activities at the Cigéo BNI will primarily consist of handling and inspecting radioactive waste packages. The manufacturing processes used by the various producers of the waste packages will have been previously approved. With the exception of a few workstations requiring the presence of operators near the equipment, the operational sequences related to the nuclear process for disposal of packages are mostly fully automated.

Throughout all phases of the BNI's operational life, these activities are governed by a set of measures related to monitoring and protection of the interests, as defined in the French Environment Code within the framework of its operation.

The operation of the BNI primarily enables in the surface facilities the reception and unloading of primary packages (*colis primaire* - CP) from transport containers delivered to the ramp zone. Within the surface nuclear building, it then allows for the preparation, as well as various inspections and handling of disposal packages (*colis de stockage* - CS). These disposal packages are then placed in transfer casks and then transferred to the funicular located at the head of the waste package ramp.

Once individually positioned on the funicular, the casks containing the disposal packages are transferred through the network of underground tunnels to the disposal cells. The packages are finally removed from the casks and placed within the cells. All these operations are remotely controlled from the centralised control room located in the surface nuclear building in the ramp zone.

The figure 2-13, outlines the overall operation of the Cigéo BNI in terms of nuclear processes, with the following main functions:

- reception and preparation of transport containers holding the primary packages;
- unloading of primary packages from transport containers;
- preparation of disposal packages;
- transfer and sealing of disposal packages;
- placement of disposal packages in transfer casks;
- transferring and placing the transfer casks on the funicular;
- transferring the transfer casks on the funicular down the package ramp;
- transferring the casks through the underground drfits;
- emplacing the disposal packages in disposal cells.

» DISPOSAL METHODS FOR RADIOACTIVE WASTE PACKAGES

In the EP1 surface nuclear building, "HLW" primary packages are placed in disposal containers made of unalloyed or low-alloy steel that have been welded prior to their underground disposal in disposal cells.

As for the disposal of "ILW-LL" primary waste packages in disposal cells, two disposal methods are used:

- the option of emplacing the packages directly in the cell (also referred to as "direct disposal"), considering the following two cases based on their characteristics:
  - ✓ direct disposal of the primary package;
  - ✓ disposal of the primary package in a disposal basket;
- disposal of packages after placement in a disposal container, with two sub-configurations:
  - ✓ disposal in a standard container;
  - ✓ disposal in a reinforced container with enhanced containment capability.

TRANSPORT OF WASTE PACKAGES TO THE CIGÉO DISPOSAL FACILITY

High-level waste (HLW) and intermediate-level waste long-lived (ILW-LL) packages are mainly transported by rail from the producers' sites, where they are currently stored, to the Cigéo repository for final disposal.
This mode of transport requires a rail connection between Gondrecourt-le-Château and the 'Ramp zone' of the Cigéo disposal facility : this is the 'Connected terminal' (ITE). Only a few ILW-LL packages arrive by road.



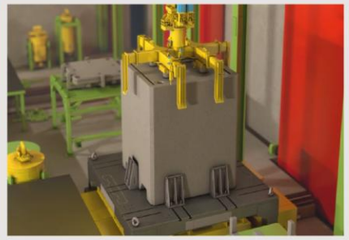
INSPECTION AND PREPARATION OF WASTE PACKAGES

Waste packages are inspected after being unloaded at the facility. The packages are then prepared for disposal:

- Depending on their characteristics, ILW-LL packages may be placed in concrete or steel containers, in steel baskets, or directly disposed.
- HA waste packages are placed in welded steel containers.



HLW packages



ILW-LL packages

TRANSFER OF WASTE PACKAGES TO THE UNDERGROUND FACILITY

The transfer cask is placed on a ramp transfer system that transports the waste packages down to the disposal level at a depth of approximately 500 metres. This transport system has been designed to be as safe as possible: the motors are located above ground, the trolley remains in place in the event of a breakdown, and the speed of movement is reduced.



Example of the HLW transfer cask

1 2 3 4 5 6

RECEPTION OF WASTE PACKAGES

Upon arrival at the Cigéo disposal facility, the transport containers are received. The waste packages are unloaded from their transport containers in surface buildings.



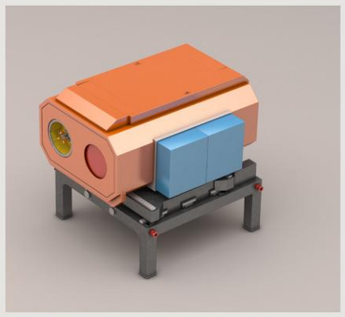




Example for ILW-LL packages

PLACING WASTE CONTAINERS IN TRANSFER CASKS

The waste packages are then placed in a 'transfer cask', which provides radiation protection whilst they are being transferred from the surface to the disposal cells in the underground facility.



HLW transfer cask

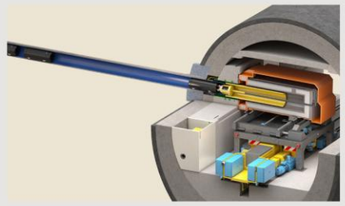


ILW-LL transfer cask

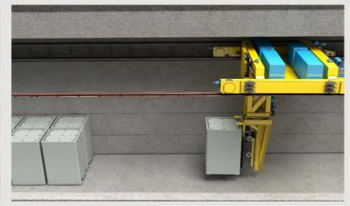
DISPOSAL OF WASTE PACKAGES

The transfer cask is moved onto a robotic transfer shuttle, which transports the waste packages to the disposal cells.

- HLW packages are emplaced in micro-drifts with an internal diameter of approximately 60 cm and a length of around 100 metres. They are pushed into the cell using a pusher robot.
- ILW-LL packages are emplaced in drifts with an internal diameter of approximately 8 metres and a length of several hundred metres. Depending on their nature, they can be arranged on a single level or stacked up to three levels high.



HLW cell



ILW-LL cell

CG-TE-D-MGE-AMOA-CM0-0000-18-0023-H-EN

Figure 2-13 Route of waste packages to their disposal location

2.3.1.1.4 The Basic Nuclear Installation (BNI)

A basic nuclear installation (BNI) is a facility that, due to its nature or the quantity or activity of the radioactive substances it contains, is subject to specific provisions to protect people and the environment.

The French Environment Code specifies that the perimeter of a BNI includes:

- the basic nuclear installation (Article R. 593-26, paragraph II 2° a);
- the equipment, facilities, structures, works, or activities located or carried out within its perimeter and under the responsibility of the same operator, which are necessary for its operation, including those listed in the nomenclatures provided for in Article L. 214-2 of the French Environment Code, known as the IOTA classification, and/or in Article L. 511-2 of the French Environment Code, known as ICPE (Article L. 593-3 and Article R. 593-26, II. 2° a);
- equipment, facilities, structures, works, or activities listed in the nomenclatures provided for in Article L. 214-2, known as the IOTA classification, and/or in Article L. 511-2, known as the ICPE classification, located or carried out within its perimeter and under the responsibility of the same operator, not necessary for its operation but which, due to their proximity or connection to the facility that is the subject of the creation licence application (DAC), are likely to alter the risks or drawbacks it may present to public safety, health and hygiene or the protection of nature and the environment (Article R. 593-26, paragraph II. 2° b) and Article L. 593-33).

The Cigéo disposal facility is shown below (see Figure 2-14). Details of the facilities and structures included within the Cigéo BNI perimeter are provided in chapter 3.2.1.3 of Volume II of this impact assessment.

PERIMETER OF THE BASIC NUCLEAR INSTALLATION (BNI)

In the creation licence application file for the BNI, to which the environmental impact assessment is attached, the Cigéo BNI perimeter is continuous (a single BNI). This perimeter is shown on the figure 2-14 as a red dotted line: it consists of two surface areas separated by several kilometres (one in the ramp zone and the other in the shaft zone), but connected by an underground area (the underground structures zone).

The BNI perimeter constitutes a subset of the Cigéo disposal facility. It is shown in red on the figure 2-15 and the figure 2-16.

This BNI perimeter will be ratified by the Nuclear Safety Authority upon issuance of the authorisation to create the BNI. The final perimeter may differ from the one proposed in the application submitted by Andra.

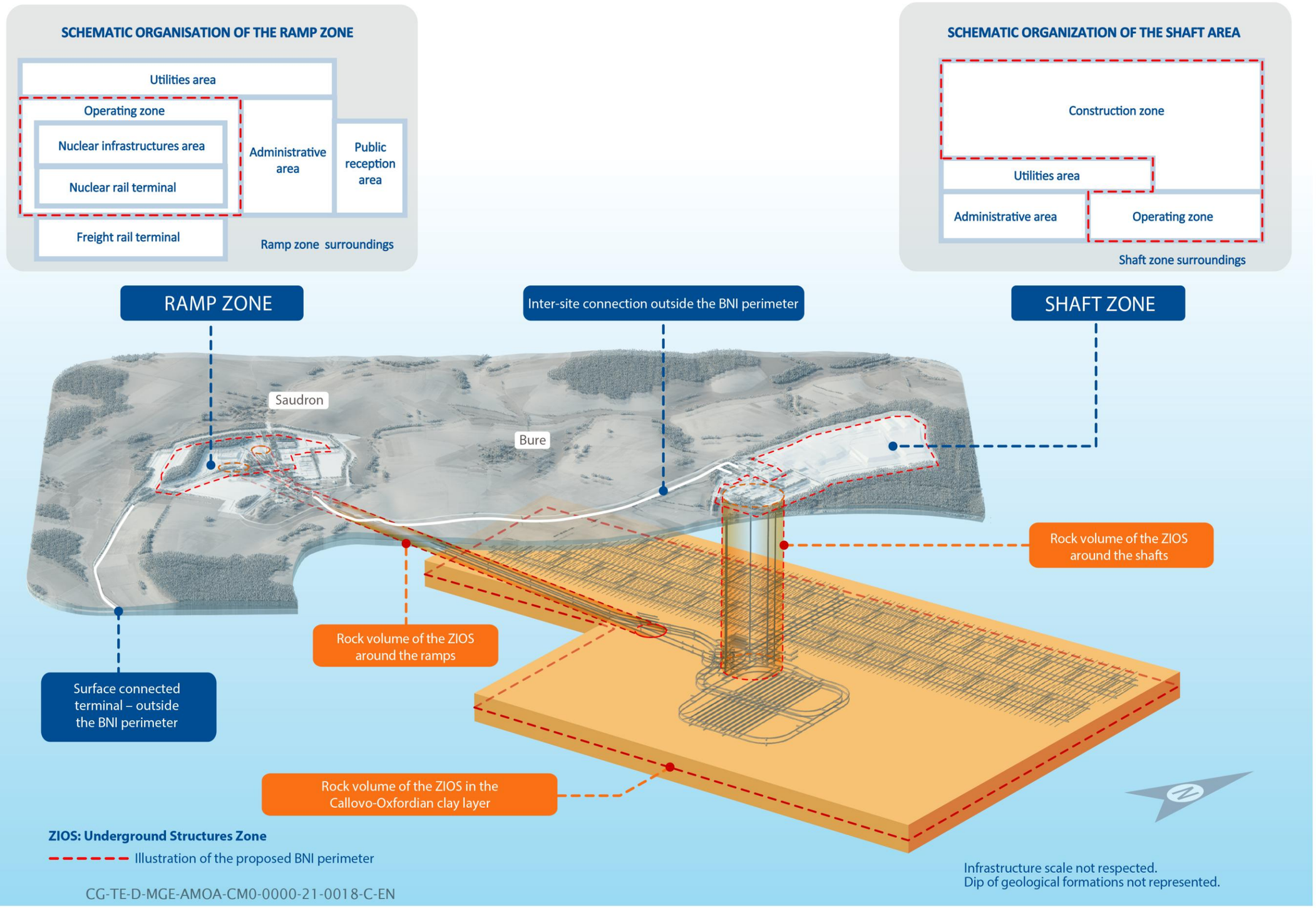


Figure 2-14 *Illustrative representation of the Cigéo BNI perimeter*

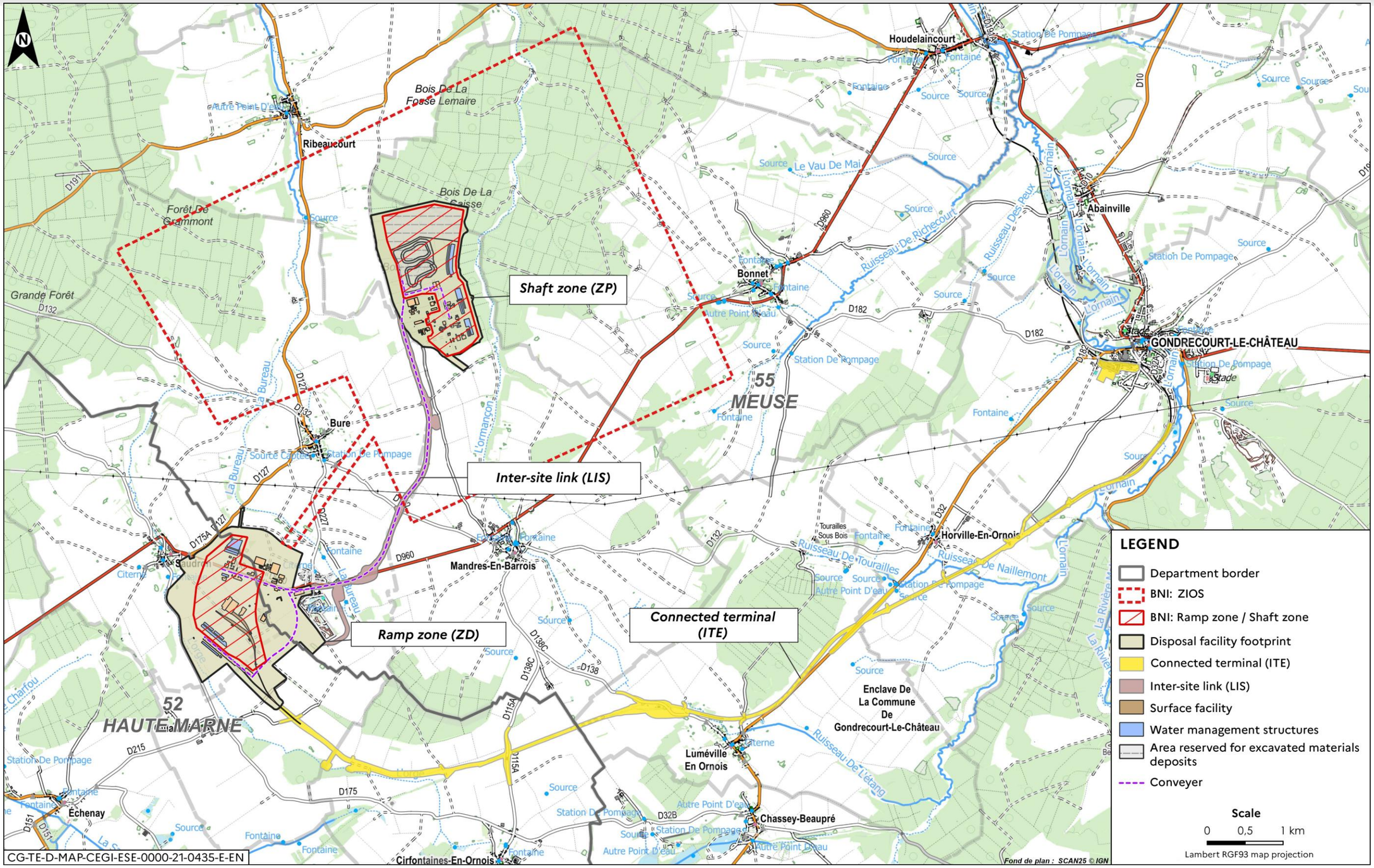


Figure 2-15 Overview of the Cigéo BNI site – Surface areas

2.3.1.2 The ramp zone

The ramp zone (ZD), with a total surface area of 296 ha, including 269 ha of which would be subject to earthworks and development, is dedicated to the reception, inspection and preparation of radioactive waste packages prior to their transfer for disposal in the underground facility. To help meet some of the requirements related to environmental compensation measures in its immediate vicinity, it includes a strip of approximately 24 ha of agricultural land (known as the area surrounding the ramp zone).

The ramp zone (ZD) is located in the municipalities defined in table 2-2.

Table 2-2 Municipalities where the ramp zone is located

Department	Municipality	Cigéo disposal facility area
Meuse (55)	Bure	Ramp zone
Haute-Marne (52)	Gillaumé	Ramp zone
	Saudron	Ramp zone

It comprises all areas with buildings, structures, equipment and landscaping of the ramp zone (see Figure 2-16), namely:

- an area dedicated to nuclear processing operations housing the facilities required to carry out all operations necessary for the handling of radioactive waste packages, from their reception through to their transfer to underground disposal facilities, including:
  - ✓ the nuclear rail terminal (TF BNI) receiving radioactive waste packages;
  - ✓ the surface nuclear building (EP1 building, eventually supplemented by ETH and EP2 buildings) housing the nuclear facilities used for the reception, inspection and preparation of waste packages prior to their descent into the underground structures *via* the waste package ramp head (TDC building);
  - ✓ support facilities including (non-exhaustive list):
    - the service ramp head (TDS builing);
    - the safety/security/environment building and associated guard posts;
    - the emergency generator (normal and emergency power supply);
    - the liquid effluent treatment plant;
    - water management basins, etc.
- an administrative zone housing:
  - ✓ the administrative buildings for the entire Cigéo disposal facility;
  - ✓ the Cigéo disposal facility's staff training and equipment testing center;
  - ✓ the staff cafeteria;
  - ✓ the medical centre;
  - ✓ the conventional surface maintenance workshop;
  - ✓ the fuel distribution area for light vehicles.
- an area dedicated to public reception, comprising in particular a public reception building and a building dedicated notably to preserving memory;
- a utilities zone housing the facilities for the production and distribution of energy and fluids in the ramp zone;
- an area for the freight rail terminal facilities;
- an area known as the "surroundings area," comprising the emergency exit from the ramp zone, the landscaping created to integrate the ramp zone into the surrounding landscape (lawns, trees and forest edges) outside the fences of the latter, and a strip of approximately 24 hectares of agricultural land to cover part of the requirements related to environmental compensation measures. This zone is crossed by discharge systems leading to the Orge and Bureau rivers.

All facilities are served by pedestrian paths as well as a network of internal roads designed for low-speed traffic of light and heavy vehicles.

The structures in this zone are enclosed within fences to control access and provide the appropriate level of protection. Access to this zone is from the east, near the roundabout on Departmental Road D60/960.

FACILITIES AND STRUCTURES IN THE RAMP ZONE OPERATING ZONE

The nuclear buildings in the ramp zone perform nuclear operations functions, primarily the reception, inspection and transfer of waste packages: namely, the reception of waste packages in transport containers, the unloading of primary waste packages, the preparation of disposal packages, their transfer, and their placement in the transfer cask, while performing inspections on the packages at each stage (see the operating principle presented in chapter 2.3.1.1 of this non-technical summary).

These nuclear buildings are deployed in two phases:

- a first surface nuclear building known as EP1, dedicated to the unloading, inspection and preparation for disposal of long-lived intermediate-level waste (ILW-LL) packages and low-heat-generating high-level waste (HLW0) packages until the package-loaded transfer casks are made available at the waste package ramp head structure to allow their transfer to the underground facilities *via* the waste package ramp;
- a second, smaller surface nuclear building, known as EP2, dedicated to the unloading, inspection and preparation for disposal of high-activity packages known as "HLW1/HLW2" by 2080, following thermal decay storage at the producers' facilities, prior to shipment to the Cigéo disposal facility. Its construction and commissioning, subject to obtaining the appropriate administrative authorisations, are not planned until several decades after operations begin.

These buildings, approximately 20 to 25 metres high, consist of three levels and are partially underground. They are connected by a tunnel to the waste package descent ramp head structure (TDC), which allows packages to be lowered to the underground disposal facilities. The service ramp head (TDS) structure provides access to the service ramp for maintenance operations and for evacuation and rescue in the event of an accident in the underground facility.

After passing through a very high-efficiency filtration system (HEPA filters), the exhaust gases from the ventilation of these surface nuclear facilities are channelled and discharged through an exhaust stack of sufficient height to ensure proper dispersion (approximately 40 metres high from the building's access roads).

All operations involving the packages are automated and monitored by video surveillance from the centralised control room.

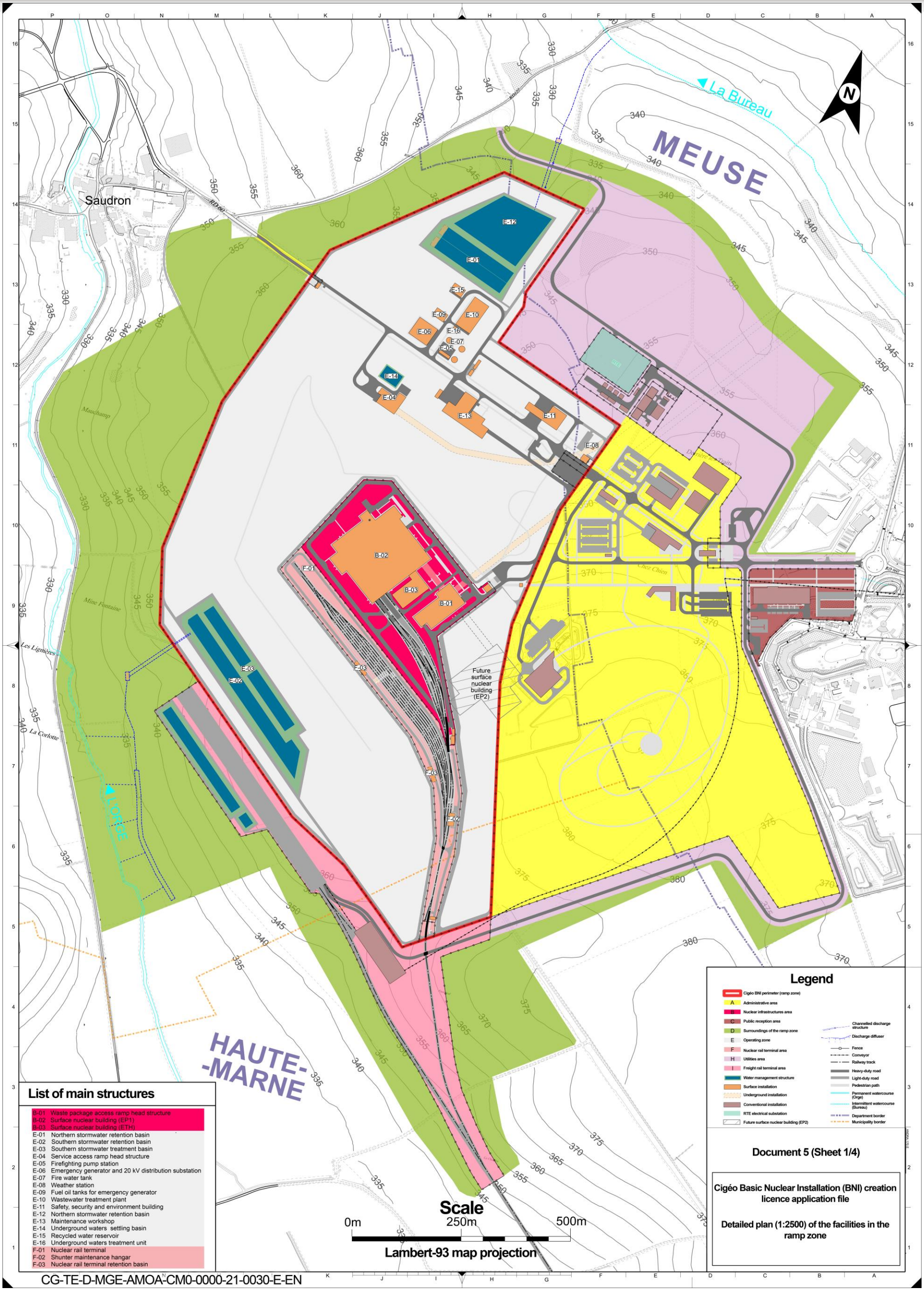


Figure 2-16 *General layout of the ramp zone (illustration from "Document 5 of the licence application file of the Cigéo basic nuclear installation (BNI)" (63)*

2.3.1.3 The shaft zone

The shaft zone (ZP), with a total future surface area of 202 ha, including 184 ha of which would be subject to earthworks and development, is primarily dedicated to facilities supporting underground disposal and construction activities (gradual deployment of disposal zones).

It is located in the southern part of the Lejuc forest, on land that naturally slopes eastward towards the Ormançon Valley. Its location encompasses the municipalities listed in the table 2-3.

Table 2-3 Municipalities where the shaft zone is located

Department	Municipality	Cigéo disposal facility area
Meuse (55)	Mandres-en-Barrois	Shaft zone
	Bonnet	Shaft zone (starting with the second deposit area for excavated materials a few years after the disposal facility becomes operational)

It includes all areas with buildings, structures, equipment and landscaping of the shaft zone (see Figure 2-19 and figure 2-18), namely:

- a "construction" zone dedicated to facilities supporting the excavation work for the underground facility and the storage of Callovo-Oxfordian excavation materials, comprising in particular:
  - ✓ ventilation shafts for construction work or for the transfer of equipment and materials:
    - the shaft providing fresh air and transporting personnel to the underground construction zone;
    - the shaft for extracting exhaust air from the underground construction zone;
    - the shaft used to transport equipment, materials and excavated materials.
  - ✓ the management area for Callovo-Oxfordian excavation materials deposits, specifically for storing materials that will be reused after the disposal facility is closed.
- an "operating" zone, including in particular:
  - ✓ the operating zone ventilation shafts:
    - the shaft used to extract air from the underground operational zone;
    - the shaft providing fresh air and facilitating the transfer of personnel, equipment, machinery and materials to the underground zone in operation.
  - ✓ support facilities comprising:
    - guard posts and access control stations;
    - firefighting and rescue buildings;
    - the "lamp room" located in the operating zone;
    - the high-voltage power supply station;
    - the liquid effluent treatment plant;
    - water management basins;
- an administrative area housing, in particular:
  - ✓ a multi-level parking garage;
  - ✓ a building housing service sector activities;
  - ✓ the cafeteria;
  - ✓ a conventional surface maintenance workshop.
- an area dedicated to utility management, housing the facilities for the production and distribution of energy and fluids for the shaft zone and the underground facility, as well as a construction reception area;
- an area known as the "surroundings area," comprising the emergency exit from the shaft zone, the woodlands maintained along the western boundary of the shaft zone, and the landscaping created to integrate the shaft zone into the surrounding landscape (lawn, woodland and restored forest edge) outside the shaft zone's fencing. This area is traversed by discharge systems leading to the Ormançon River.

All facilities are served by pedestrian paths as well as a network of internal roads designed for low-speed traffic of light and heavy vehicles. The main parking area is located at the entrance to the shaft zone.

The shaft zone structures are integrated into fenced-off areas to ensure control procedures and provide the appropriate level of protection. Access to the shaft zone is *via* a road that is part of the inter-site link, from the D60/960 departmental road. In the event of an emergency, a private emergency access road provides a route to this road. During the first construction phase, the surface area of the shaft zone is approximately 136 ha of reclaimed land. This includes the approximately 60 ha required for the management of excavated materials (Z1). A few years after the Cigéo disposal facility becomes operational, a second area for managing excavated materials (Z2) of approximately 48 ha will be required. The shaft zone will be extended northward.

To manage the Callovian-Oxfordian rock excavated during the construction of the final underground structures, a third zone (Z3), covering approximately 39 ha of reclaimed land, could be developed in several decades if excavated materials recovery pathways are not available in the meantime. This potential extension of the shaft zone is taken into account in the environmental impact assessment, particularly for the assessment of impacts.

FIVE SHAFTS AND A ZONE FOR STORING EXCAVATED MATERIAL

The shaft zone includes the heads of the five shafts and their supporting structures. It is divided into two distinct zones, as in the underground facility, allowing for the separation of operating activities from construction activities.

The operating zone houses the heads of the two shafts in the Operating Logistics Support Zone (ZSLE), incorporating their machinery and the ventilation systems associated with the supply and extraction of air from the underground operating zone. The air extraction shaft head is equipped with an exhaust stack to channel and control potentially radioactive atmospheric emissions from the underground disposal area. These shafts are:

- the "operational fresh air ventilation" shaft (VFE) ensures the transfer of personnel to the operational logistics support area and the supply of fresh air to the underground structures in operation;
- the "operational exhaust ventilation" shaft (VVE) channeling the extraction of air from the underground structures in operation.

In the construction zone, the heads of the three shafts in the construction logistics support zone (ZSLT) are located, incorporating their machinery and the ventilation systems associated with the supply and extraction of air from the underground structures under construction. These shafts are:

- the "construction zone - fresh air and personnel" shaft (VFT) provides fresh air and allows personnel to be transported by elevator to the construction section of the underground facility;
- the "construction zone - exhaust air" shaft (VVT) channels the extraction of air from the underground construction zone;
- the "construction zone – equipment" shaft (MMT) allows for the transfer of heavy equipment and materials, as well as the materials needed for underground work, to the construction zone of the underground facility. It also allows for the removal of excavated materials to the surface.

This zone also includes a management zone for excavated material from the Callovian-Oxfordian layer, which will be deployed gradually. A portion of the deposits of excavated material is retained for use in the closure of the underground structures.

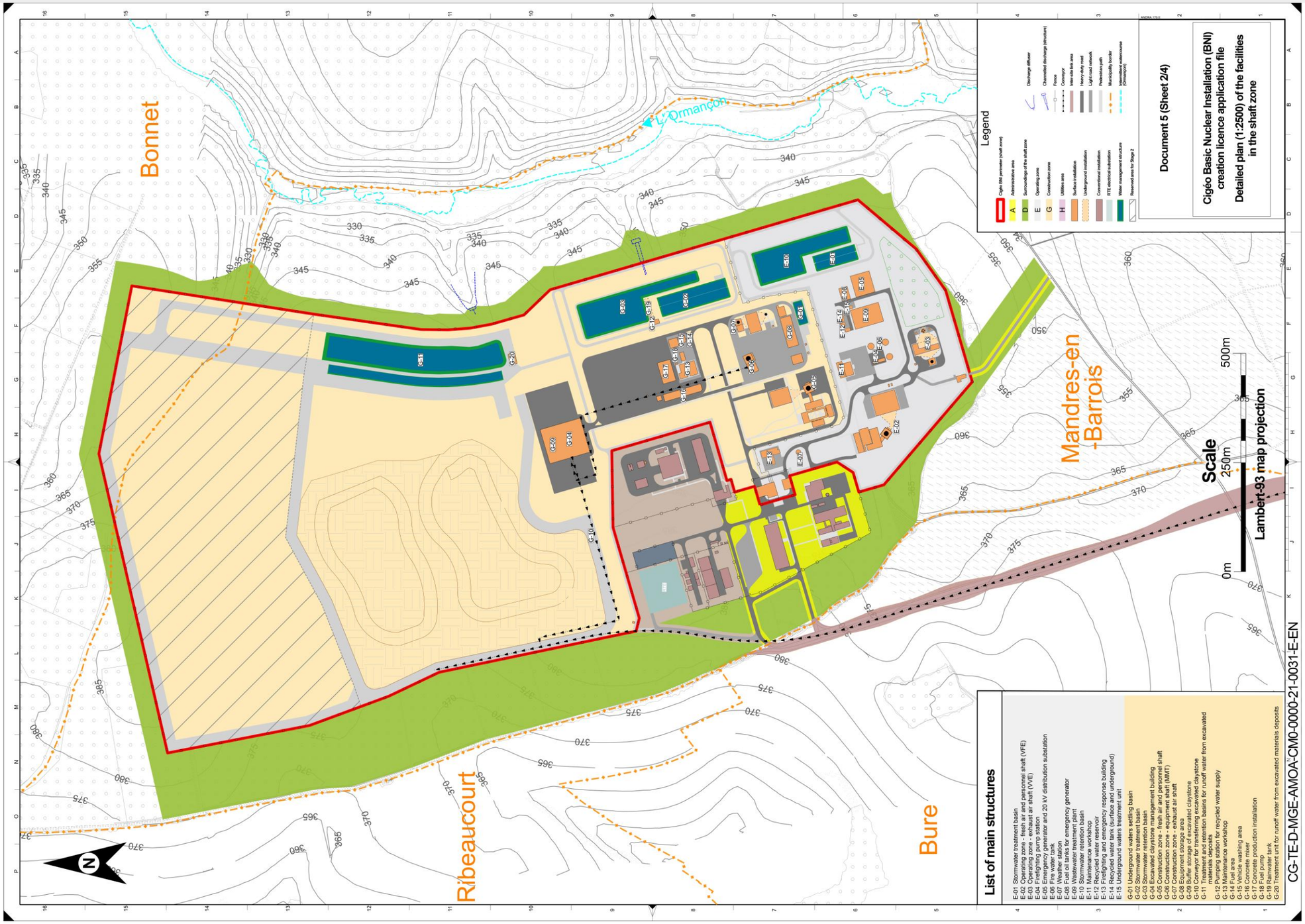


Figure 2-17 *General layout of the shaft zone (illustration from Document 5 of the licence application file of the Cigéo basic nuclear installation (BNI) (63))*

2.3.1.4 The underground structures zone

The underground structures of the Cigéo disposal facility are deployed progressively within the Underground Structures Zone (*Zone d'implantation des ouvrages souterrains* - ZIOS). The gradual deployment of the underground structures, in stages—that is, in groups of structures—will be subject to compliance with decision milestones to be set by the French Nuclear Safety and Radiation Protection Authority (ASNR).

The structures dedicated to the disposal of packages are located in the Callovian-Oxfordian clay layer at a depth of approximately 500 metres. Surface-underground connections (shafts and ramps) link the ramp zone and the shaft zone, described previously, to the parts of the underground facility located in this rock layer.

The Underground Structures zone (ZIOS) covers approximately 29 km² (see Figure 2-18).

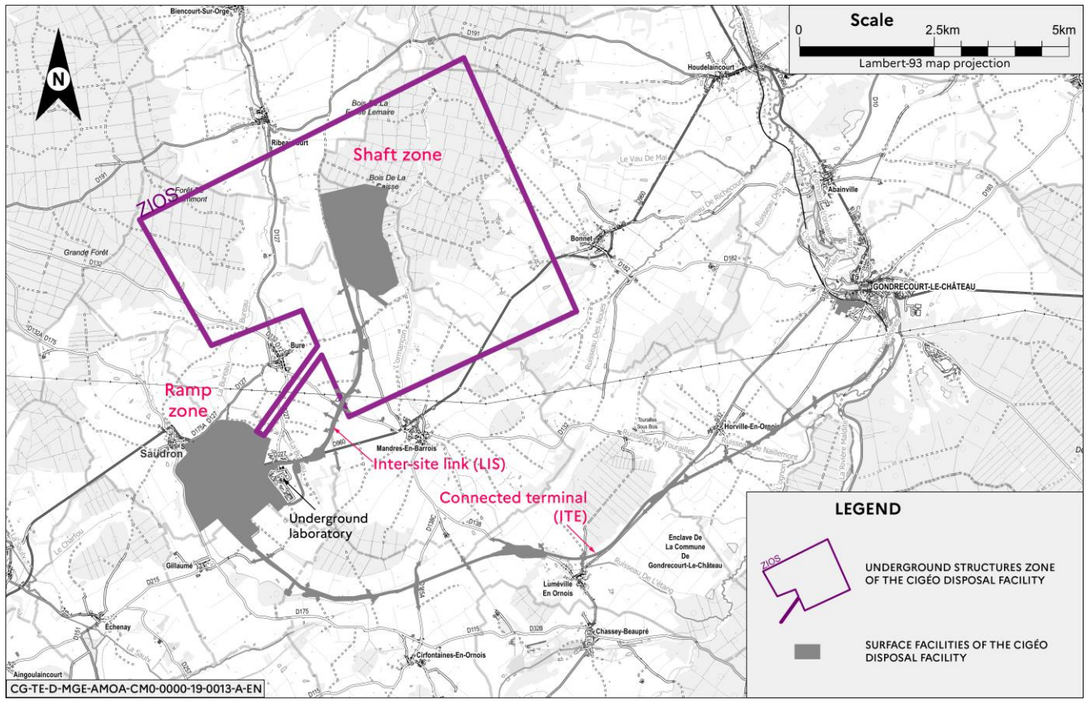


Figure 2-18 Location of the Underground Structures Zone (ZIOS)

It is located in the municipalities listed in table 2-4 .

No residential buildings are located directly above this zone.

Table 2-4 Municipalities directly above the potential deployment zone for underground disposal facilities

Department	Municipality	Cigéo disposal facility area
Meuse (55)	Mandres-en-Barrois	Ramps/shafts and disposal areas
	Bonnet	Disposal areas
	Bure	Ramps and disposal areas
	Ribeaucourt	Possible deployment of the underground installation at completion
	Houdelaincourt	
	Saint-Joire	

Depending on the characteristics of the waste packages, the Underground Structures Zone (ZIOS) is subdivided into three disposal cell areas (see Chapter 2.3.1.4.3 of this non-technical summary) based on the characteristics of the HLW and ILW-LL packages:

- a HLW pilot area, for the disposal of high-level waste packages, in particular low-heat-generating packages, known as 'HLW0';
- a ILW-LL disposal area, for the disposal of long-lived intermediate-level waste packages. The first four disposal cells, as well as the "demonstrator" cell in the ILW-LL disposal section, are scheduled to be constructed during the industrial pilot phase. Beyond this period and subject to authorisation to continue operations, the remaining cells will be progressively deployed in successive phases;
- a HLW disposal area for the disposal of high-level waste packages known as "HLW1/HLW2" by 2080, following thermal decay storage, as well as HLW0 packages and certain vitrified ILW-LL packages, used as spacers.

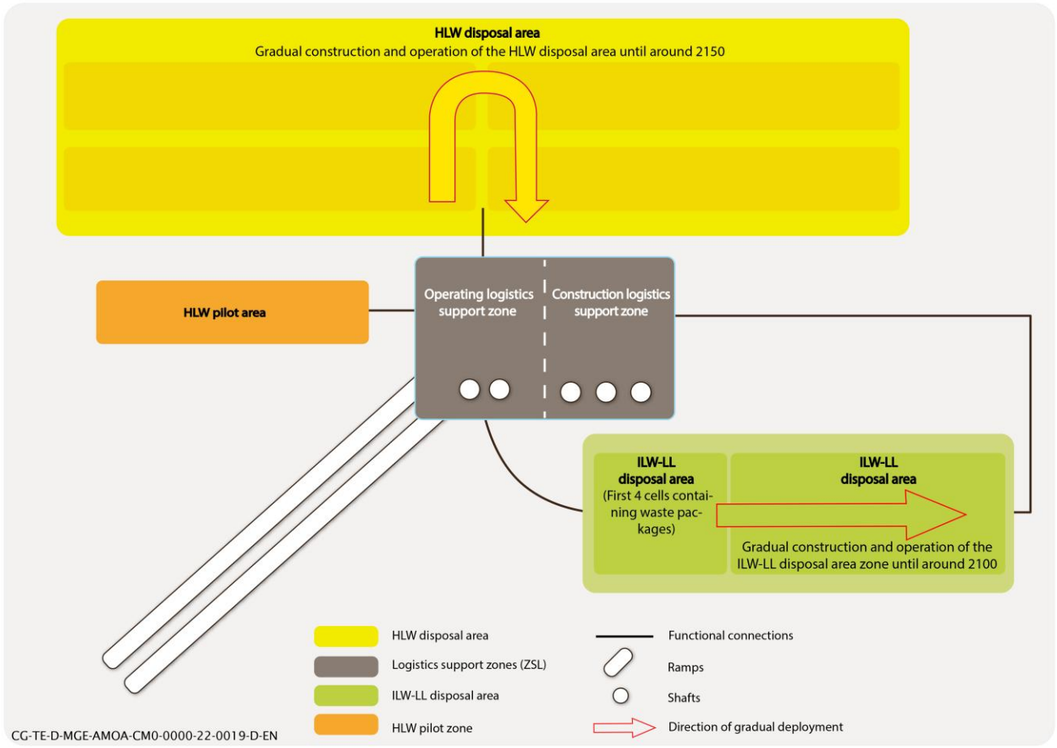


Figure 2-19 General layout of underground structures

The Underground Structures Zone (ZIOS) is connected to two logistics support zones (see Chapter 2.3.1.4.2 of this non-technical summary):

- the operating logistics support zone (ZSLE), which supports the activities of the underground operating zone, is connected to the ramp zone by two ramps and to the shaft zone by two shafts;
- the construction logistics support zone (ZSLT), which supports activities in the underground construction zone and through which equipment and materials for the construction of underground structures pass, is connected to the surface shaft zone by three shafts.

Following authorisation issued by the French Nuclear Safety and Radiation Protection Authority, the first shipments of radioactive waste packages will begin to arrive for active equipment testing, followed by disposal operations.

The deployment of the disposal areas is carried out gradually, in successive stages, beginning with the HLW pilot area and the first four disposal cells in the ILW-LL disposal area.

The Cigéo disposal facility is designed to operate for over a century, during which time the reception and disposal of radioactive waste packages will occur simultaneously with the expansion of disposal areas in successive stages. Lessons learnt from the construction, operation, and monitoring of the operational facilities contribute to improvements made possible by scientific and technological advancements.

For safety reasons, operating nuclear zones are always physically separated from zones under construction (management of coactivity risks) (see Figure 2-20). All construction and operational flows (electrical networks, ventilation, personnel, equipment, etc.) are separated. Deployment is therefore carried out by ensuring physical separation and operational independence between the underground operating zone and the underground construction zone. Each of these zones is connected to the surface by a logistics support zone (for operations and construction) and several surface-underground connections (ramps and shafts). Thus, construction work can be carried out without impacting ongoing disposal operations. An event in one zone has no effect on the other zone.

Subject to authorisation, seal and closure works of cells, drifts and disposal quarters may also be carried out during the operational phase of the Cigéo disposal facility, following the same principle of separating activities.

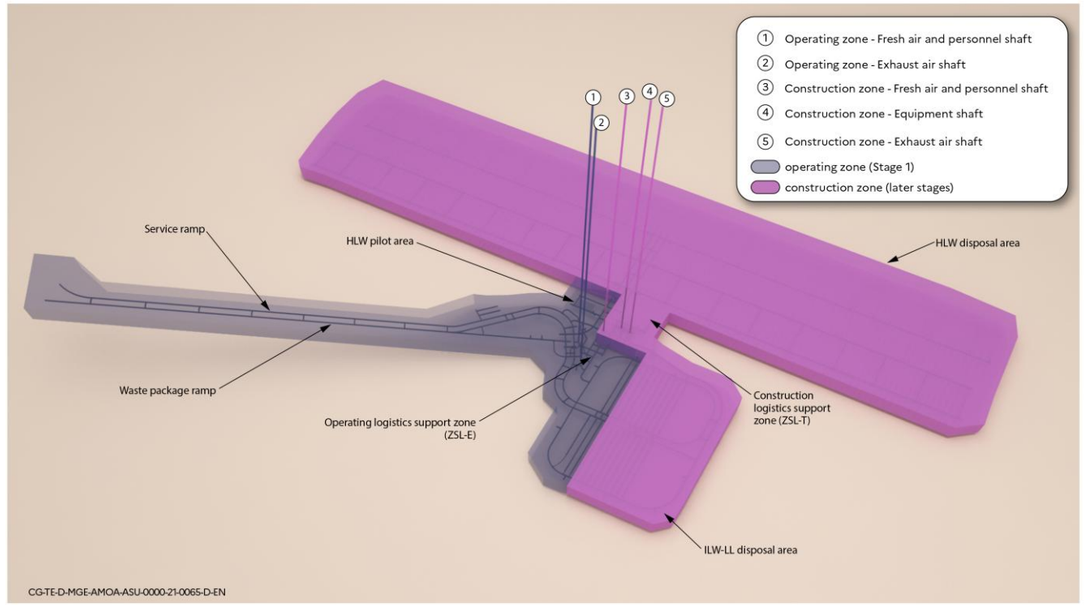


Figure 2-20 Schematic illustration of the separation of underground zones for operation and construction, and associated surface-underground connections (dimensions and proportions are not to scale)

All operations involving packages in the area where the underground structures are located are automated and monitored by video surveillance from the centralised control room located in the surface nuclear building.

2.3.1.4.1 Surface-underground connections

Surface-underground connections (LSF – *Liaisons surface-fond*) link:

- the ramp zone to the operating logistics support zone (ZSLE);
- the shaft zoneto the construction logistics support zone (ZSLT).

They consist of:

- two ramps (inclined tunnels) connecting the operating area of the ramp zone to the operating logistics support zone:
  - ✓ the waste package ramp;
  - ✓ the service ramp.
- five shafts, including:
  - ✓ two vertical shafts connecting the operating area of the shaft zone to the operating logistics support zone;
  - ✓ three shafts connecting the construction area and excavated materials deposit area of the shaft zone to the construction logistics support zone.

The surface-underground connections are fully constructed so that they will be operational before the first package is lowered.

The ramps are two parallel inclined tunnels approximately 4 km long (see Figure 2-21).

The waste package ramp is used to transport the transfer cask containing the radioactive waste packages to the operating logistics support zone (ZSLE) via a funicular. It also provides a pedestrian walkway on the platform on either side of the funicular track, for inspection, maintenance and evacuation/rescue. It is also used to route part of the utility networks supplying the structures in the operating underground zone. The base of the waste package ramp connects to the tracks used by the funicular's unloading trolleys, enabling the transfer of the container to the disposal areas.

The service ramp, dedicated to operational functions, is connected to the operating logistics support zone (ZSLE). It facilitates transfers related to maintenance, the transport of equipment and materials, the evacuation of personnel and access for emergency response teams. This structure is also used to route part of the utility networks supplying the operating underground facilities. It allows effluents collected underground to be brought to the surface and upward ventilation. Two vehicles (rescue or service) can pass each other here.

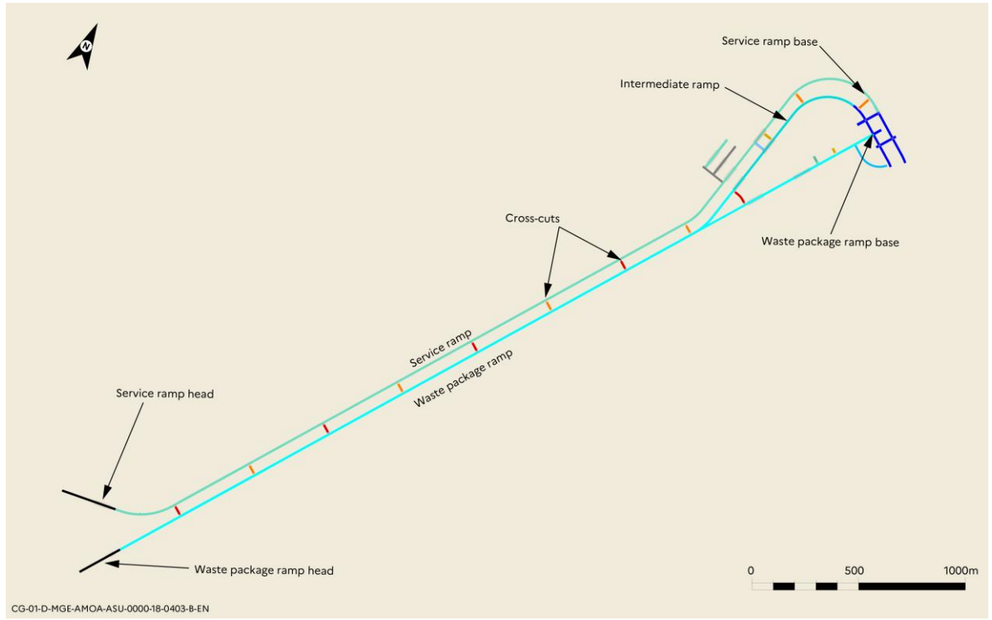


Figure 2-21 Overview of service and package ramps

The shafts serve as vertical connections between the surface shaft zone and the underground logistics support zones.

The diagram at figure 2-22 provides an overview of a shaft.

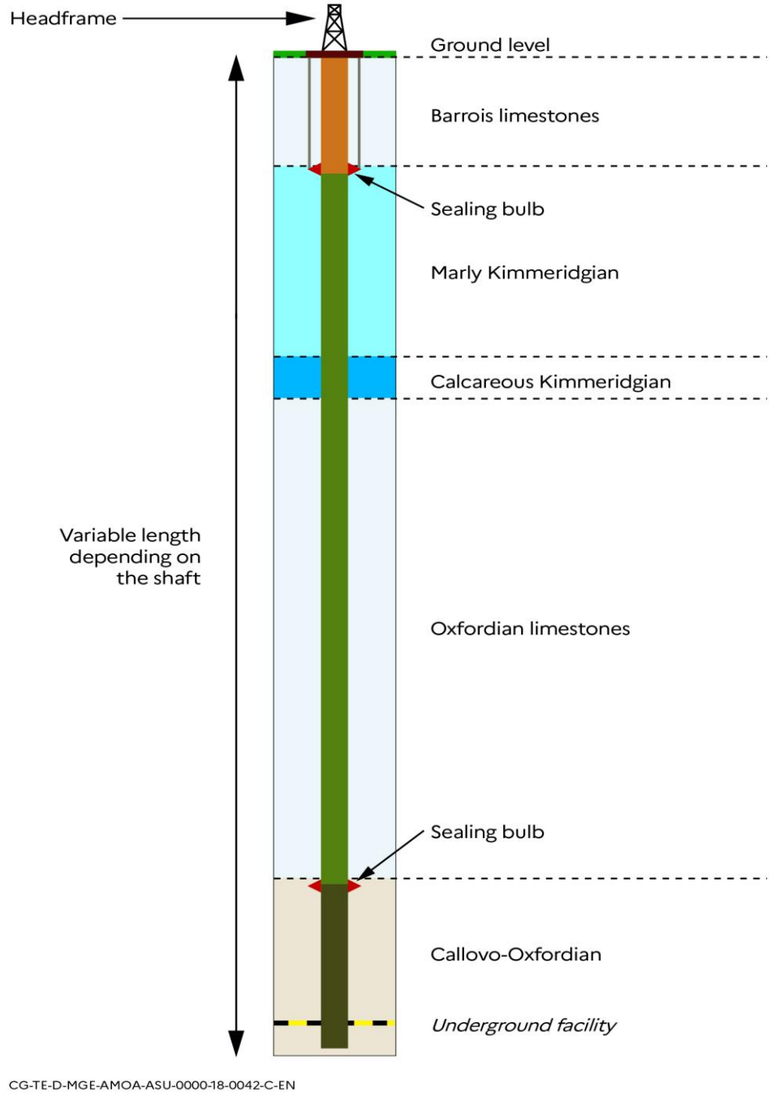


Figure 2-22 Overview of a shaft (principle)

The shafts and ramps are backfilled and sealed[15] during final closure[16].

[15] In accordance with the French ASN Safety Guide No. 1 of 2008 on the final disposal of radioactive waste in deep geological formations.

[16] Only a law (Article L. 542-10-1 of the French Environment Code) can authorise the final closure of the Cigéo disposal facility

2.3.1.4.2 Logistics support zones

The logistics support zones (ZSL) are divided into two distinct areas: a logistics support zone dedicated to operations (ZSLE) and a logistics support zone dedicated to construction (ZSLT).

The Operating Logistics Support Zone (ZSLE) serves as the interface between the surface nuclear facilities and the operational disposal structures. It supports the activities of the underground operating zone. It is connected to the surface ramp zone by two ramps and to the shaft zone by two shafts:

- the "waste package ramp" allows for the transfer of radioactive waste packages from the surface to the underground disposal facility. This transfer is carried out using a ramp transfer system;
- the "service ramp," dedicated to operational functions, enables:
  - ✓ on the one hand, transfers related to maintenance and the transport of equipment and materials;
  - ✓ on the other hand, emergency response (access for rescue teams) and the evacuation of personnel, if necessary.
- a first shaft allows for the extraction of air from the underground operating zone;
- a second shaft allows:
  - ✓ on the one hand, the supply of fresh air to the underground operating zone;
  - ✓ on the other hand, the transfer of personnel, equipment, supplies, and materials to the underground operating zone.

The Construction Logistics Support Zone (ZSLT) serves as the interface between surface facilities and underground structures located outside the BNI zone currently under construction. It supports activities in the underground construction zone and serves as a transit point for equipment and materials used in the construction of underground structures. It is connected to the surface shaft zone by three shafts:

- the first shaft allows air to be extracted from the underground construction zone;
- a second shaft allows:
  - ✓ on the one hand, the supply of fresh air to the underground construction zone;
  - ✓ on the other hand, the transfer of personnel to the underground work zone.
- a third shaft allows for the transfer of equipment and materials.

2.3.1.4.3 Deep underground nuclear facilities

In the underground facility, waste is placed in disposal cells based on its nature and activity level (HLW or ILW-LL – see Figure 2-23).

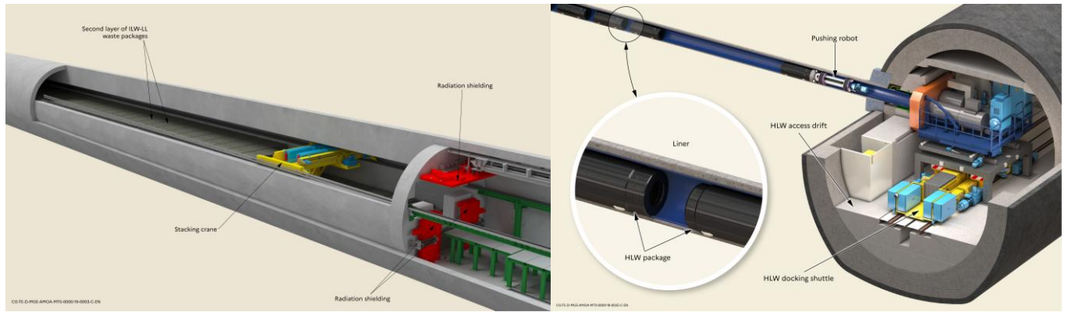


Figure 2-23 Illustration of an ILW-LL cell (left) and a HLW cell (right)

The disposal of long-lived intermediate-level and high-level waste packages takes place, respectively, within the underground nuclear facilities known as the HLW and ILW-LL disposal facilities:

- ILW-LL packages are stored within a single area in the underground facility known as the ILW-LL disposal area;
- High-level waste packages are stored within the same area of the underground facility but in two separate sections:
  - ✓ the HLW pilot area, a first area dedicated to the disposal of high-level waste packages (particularly HLW0 packages that generate little heat);
  - ✓ the HLW disposal area, a second area comprising four sub-sections, designed to accommodate high-level waste packages known as "HLW1/HLW2", HLW0 packages and certain vitrified ILW-LL waste packages used as spacers; it will be deployed at a later date, with commissioning planned for around 2080.

a) The ILW-LL disposal facilities

The ILW-LL disposal area, dedicated to the disposal of long-lived intermediate-level (ILW-LL) waste packages, is located south of the Underground Structures Zone (ZIOS). The disposal area consists of a network of disposal cells and drifts. It is connected to the west to the operating logistics support zone and to the north to the construction logistics support zone *via* the construction drifts. It enables the transfer of the casks containing the waste packages to the disposal cells.

The cells are concrete structures with a concrete lining. They are sized and arranged according to the nature and dimensions of the type of ILW-LL package they accommodate in order to minimise the void ratio after filling. The ILW-LL cells are cross-ventilated (see Figure 2-24).

At the start of deployment (Stage 1), the first four cells and the ILW-LL demonstrator are constructed. Subject to authorisation, the remaining cells and cross-cuts are then deployed progressively during the operational phase of the Cigéo disposal facility.

The ILW-LL disposal area consists of about twenty cells (including four in reserve) designed to receive and dispose of approximately 50,000 disposal packages representing about 150,000 "primary packages".

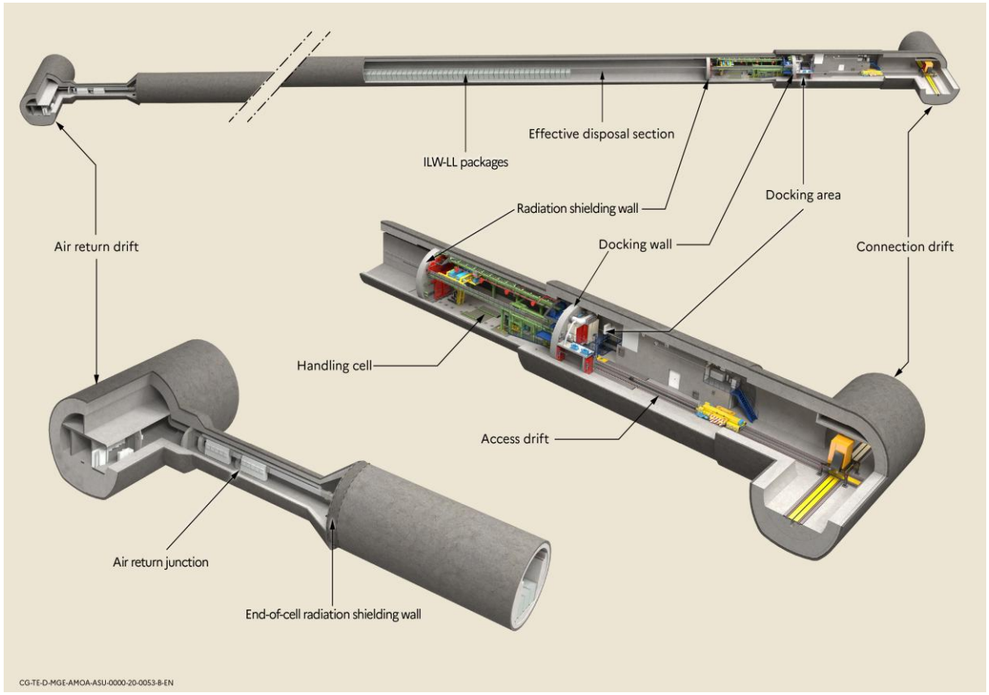


Figure 2-24 Illustration of the different parts of the ILW-LL cell

b) The HLW disposal structures

HLW pilot area

The HLW pilot area is intended for the disposal of high-level waste packages, particularly HLW0 packages that generate little heat.

The disposal cells in the pilot area are dead-end structures, slightly inclined and lined with steel.

The HLW pilot area comprises up to twenty cells, without prejudice to future developments integrated as part of the gradual deployment of disposal, three reference cells, and a closure demonstrator, for a total capacity of approximately 800 emplaced packages.

HLW disposal area

The HLW pilot area, designed to receive high-level waste packages—particularly low-heat-generating HLW0 packages—is constructed and operated several decades prior to the construction of the HLW disposal area intended to receive so-called "HLW1/HLW2" high-level waste packages, HLW0 packages and certain vitrified ILW-LL packages used as spacers. The HLW pilot area also serves as an industrial pilot for the future HLW disposal area.

The HLW disposal area comprises approximately one thousand HLW disposal cells and reference cells, grouped into four sub-areas.

HLW disposal cells

The design principles for the cells in the HLW disposal area are, at this stage, similar to those for the cells in the HLW pilot area.

The cells in the HLW pilot area adhere to design principles that support their functionality during operation and in the post-closure phase of the structures. At this stage, they have:

- an excavated diameter of approximately 0.8 metres;
- a length of approximately 80 metres with a downward slope towards the cell head;
- a cylindrical steel liner with a thickness of approximately 1 inch, or about 25 mm.

Only the length of the cells in the HLW disposal area differs; at this stage, 150 metres are considered, without prejudice to future developments (incorporating lessons learnt from the operation of the HLW pilot area and available technological advancements) that could be implemented by the time of its planned commissioning in 2080.

These elements are shown in figure 2-25 and figure 2-26.

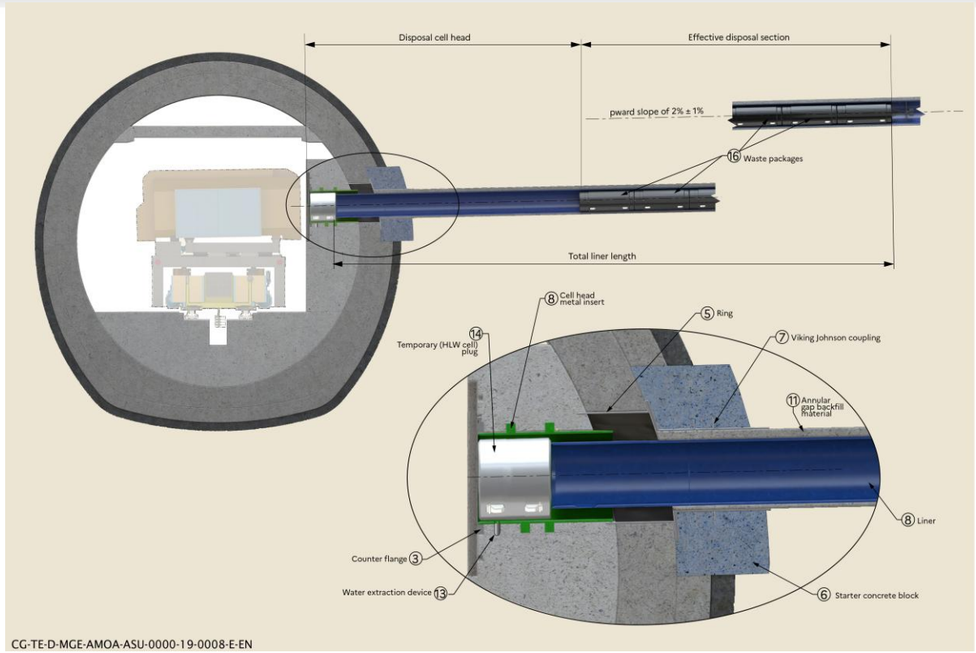


Figure 2-25 Cross-section of a cell in the HLW pilot area

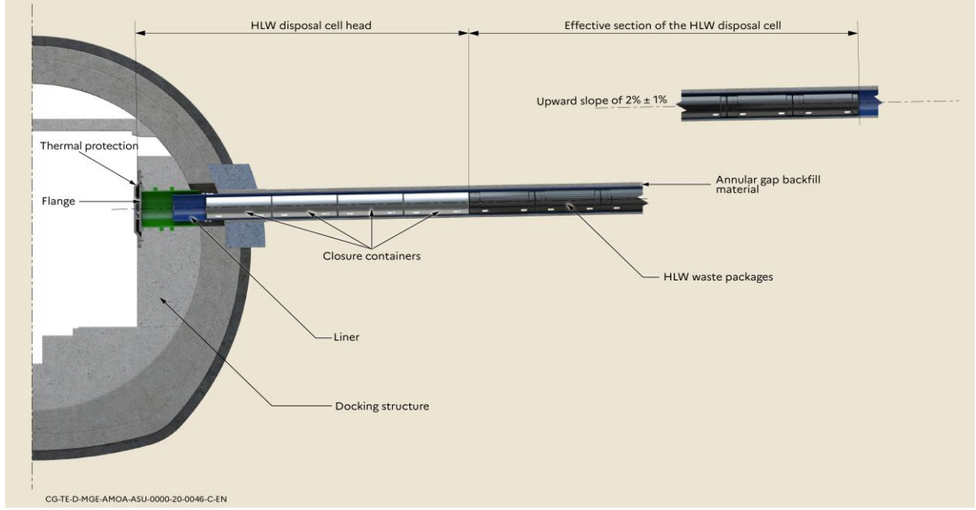


Figure 2-26 Cross-section of a cell in the HLW disposal area after installation of the closure plug

2.3.1.4.4 Closure of the underground facilities

To ensure the safety of the emplaced waste over very long periods of time, the underground facilities of the Cigéo overall project must be sealed. This sealing will be carried out gradually, following a process of specific authorisations. The geological environment is selected and the disposal facility is designed in such a way that, after the facility's final closure, safety is ensured passively—that is, people and the environment will be protected from the radioactive substances and toxic chemicals contained in the radioactive waste without the need for intervention.

Prior to the permanent closure of the Cigéo disposal facility, during its operational phase, the initial operations to seal cells and drifts and close disposal areas may be carried out in advance, if the generations responsible for operating the Cigéo disposal facility so decide. In practice, these operations involve dismantling operational equipment and constructing structures that complement the geological barrier to ensure the proper functioning of the disposal facility after its permanent closure.

The backfilling of the drifts is carried out by reusing the excavated clay material removed during tunnelling and stored at the surface.

If closure decisions were made during operation, structures would be built to:

- seal the disposal cells;
- backfill the drifts;
- seal the drifts.

During the operational phase of the Cigéo disposal facility, certain surface facilities could also be dismantled. The main dismantling operation planned prior to final closure would concern EP1 nuclear building, in connection with the completion of filling and the possible early closure of the ILW-LL disposal area.

Each disposal area would be closed in a single operation combining the construction of sealing structures for all disposal cells with the backfilling and sealing of the drifts. This approach allows for optimised organisation of the closure work.

After the final packages are received and the disposal areas are closed, the permanent closure of the Cigéo disposal facility—which can only be authorised by law (Article L. 542-10-1 of the French Environment Code)—involves backfilling the last drifts in the logistics support zone, sealing and backfilling the shafts and ramps. Surface facilities are dismantled. Some of them will remain in place for the purposes of the monitoring phase. The "memory" building will be preserved with no predecided time limit.

2.3.1.5 The inter-site link

The inter-site link (LIS – *Liaison inter-sites*), with a total area of 46 ha, 23 ha of which would be subject to earthworks, facilitates traffic between the ramp zone and the shaft zone and allows light vehicles access to the shaft zone.

It consists of three infrastructures: a road, a semi-underground conveyor belt (material conveyor), both of which are private, as well as a road open to the public.

Their functions are:

- the movement of heavy lorries between the shaft zone and the ramp zone (the LIS can be accessed from the D60/960 departmental road);
- transporting excavated materials from the ramp zone to the shaft zone for deposit, primarily during the initial construction phase;
- transporting construction materials delivered to the ramp zone to the shaft zone.

The objectives of the road open to the public are:

- to provide access to the shaft zone from the south via the D60/960 departmental road for light vehicles;
- to provide access to agricultural plots *via* rural roads blocked by the two private infrastructures.

The route of the inter-site link, with a total length of approximately five kilometres, extends across two municipalities in the Meuse department: Bure and Mandres-en-Barrois.

Andra does not plan to fence off the inter-site link. The road open to the public may be transferred to the Meuse Departmental Council. The route of the inter-site link crosses and/or alters two departmental roads, twelve rural roads, and two farm access roads along their existing sections.

2.3.1.6 The connected terminal

The connected terminal (ITE – *Installation terminale embranchée*) of the Cigéo disposal facility comprises a private railway infrastructure and a logistics platform.

The private railway infrastructure of the connected terminal, covering a total area of 121 ha, including 53 ha of which would be subject to earthworks, connects the ramp zone of the Cigéo disposal facility to the national rail network (RFN – *Réseau ferré national*).

The objectives of this infrastructure are:

- to transport radioactive waste packages from the producers' sites;
- to transport construction materials as early as possible to supply construction sites during the various phases of the Cigéo disposal facility's deployment.

The territory traversed by the rail infrastructure of the connected terminal spans four municipalities in the Meuse and Haute-Marne departments: Gondrecourt-le-Château, Horville-en-Ornois, Cirfontaines-en-Ornois and Gillaumé.

The total length of the railway infrastructure of the connected terminal is approximately 14 km, 10 km of which follow the route of a former railway line (the former Gondrecourt-le-Château/Joinville line), whose right-of-way it utilises. The latter has been decommissioned for several decades and no longer contains any railway equipment (rails, ties and ballast). Only the engineering structures and gatekeeper's houses remain on the site.

The railway infrastructure consists of a single track with a supporting side track that will not be open to public traffic. Andra has not planned to fence off the railway infrastructure. The railway infrastructure of the connected terminal intersects roads and paths, the continuity of which must be restored under good traffic and visibility conditions.

During the initial construction phase, the connected terminal will be in operation. It will be used to transport freight to the rail freight terminal located in the ramp zone. Freight traffic is estimated at approximately three trains per day (maximum monthly average during the initial construction phase). Traffic will occur primarily during the day. The speed on the connected terminal will be 30 km/h.

During the operational phase of the Cigéo disposal facility, rail access will enable:

- the arrival of the vast majority of radioactive waste packages destined for disposal at the nuclear rail terminal in the ramp zone. Indeed, primary packages of HLW and ILW-LL will arrive at the Cigéo disposal facility primarily by rail convoys from the producers' shipping sites where they are stored. At the start of radioactive waste disposal during the operational phase of the Cigéo disposal facility, the flow of rail shipments is estimated at approximately eight trains per year. Subsequently, the flow is expected to increase to approximately 80 trains per year, or an average of about six trains per month. Trains will run primarily during the day;
- the continued transport of materials; freight traffic is estimated at between one and two trains per week, during the day.

Andra has a private logistics platform covering an area of 9 hectares located on a former industrial site in Gondrecourt-le-Château.

2.3.2 Other operations of the Cigéo overall project related to its construction and operation

The other operations of the Cigéo overall project related to the construction and operation of the Cigéo disposal facility are:

- the “electric power supply” operation, enabling a connection to the existing 400 kV Houdreville-Méry transmission line (RTE);
- the “drinking water supply” operation, enabling supply from the Thonnance-lès-Joinville, Échenay and Gondrecourt-le-Château catchments (SIVU du Haut Ornain and SIAEP d’Échenay);
- the upgrade of the 027000 railway line between Nançois-Tronville and Gondrecourt-le-Château, also known as the 027000 line modernisation project (SNCF Réseau);
- the diversion of the D60/960 departmental road (Haute-Marne Departmental Council);
- the shipping and transport of waste packages from the waste producing sites (EDF, Orano, CEA).

In addition, environmental characterisation and monitoring operations are conducted by Andra and other project owners, both within and outside the perimeter of the Cigéo disposal facility; these are necessary to acquire knowledge, validate the design and construction, and monitor the operation of the facilities.

2.3.2.1 Power supply

The Cigéo disposal facility is powered by a connection to the existing 400 kV Houdreville-Méry transmission line[17]. This “very high voltage” line runs between the ramp zone and the shaft zone.

The new underground power lines that distribute electricity to the Cigéo disposal facility are connected to the existing 400 kV transmission line via a substation.

The complete power supply for the Cigéo disposal facility requires the completion of:

- safety works on the 400 kV transmission line over a 124 km stretch, from tower No. 79 in the municipality of Balignicourt (Aube) to the Houdreville substation (Meurthe-et-Moselle);
- a 400/90 kV substation, connected to the 400 kV Houdreville-Méry transmission line; this involves installing two new transmission towers between the overhead power line and the new substation;
- approximately 10 km of underground 90 kV power lines:
  - ✓ an underground power line between the new 400/90 kV substation and the RTE power delivery substation in the ramp zone;
  - ✓ an underground power line between the new 400/90 kV substation and the RTE power delivery substation in the shaft zone;
  - ✓ an underground power line between the two delivery substations in the ramp and shaft zones.
- two 90/20 kV substations, managed by Andra, located adjacent to the RTE power delivery substation in the ramp zone and the shaft zone, respectively.

In May 2020, RTE proposed selecting the 3S location for the 400/90 kV substation, which was the preferred choice of participants in the preliminary consultation. The solution selected from among six options, approved by the Prefect of Meuse on February 24, 2022 (64), will be subject to further detailed studies and an updated environmental impact assessment.

The facilities offer a high level of reliability and allow the nominal power to be maintained even if a transformer is unavailable for several months. The connection circuits are duplicated, and the substations in the ramp zone and the shaft zone are connected to ensure power supply redundancy.

VEGETATION MANAGEMENT UNDER THE POWER LINE

The French government has entrusted RTE, as part of its public service missions, with the operation, maintenance and development of France’s public electricity transmission grid.

RTE is responsible for ensuring the operational safety of the power system and the safety of people and property in the vicinity of its facilities.

Pursuant to Article L. 323-4 of the French Energy Code and the amended interministerial decree of May 17, 2001, known as the “technical decree” (65), RTE is responsible, in particular, for monitoring vegetation under and near the power lines it operates.

Indeed, below a certain distance, vegetation is likely to interfere with the power grid. Consequently, RTE regularly contracts service providers to carry out the necessary cutting work.

The use of pesticides is prohibited for the management of vegetation surrounding the 400 kV/90 kV substation (remote protection zone of the Rupt-en-Nonains water intake).

Vegetation control along the right-of-way of the 400 kV transmission line is carried out in accordance with the areas the line crosses (protection zone of a drinking water intake, Natura 2000 area).

[17] Houdreville is located south of Nancy, east of the disposal facility. Méry is located north of Troyes, west of the disposal facility.

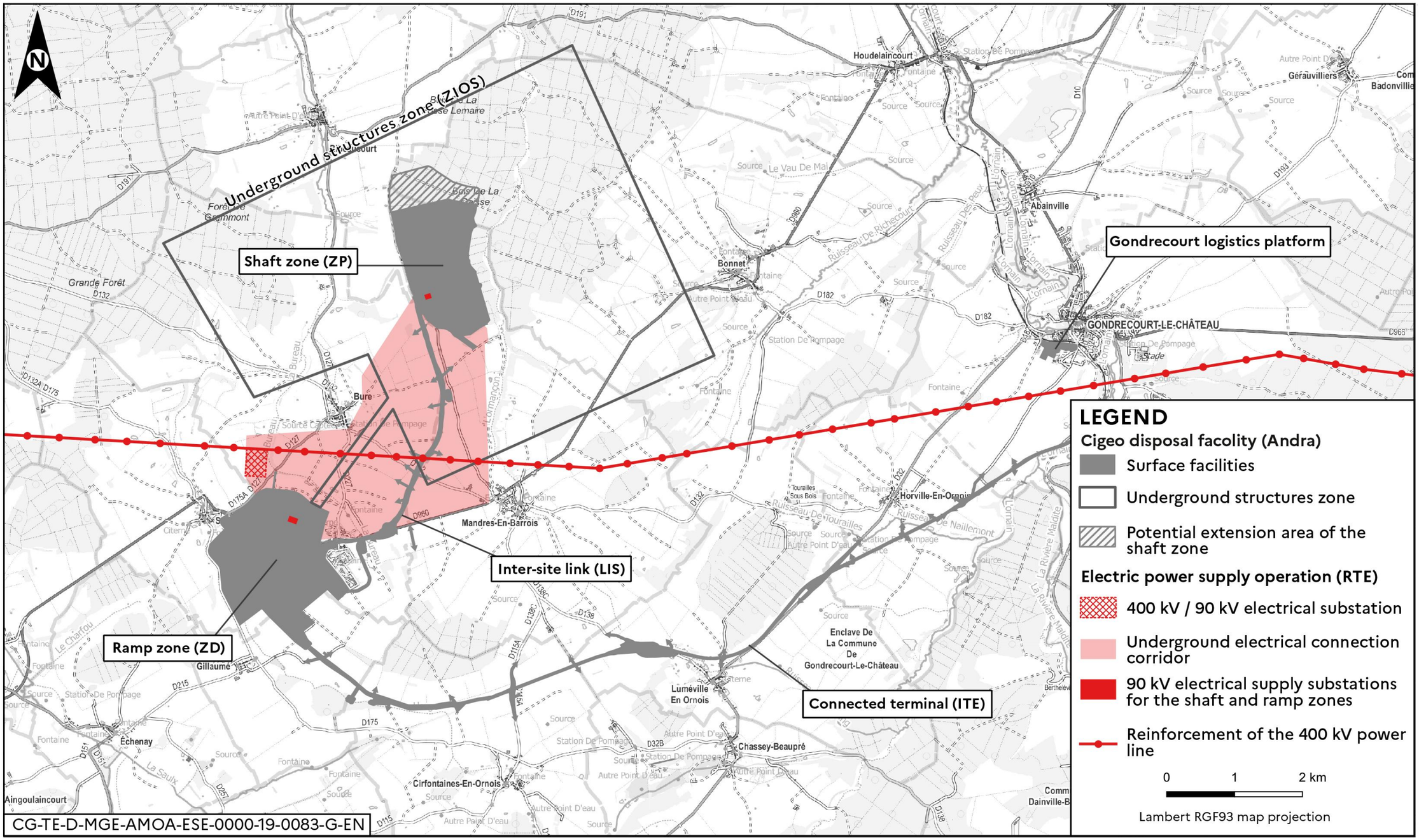


Figure 2-27 *Location map of the power supply facilities for the Cigéo disposal facility (S3 location approved by the Prefect of Meuse on February 24, 2022)*

2.3.2.2 Water supply for the Cigéo disposal facility

Peak water demand at the Cigéo disposal facility is estimated at a maximum of 500 m³/day during the preliminary development and initial construction phases, then at an average of 200 m³/day thereafter.

Certain water uses do not require a quality equivalent to that of drinking water. It was therefore decided to design water treatment systems to directly recycle a portion of the sanitary and industrial wastewater produced at the Cigéo disposal facility. The quality of the recycled water is thus adapted to the disposal facility's non-drinking water needs, as well as to ensure that discharges from the Cigéo disposal facility comply with the criteria for good chemical and ecological status of surface waters.

This recycled water will supply the operations with the highest water consumption: concrete production, irrigation of green spaces and operation of the tunnel boring machine. Any excess recycled water will be discharged in a manner consistent with the criteria for good chemical and ecological status of surface waters. Only sanitary uses will be supplied with potable water.

Drinking water supplies are planned jointly from the following springs and wells:

- Gondrecourt-le-Château, managed by the Haut Ornain water utilities syndicate (SIVU - *syndicat intercommunal à vocation unique*);
- Échenay, managed by the water utilities syndicate of the Échenay region (SIAEP - *syndicat intercommunal d'alimentation en eau potable*);
- Thonnance-lès-Joinville, managed by the water utilities syndicate (SIAEP) of Thonnance-lès-Joinville/Suzannecourt.

The networks supply two drinking water reservoirs with a combined capacity of 500 m³ each, one located in the ramp zone and the other in the shaft zone.

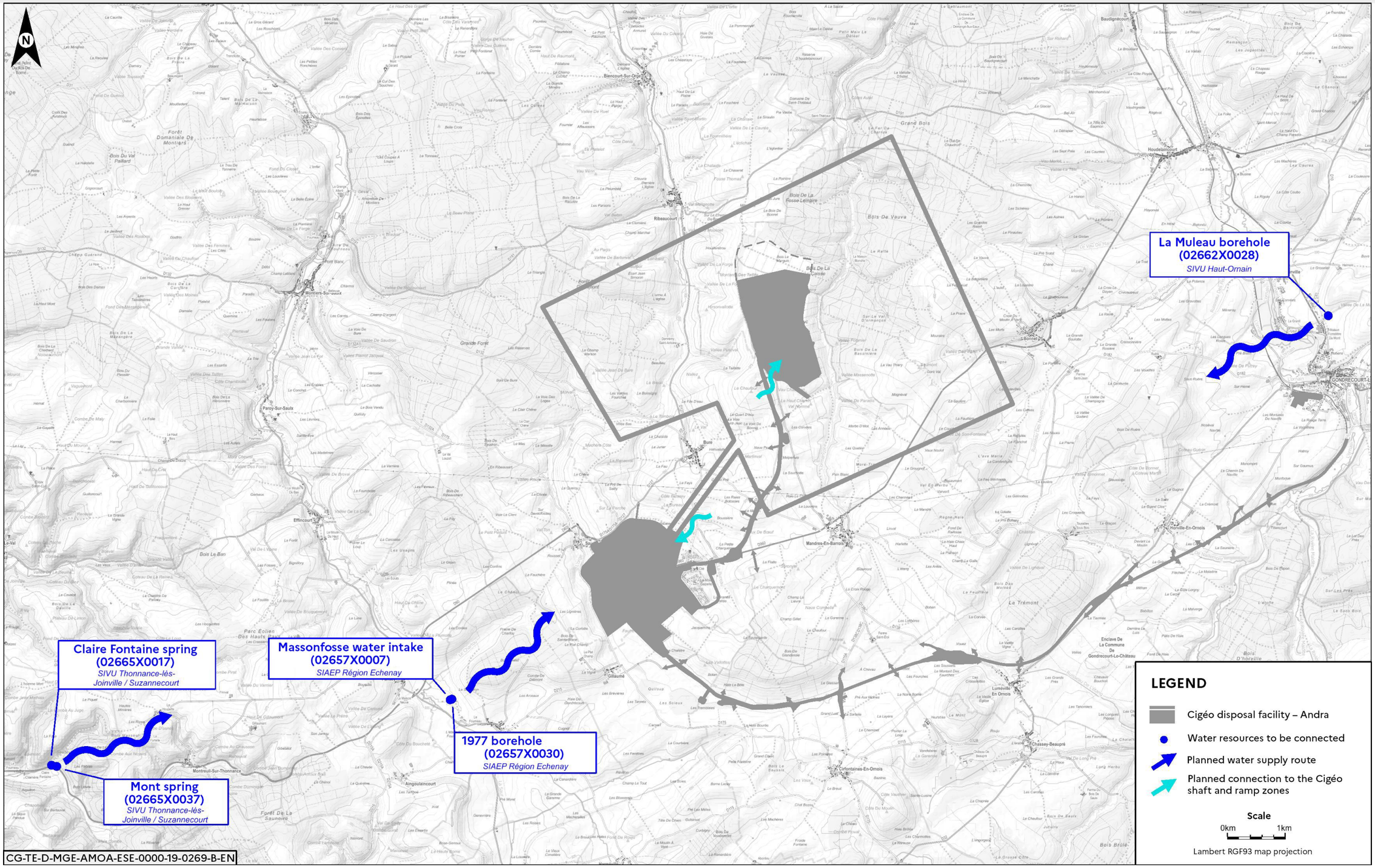


Figure 2-28 Location of the water supply project

The works to connect the Cigéo disposal facility to these networks is designed to restructure the networks and improve and secure local distribution. Feasibility studies (66) show that the works will provide sufficient flow to meet the combined needs of the Cigéo disposal facility and the surrounding area. The works will be carried out under the project management of the water utilities syndicates.

Several options (which are not mutually exclusive) include:

- reinforcing the existing supply networks of the Échenay SIAEP and the Haut Ornain SIVU;
- the construction of pipelines, sump pumps and reservoirs to deliver drinking water to the Cigéo disposal facility;
- interconnecting existing networks near the Cigéo disposal facility;
- limited extension of existing networks to supply other municipalities if their drinking water supply were to be affected by the construction and/or operation of the Cigéo disposal facility.

The selected solutions will be the subject of further detailed studies. This work will primarily be carried out along existing infrastructure.

2.3.2.3 Upgrade of the 027000 railway line

Railway line 027000 (see Figure 2-29) of the national rail network connects the connected terminal of the Cigéo disposal facility, to the Paris-Strasbourg line.

This 36-km-long line is located entirely within the Meuse department (dep. 55). The line includes 26 engineering structures, 57 hydraulic structures and 59 level crossings, 43 of which have no barrier.

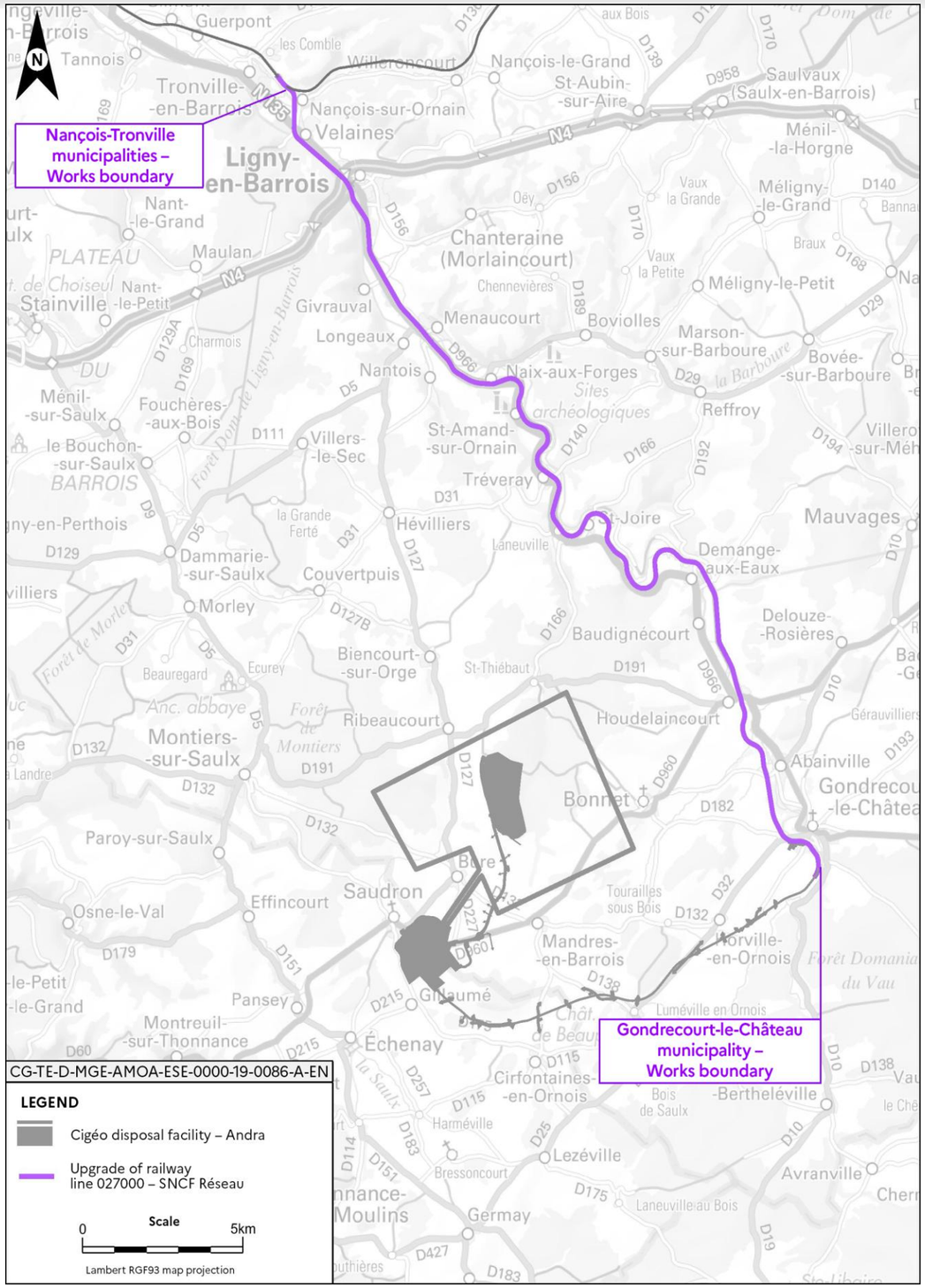


Figure 2-29 Location of the 027000 railway line

2.3.2.4 Diversion of the D60/960 departmental road

Design studies for the Cigéo disposal facility show the need to locally reroute the D60/960 departmental road to allow the facilities in the ramp zone to be deployed along a continuous location. The realignment modifies the route of the D60/960 departmental road on the section between Saudron and Mandres-en-Barrois.

The objective of the project is to bypass the ramp zone while maintaining the following current functionalities, service levels and safety standards:

- a two-way road consisting of two lanes of varying lengths depending on the options;
- maintenance of the current cross-section of the D60/960 departmental road;
- a road classified as a high-traffic route, allowing in particular the passage of oversized loads.

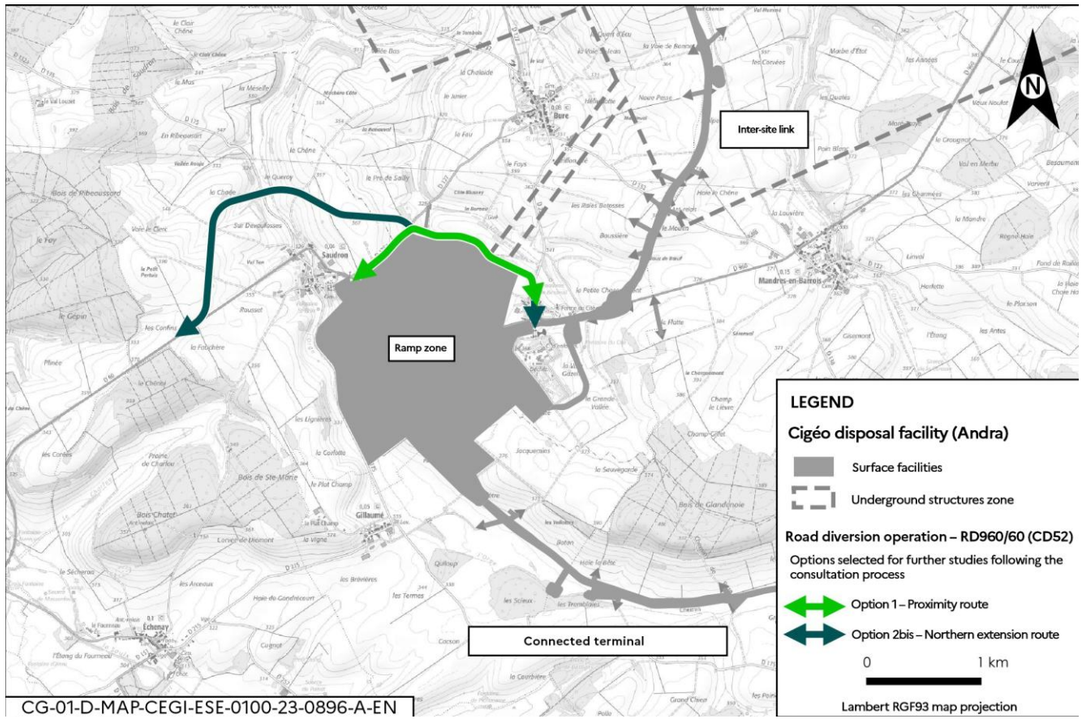


Figure 2-30 Presentation of the D60/D960 departmental deviation options

2.3.2.5 Shipping and transport of radioactive waste packages

Waste packages destined for the Cigéo disposal facility are temporarily stored in dedicated facilities at the various producers' sites, then transported from:

- the Orano facilities at the La Hague site in the Manche department;
- the EDF ICEDA facility (a facility for the conditioning and storage of activated waste), which began operations in November 2020 at the Bugey nuclear power plant site in the Ain department;
- the CEA facilities : the Marcoule facility in the Gard department, the Cadarache facility in the Bouches-du-Rhône department and the Valduc facility in the Côte d'Or department.

The locations of the producers' facilities from which waste packages destined for the Cigéo disposal facility will be shipped are shown in figure 2-31, which illustrates the planned transport routes to the Cigéo disposal facility.



Figure 2-31 Illustration of the transport of radioactive waste packages to Cigéo

Facilities dedicated to the shipment of waste packages are already in place at the existing sites of waste producers. The handling of HLW and ILW-LL packages for transport to the Cigéo disposal facility is therefore carried out from these existing shipping facilities. Depending on the shipment schedules for waste packages to the Cigéo disposal facility and the waste producers' studies regarding the use of potential new transport containers, modifications to these facilities—or even the construction of new facilities—at the existing sites of waste producers may be necessary. In this case, the environmental impact assessment for the Cigéo overall project will be updated to account for the impacts of the construction and operation of these modified or new facilities.

It should be noted, however, that waste treatment and conditioning activities at waste-generating sites are carried out upstream of the shipping facilities, independently of the very existence of the Cigéo disposal facility (regardless of the waste's destination). They are therefore independent and consequently excluded from the scope of the Cigéo overall project.

2.3.2.6 Environmental characterisation and monitoring operations

Environmental characterisation and monitoring operations are described below in relation to their objectives:

- characterisation activities;
- monitoring activities;
- follow-up of the environmental measures.

The first environmental characterisation and monitoring activities, which were the subject of the first application for environmental and planning permits, are described in the dossier available in French on the Andra website[18]. These applications were submitted on March 6, 2024, and the permits were issued on July 11, 21, and 22, 2025 (67).

2.3.2.6.1 Characterisation activities

At this stage of the project, the knowledge of the environment—including site geology, biodiversity and the physical environment—acquired over more than 20 years regarding the Cigéo disposal facility must be refined in order to consolidate and improve the design of the Cigéo overall project and to meet regulatory requirements. This is the purpose of the characterisation operations conducted by Andra and the other project owners.

Thus, additional characterisation activities will need to be conducted before, during construction, and during the operation of the Cigéo disposal facility:

- on the Cigéo disposal facility's footprint during the preliminary development, initial construction and operation phases, such as geotechnical drilling[19]. In this case, they are included in the permit applications for operations conducted in the ramp zone, the shaft zone, the underground structure site, the inter-site linklink, and the connected terminal;
- outside the Cigéo disposal facility. They will be subject to additional information requirements and regulatory authorisation processes tailored to their nature and potential environmental impacts.

Gathering this information may sometimes be required to meet regulatory obligations. For example, updating the environmental impact assessment for the Cigéo overall project (particularly the chapter on the "initial" state of the environment) as part of a future permit application may require new investigations. Characterisation activities may also be useful to reinforce or even improve the design, construction, and operation of the Cigéo disposal facility, or to better manage its impacts.

Characterisation activities fall into three main categories: geological characterisations, environmental inventories, and investigations related to preventive archaeology.

a) Geological, hydrogeological, and geotechnical investigations

Since the 1990s, Andra has conducted numerous investigation campaigns to study regional and local geology as part of its site search mission and subsequent design of the facility. Drilling operations and surface geophysical surveys have been carried out in particular in the Meuse/Haute-Marne region.

New drilling campaigns are needed to continue research and development studies and to refine certain data used in the design of the Cigéo disposal facility.

b) Environmental inventories

As with geological characterisation operations, Andra has been conducting field investigations in the region for years to gain a thorough understanding of the environment.

Specific studies will still need to be conducted to update inventories, primarily of biodiversity, in areas likely to be affected by the development of the Cigéo overall project. These inventories help maintain a solid understanding of the conservation status of populations and assess their movements and the extent of their habitat. These include, for example, listening protocols (fixed listening posts or installation of recorders) or searches for bat roosts, bird observations (fixed or mobile, diurnal or nocturnal), surveys of reptile presence (walkabout or with refugia), mammal observations (camera traps, counts, etc.) and field surveys by naturalists to catalogue natural habitats and flora.

Other characterisation measures, with lesser environmental impact, may also be carried out in the physical environment outside the Cigéo disposal facility (topographic surveys, stream flow measurements, noise measurements, etc.). These operations may involve one-time measurements resulting from the movement of people (or equipment) or measurements taken using devices physically installed in the field (topographic markers, monitoring stations, river gauging stations, etc.).

c) Investigations related to preventive archaeology

In 2015–2016, Andra conducted an initial archaeological survey campaign covering most of the future ramp zone and part of the ITE, at the border between the municipalities of Bure (Meuse) and Saudron (Haute-Marne).

With regard to preventive archaeology investigations, whether already conducted or still to be carried out, they are conducted in two phases:

- First, archaeological surveys are conducted by the French National Institute for Preventive Archaeological Research (INRAP);
- depending on the results of the survey, excavations may be mandated by prefectural order. In this case, excavations are then carried out by INRAP or by any other operator approved by the State.

[18] https://www.andra.fr/cigeo/les-documents-de-reference (2).

[19] Geotechnical characterisation drilling is a standard procedure in the construction of structures and facilities. It is carried out prior to construction work and does not warrant a specific discussion in this environmental impact study.

2.3.2.6.2 Environmental monitoring activities

Environmental monitoring operations will be mandated by the authorities as soon as the first works begin, starting with the preliminary development phase of the Cigéo overall project, during its initial construction phase, its operational phase, and during the post-closure monitoring phase, for as long as they are deemed necessary for the protection of health and the environment.

These environmental monitoring activities involve the implementation of continuous or periodic measurements, specifically to:

- monitor the operation of the Cigéo disposal facility, and in particular its basic nuclear installation (BNI), to detect any deviations, identify their causes and implement corrective actions;
- verify compliance with the regulatory obligations incumbent upon Andra regarding environmental protection.

Environmental monitoring thus plays an essential role in tracking, in particular, the impact of the Cigéo disposal facility's activities on its environment, in limiting any risk of contamination, pollution, or nuisance, and in mitigating the consequences of abnormal, degraded or accidental situations. Environmental monitoring operations will be required on the Cigéo disposal facility's site, such as measurements of water quality from piezometers. In this case, they are included in the operations conducted in the ramp zone, the shaft zone, the underground structure site, the inter-site linklink, and the connected terminal.

Certain environmental monitoring operations will need to be conducted outside the Cigéo disposal facility, including for project owners other than Andra. These operations are part of the Cigéo overall project.

The locations of the monitoring systems will be determined by the various permits, based on the criteria and parameters to be measured and surface environmental constraints. They may be located near the Cigéo disposal facility or in an area several kilometres away.

Among the monitoring devices, boreholes will be used to track the quality, fluctuations and flow of groundwater (hydrogeological boreholes) and the behaviour of the geological formations hosting the disposal facility.

In addition to the boreholes, monitoring devices with a lower environmental impact will be deployed across the area for environmental monitoring. These include monitoring stations for air sampling and measurements, particularly of air quality and radioactivity. Devices will also be used to monitor the quality and flow rates of surface water.

Samples from watercourses, as well as soil, vegetation and agricultural produce, will also be collected to monitor terrestrial and aquatic ecosystems.

Sampling and measurements will be carried out by Andra or its contractors in accordance with requirements set by the authorities. Analyses of the samples will be performed by laboratories—either internal to the Cigéo disposal facility or external—approved by the French Nuclear Safety and Radiation Protection Authority (ASNR) or by the Ministry of Environment.

2.3.2.6.3 Follow-up of environmental measures

Environmental monitoring of the ARC measures consist of actions taken to verify the effectiveness of measures to avoid, reduce, and compensate the impacts of the Cigéo disposal facility, as mandated for Andra in various administrative authorisations (exemption from restrictions on protected species, known as the "CNPN exemption", environmental permits such as those for land clearing, development permits, IOTA, etc.). Similar measures will be required of the other project owners involved in the Cigéo overall project.

These operations will be required of Andra and the other project owners as soon as the first preliminary development work on the Cigéo disposal facility begins, during its initial construction phase, and throughout its entire operational phase.

These measures may be of the same type as those prescribed for environmental monitoring (monitoring of groundwater, surface water, air quality, impacts on terrestrial and aquatic ecosystems, etc.).

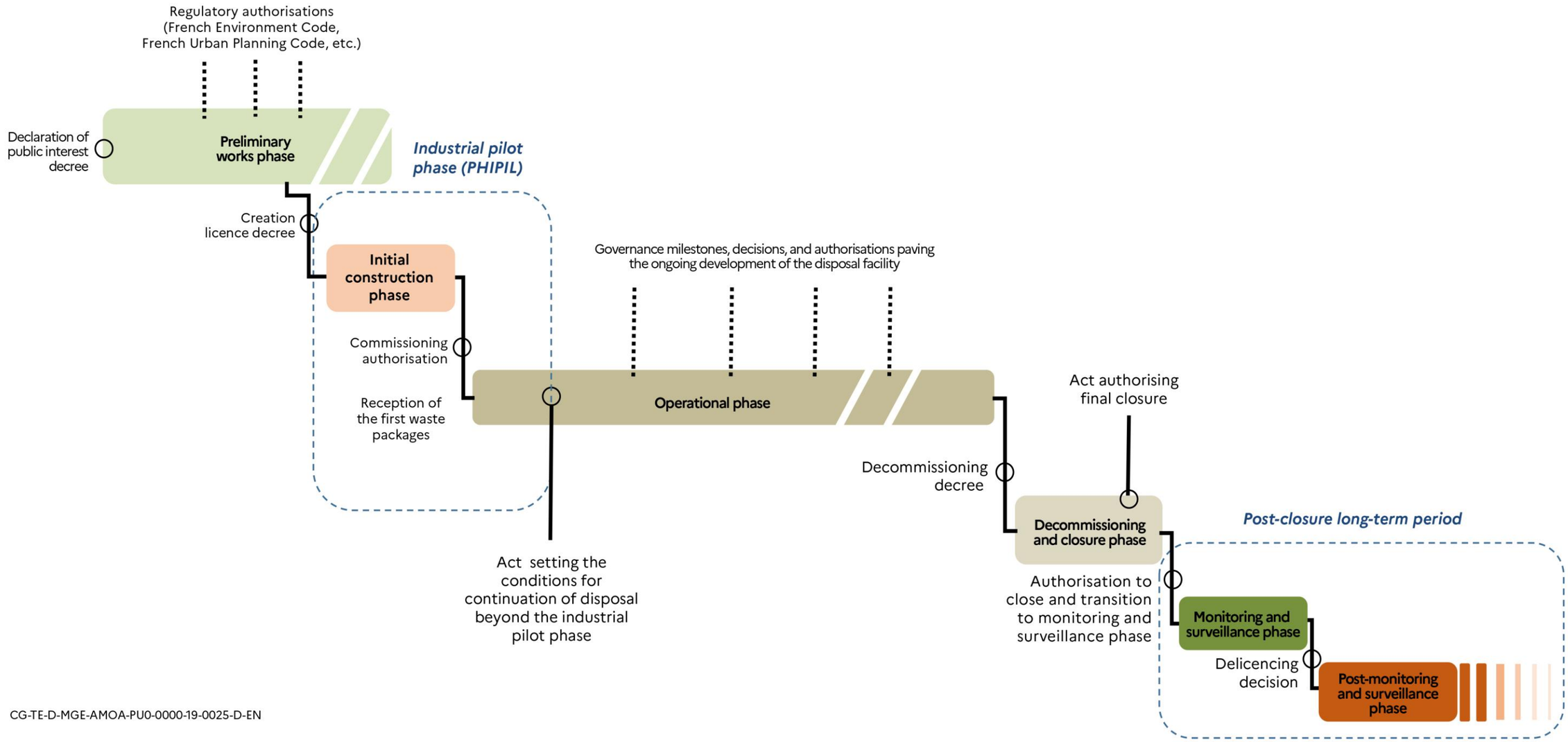
Certain environmental monitoring activities will be coordinated with local residents to take their specific concerns into account, and even to involve them in certain monitoring measures.

2.4 The successive phases of the projected timeline for the Cigéo overall project

The planned timeline for the Cigéo overall project consists of several successive phases (see Figure 2-32):

- The preliminary works phase begins upon issuance of the declaration of public interest decree of Cigéo disposal facility (and after obtaining the other authorisations required for the relevant works) and ends upon the granting of the creation licence decreeof Cigéo basic nuclear installation (BNI). It is during this phase that the creation application for the BNI is reviewed. The preliminary works consist of initial operations carried out to prepare for the construction of the Cigéo disposal facility, notably through connections to utility networks (water, power, transportation) and earthworks (see Chapter 2.4.1.1 of this non-technical summary);
- the initial construction phase, which begins upon issuance of the creation licence decree of the Cigéo BNI and ends upon the granting of its commissioning licence. The work carried out during the initial construction phase aims to complete all the structures necessary for this commissioning (see Chapter 2.4.1.2 of this non-technical summary);
- the operational phase, which begins with the issuance of the commissioning licence of the Cigéo deep geological repository, allowing for the reception of the first radioactive waste packages, and ends with the granting of its decommissioning decree. This phase lasts for more than a hundred years, during which activities will primarily involve the reception and disposal of waste packages and the expansion of the underground facility in successive stages to continue receiving packages from the inventory (see Chapter 2.4.1.3 of this non-technical summary);
- the decommissioning and closure phase, which begins upon issuance of the Cigéo BNI decommissioning decree and ends with the decision authorising final closure and transition to the monitoring and surveillance phase (see Chapter 2.4.1.4 of this non-technical summary). This phase includes operations aimed at the final closure of the Cigéo repository, which can only be authorised by law;
- the monitoring and surveillance and post-monitoring and surveillance phases (see Chapter 2.4.1.5 of this non-technical summary). Following the final closure of the Cigéo disposal facility, the monitoring and surveillance phase begins upon the decision to authorise the closure and transition to the monitoring and surveillance phase of the Cigéo BNI. It ends with the decision to delicence the Cigéo BNI. During this phase, disposal safety is ensured passively. After the delicencing decision, the post-monitoring and surveillance phase begins.

The French Environment Code provides for an industrial pilot phase (Phipil) for the Cigéo disposal facility (Article L. 542-10-1). Andra proposes that this specific phase cover the initial construction phase and the first few years of the operational phase (see Chapter 2.4.2 of this non-technical summary).



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Figure 2-32 Successive phases of the Cigéo overall project's deployment

2.4.1 Description of the deployment phases

2.4.1.1 The preliminary works phase

The preliminary works phase begins upon issuance of the declaration of public interest decree of Cigéo disposal facility (and after obtaining the other authorisations required for the relevant works) and ends upon granting of the creation licence decree of the basic nuclear installation (BNI) of the Cigéo disposal facility. Preliminary works consist of the initial operations carried out to prepare for the construction of the facility. Some of these works, which begin during the preliminary works phase, may be completed after the creation licence decree is obtained, during the initial construction phase.

The works carried out during the preliminary works phase at the Cigéo disposal facility are intended to prepare for the construction of the Cigéo disposal facility's installations. At the same time, works by other contractors—including water supply, power supply, upgrade of the 027000 railway line (modernisation of the 027000 line), and diversion of the D60/960 departmental road—are carried out and gradually put into service.

As with any project, these works are undertaken prior to the actual construction. Some of them may be completed after the creation licence decree for the Cigéo basic nuclear installation (BNI) is obtained during the initial construction phase, in particular the earthwork for the platforms.

The preliminary works at the Cigéo disposal facility are primarily aimed at securing the sites, providing utilities and organising the surface areas to accommodate the first construction contractors. They then focus on earthworks for utility platforms (water, electricity, telecommunications), before gradually extending to earthworks across all surface areas of the Cigéo disposal facility (ramp zone, shaft zone, inter-site link, connected terminal).

The first clearing operations are carried out in the Lejuc woods. They concern the site for the surface facilities of the shaft zone and the area designated for managing the Callovo-Oxfordian materials excavated during the initial digging ('Z1' of the excavated materials deposit area).

Initial excavation operations were mandated for Andra following the preventive archaeological surveys conducted in 2015-2016 by INRAP on the sites selected for the the ramp zone and the connected terminal of the Cigéo disposal facility (68, 69). Surveys of the shaft zone and the site of the inter-site link are to be conducted, potentially followed by excavations if remains of interest are discovered. These will enable construction work on the Cigéo disposal facility to proceed without the risk of inadvertently destroying remains of scientific and heritage interest.

In the portion of the shaft area dedicated to excavated materials deposit, only an initial areais developed. It is used to manage the Callovian-Oxfordian spoil excavated during the construction of the underground structures required for the commissioning of the Cigéo disposal facility. It will be expanded later in conjunction with the gradual extension of the underground facility.

All preliminary works are accompanied by the deployment of the utility networks required for the construction facilities, as well as the main roads enabling the flow of traffic to and from the sites.

Water basins and drainage structures will manage stormwater and runoff during the first years of construction, prior to the commissioning of the permanent facilities. Drainage structures are built to manage wastewater from the construction facilities, pending the commissioning of the facilities planned for the operation of the Cigéo disposal facility.

Some of these works, which began during the preliminary works phase, may be completed after the creation licence decree of Cigéo BNI is obtained, during the initial construction phase, in particular the earthwork for the platforms.

The first environmental characterisation and monitoring operations—referred to as DR0—are conducted at the start of this preliminary works phase, both within and outside the Cigéo disposal facility's boundaries. These operations are described in chapter 3 of this non-technical summary. They also involve the other project owners.

» OPERATIONS BY OTHER PROJECT OWNERS

The works carried out during the preliminary works phase outside the Cigéo disposal facility primarily concern the following other operations of the Cigéo overall project:

- the "Cigéo disposal facility power supply" operation;
- "drinking water supply" operation;
- "Upgrade of the 027000 railway line between Nançois-Tronville and Gondrecourt-le-Château" (also referred to as the "Modernisation of the 027000 line");
- "Diversionof the D60/960 departmental road " project.

These projects require earthworks, the construction of buildings, and the installation of equipment (transformers, busbar assemblies, etc.). The installation of 90 kV underground connections and work on the 400 kV transmission line are also carried out during the preliminary works phase.

Characterisation, environmental monitoring, and tracking of environmental measurements (drilling, measurements of the natural environment, inventories) begin during the preliminary works phase, both within and outside the boundaries of the Cigéo disposal facility.

The shipment and transport of radioactive waste included in the overall project are not currently underway during the preliminary works phase.

2.4.1.2 The initial construction phase

The initial construction phase begins upon issuance of the creation licence decree of the Cigéo Basic Nuclear Installation (BNI) and ends with the commissioning of this nuclear facility. The works carried out during the initial construction phase are aimed at completing all the structures within the BNI perimeter that are necessary for this commissioning.

The main works carried out during this phase involve the construction of structures required for the commissioning of the Cigéo BNI. This includes the construction of the first surface buildings, surface-underground connections, and underground structures to emplacethe first waste packages.

The main structures built and equipped at the Cigéo disposal facility, under the project management of Andra, are:

- the facility for receiving and preparing radioactive waste packages prior to disposal (EP1) and all surface buildings associated with the basic nuclear installation (BNI) in the ramp and shaft zones (ZD and ZP);
- the surface-underground connections (ramps and shafts) and the underground logistics support zones in the Underground Structures Zone (ZIOS);
- the underground structures in the HLW pilot area and the first structures in the ILW-LL package disposal area within the Underground Structures Zone (ZIOS).

To enable these construction operations, various temporary construction facilities will be set up on the sites.

Characterisation, environmental monitoring, and environmental measurement activities (drilling, measurements of the natural environment, inventories) will continue during the initial construction phase, both within and outside the boundaries of the Cigéo disposal facility.

From the start of this phase and throughout subsequent phases, the structures for operations under the responsibility of other project owners will be operational; only maintenance work will be performed on them.

» OPERATIONS BY OTHER PROJECT OWNERS

All operations by other project owners are in operation during this phase, except for the shipment and transport of radioactive waste.

2.4.1.3 The operational phase

The operational phase begins with the commissioning of the Cigéo nuclear facility (BNI), i.e., upon reception of the first shipments of radioactive waste and ends with the granting of its decommissioning decree. It will last for approximately a hundred years, during which activities will primarily involve the reception and disposal of waste packages and the expansion of the underground facility in successive stages to continue receiving packages from the inventory.

During the operational phase, operations to receive and emplace packages will be carried out in parallel with work to gradually expand the underground facility in successive stages. Renovation, construction, or adaptation work on surface buildings will also be scheduled.

The main successive disposal periods for the packages are as follows (see Figure 2-33):

- in the early years, reception and disposal of HLW0 waste packages (low-exothermic packages) and ILW-LL packages in the facilities of the HLW pilot area and the ILW-LL disposal area, respectively, constructed during the initial construction phase;
- then, for approximately 30 years (until around 2070–2080), reception and disposal of ILW-LL packages in the facilities built during the initial construction phase and in new cells constructed in the ILW-LL disposal area during the operational phase;
- then, for approximately 20 years (until around 2080–2100), reception of high-level (HLW) packages and ILW-LL packages in the facilities previously constructed and in new cells built in the HLW disposal area and the ILW-LL disposal area during the operational phase. Receiving high-level (HLW) packages will require, during the operational phase, the construction of a dedicated reception and preparation facility, designated “EP2,” on the surface of the ramp zone;
- finally, for a period of approximately 50 years (until 2150), continued reception and disposal of high-level waste packages in the structures already built and in new cells in the high-level waste disposal area constructed during the operational phase.

This timeline is, however, indicative and may be adapted to account for lessons learnt and adjustments in the delivery schedules for waste to be disposed of, as well as any operations decided upon in the context of reversibility. The work to gradually expand the underground facility, in successive stages, will be organised according to future needs and the issuance of the associated authorisations.

During the operation of the Cigéo disposal facility, studies will continue to optimise the successive stages.

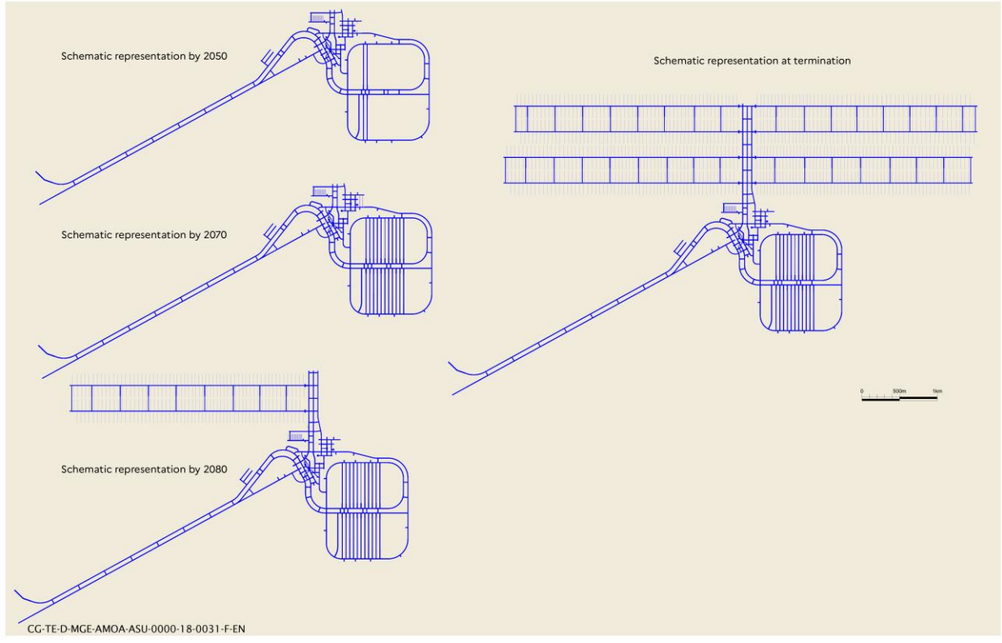


Figure 2-33 *Illustration of the phased development of the underground structures at the Cigéo disposal facility*

The gradual development of the disposal facility and the associated excavation work require the surface area of the management zone for excavated Callovo-Oxfordian spoil (excavated materials deposit area) to be progressively expanded beyond the area prepared during the preliminary works phase. A second section of the Lejuc forest will be cleared and developed following archaeological surveys. Throughout the entire operational period, Callovian-Oxfordian excavated material that will not be reused for the closure of the underground facility at the end of its operational life (deposits of excavated material unused on site) will be shipped out of the Cigéo disposal facility for recycling.

Maintenance operations are carried out throughout the entire operational period. The different types of maintenance are:

- preventive maintenance operations, which ensure equipment availability and include regulatory inspections;
- corrective maintenance operations that restore equipment to working order following a failure. These operations may be performed while the equipment is in operation, preferably during periods when the equipment or resources are not in use.

Maintenance operations are performed outside the operating periods of the equipment concerned, except when intervention is necessary following a failure. They are supplemented by refurbishment operations, which involve major renovation work on a system or a building as a whole. These operations are necessary given the long-term operational lifespan of the Cigéo disposal facility, particularly to address issues of obsolescence or ageing. They primarily concern surface buildings. The design of the buildings prioritises materials and equipment that allow for building renovation in order to limit reconstruction operations.

Where applicable and subject to authorisation, the operational phase will also include partial dismantling of certain surface facilities, sealing of disposal cells, and closure of filled disposal areas.

» OPERATIONS BY OTHER PROJECT OWNERS

All operations by other project owners are carried out during this phase.

Characterisation, environmental monitoring, and environmental measurement tracking activities (drilling, measurements of the natural environment, inventories) are also conducted during the operational phase, both within and outside the boundaries of the Cigéo disposal facility.

2.4.1.4 The decommissioning and closure phase

The decommissioning and closure phase begins upon issuance of the decree authorising the decommissioning of the Cigéo BNI and ends with the decision authorising final closure and transition to the monitoring and surveillance phase. This phase includes operations aimed at the final closure of the repository, which can only be authorised by law.

The closure strategy is outlined in the "Master Plan for Operations" (54), and the procedures for decommissioning, closure, and post-closure monitoring are presented in the "Decommissioning, Closure, and Monitoring and Surveillance Plan" (70), which constitute Documents 16 and 13, respectively, of the creation licence application file of the Cigéo basic nuclear installation.

Works carried out above ground include the dismantling of equipment, the decontamination of premises and soil, and the demolition of civil engineering structures. All hazardous and radioactive substances present in the surface facilities are transported to the appropriate management channels. Buildings and structures that are no longer needed are dismantled and, where necessary, demolished. Surface areas are redeveloped according to the objectives and uses to be defined, based on the challenges at hand, by the year 2150. For example, they may be reforested, returned to agricultural use, or landscaped in a manner suited to the site's topography and environment by that time.

Surface structures necessary for subsequent monitoring and surveillance activities after closure are maintained. The sections of the "memory" building housing the historical archives and memorial installations are preserved during decommissioning operations and are maintained for as long as possible after the decommissioning and closure phase, with no anticipated time limit (*presumably* for several hundred years) as part of the monitoring and surveillance phase of the Cigéo disposal facility.

Underground, to ensure the safety of the waste disposed of over very long periods, the underground structures of the Cigéo disposal facility must be sealed. Indeed, the geological environment is selected and the disposal facility is designed in such a way that, following the final closure of the repository (sealing and backfilling of the shafts and access ramps to the underground facility), safety is ensured passively; that is to say that people and the environment are protected from the radioactive substances and toxic chemicals contained in the radioactive waste, without the need for human intervention.

Preparatory operations for the final closure of the underground parts of the Cigéo disposal facility consist primarily, on the one hand, in dismantling equipment that cannot be left in place and on the other hand, of constructing additional structures to complement the existing geological barrier, designed to ensure the proper functioning of long term disposal (construction of concrete structures, backfilling, placing of seals). The backfilling of the drifts is carried out by reusing Callovian-Oxfordian excavated materials from the excavation work, which have been deposited in the shaft zone.

Once the operations to seal the cells, close the disposal areas, and backfill the drifts in the logistics support zones are completed, the final closure may be initiated, if so decided by Parliament. The final closure consists of permanently sealing and backfilling the shafts and ramps that provide access to the disposal areas. It is currently planned for the year 2150. The application for authorisation to close the facility and transition to the monitoring phase referred to ASNR will not be submitted before the Act authorising the final closure of the Cigéo disposal facility is enacted.

[20] Article L. 542-1 of the French Environment Code states that *"Research and the implementation of the means necessary for the permanent disposal of radioactive waste shall be undertaken in order to prevent or limit the burdens that will be borne by future generations."*

During the decommissioning and closure phase, the operations of other project owners (except for the shipment and transport of radioactive waste) will remain in operation and may be utilised by Andra. The operations of other project owners may continue after the facility's activities cease if they remain useful, particularly for the local area.

Environmental monitoring and follow-up of environmental measurements will also be conducted, both inside and outside the Cigéo disposal facility, during the decommissioning and closure phase.

2.4.1.5 The monitoring and surveillance and post-monitoring and surveillance phases

The monitoring and post-monitoring phases apply only to the Cigéo disposal facility. Following the final closure of the Cigéo disposal facility, the monitoring and surveillance phase begins upon the decision to authorise closure and transition to the monitoring phase for the Cigéo BNI. It ends with the decision to delicence the Cigéo BNI. During this phase, disposal safety is ensured passively. After the delicencing decision, the post-monitoring and surveillance phase begins.

During the monitoring and surveillance phase, the safety of the disposal facility is ensured passively. Only monitoring activities remain, aimed at verifying, through physicochemical measurements, the proper functioning of the disposal facility and compliance with regulatory obligations regarding environmental protection.

As the facility has ceased operations, there is no longer any activity involving the transport of materials and packages. The memory building and its functions will be preserved.

The duration of the monitoring phase will be specified by the authorities. It will span several centuries, as is the case for surface disposal facilities. The delicencing of the Cigéo disposal facility may be considered by the relevant authorities following the approval of the site's monitoring programme. This monitoring and surveillance phase may be subject to specific authorisation procedures, depending on the regulations in effect at that time.

The monitoring and surveillance phase is linked to a period of institutional oversight that includes the maintenance of public easements. Institutional oversight may extend beyond the monitoring and surveillance phase, particularly to help preserve the site's memory after its closure.

Following the decision to delicence the Cigéo BNI, "post-monitoring and surveillance" begins. By definition, it has no end. It corresponds to the time horizon targeted by the objective of the permanent safe disposal of radioactive waste set out in the French Environment Code[20]. It is used in particular in long-term safety assessments. It allows for the characterisation of very long-term radiological and chemical impacts following the facility's delicenceing. The safety assessment assumes the end of all institutional oversight and the loss of memory regarding the existence of the disposal facility. The Cigéo disposal facility is designed so that safety can be guaranteed in a completely passive manner during this phase.

» THE LONG TERM, PASSIVE SAFETY, AND THE MEMORY OF THE CIGÉO DISPOSAL FACILITY

The Cigéo disposal facility is designed to be closed at the end of its operational phase in order to provide lasting protection for people and the environment without requiring any subsequent human intervention. Safety will then be ensured passively.

Passive safety does not in any way imply forgetting the presence of the waste and the facility. On the contrary, the memory of the disposal facility is an element that contributes to the protection of human health and the environment. In particular, it reduces the risk of inadvertent intrusion into the disposal facility, for example through drilling. However, even if drilling were to inadvertently penetrate the disposal facility, the long-term consequences would remain limited given the facility's design.

The memory of the disposal facility's existence, its function, the hazardous nature of the waste it contains, and its design depends on the sustainability of the measures implemented during the archiving of institutional documents and the mechanisms for intergenerational transmission.

Andra is working to develop mechanisms to promote the intergenerational transmission of knowledge about the waste and its disposal site, considering this knowledge to be a collective heritage and a record of what our civilisation has created.

In its Safety Guide No. 1 on the final disposal of radioactive waste in deep geological formations (33), the ASN indicates that the loss of memory regarding the existence of the repository can reasonably be expected to occur more than 500 years after its final closure. In any case, after the final closure of the disposal facility, the protection of human health and the environment must not depend solely on institutional monitoring and control, which cannot be reliably maintained beyond a limited period, even over several centuries.

The Cigéo disposal facility is designed to passively protect people and the environment, even if knowledge of its existence were to fade.

2.4.2 Description of the industrial pilot phase

In addition to the successive deployment phases of the project presented above, a specific development period is planned for the Cigéo repository: the "industrial pilot phase" (or "Phipil").

This industrial pilot phase was introduced into the project by Andra following requests made during the 2013 public debate on the Cigéo disposal facility project. It embodies the cautious approach necessary to construct and gradually commission an industrial facility considered complex, given its depth, its unusual dimensions, and the very long lifespan for which it is designed.

Thus, since 2016, Article L. 542-10-1 of the French Environment Code has set the objectives of the pilot industrial phase. It must enable *"to confirm the reversibility and it's the safety case of the disposal facility, in particular through an in-situ testing programme. All waste packages must remain easily retrievable during this phase. The industrial pilot phase includes waste package retrieval tests*."

In accordance with this objective, the pilot industrial phase is used by Andra to progressively approve the facility's overall operation (particularly atypical industrial equipment, such as the ramp transfer system), its safety, its reversibility, and its monitoring.

Andra proposes that the industrial pilot phase begin upon issuance of the creation licence decree of the Cigéo disposal facility (and thus the start of the initial construction phase), as soon as the first structural decisions related to construction are made:

- initially, it allows Andra to test the installed equipment and planned operations by first conducting "cold" tests, i.e., using "dummy" waste packages;
- in a second phase, after the French Nuclear Safety and Radiation Protection Authority (ASNR) authorises the facility's commissioning, "hot" tests are conducted, that is, using radioactive waste packages. If these are successful, the first disposal operations are initiated.

Based on an assessment of the industrial pilot phase, Parliament will decide on the conditions for continuing the project. The objectives and success criteria for the industrial pilot phase will be set by the French National Plan for Radioactive Materials and Waste Management (PNGMDR)[21]. In 2024, Andra submitted, under the PNGMDR (Action HA MA-VL 6)[22] , a proposal for the objectives and success criteria of the industrial pilot phase (technical component) (56), informed by two dedicated consultation processes conducted in 2021/22 (53) and in 2024 (58).

Authorisation to commission the phase following Phipil will be granted, after review of an application file prepared by Andra, in accordance with Parliament's guidelines:

- if, based on the lessons learnt during the Phipil phase, Parliament decides to proceed with the deployment of the Cigéo disposal facility, a new stage of its deployment may be initiated, following the same approach of gradual implementation and consultation;
- if, based on the lessons learnt during the Phipil phase, Parliament decides to abandon disposal for all or part of the HLW and ILW-LL, then Andra will prepare an application for the decommissioning and total or partial closure of the Cigéo disposal facility, which it will submit to the authorities;
- Given these two options (shutdown or continued nominal operation), there is considerable variability in how the industrial pilot phase may unfold.

As defined, the pilot industrial phase covers the initial construction, commissioning, and the first years of the disposal facility's operational phase. In terms of governance, the Phipil implements an approach aimed at *"ensuring citizen participation throughout the entire* lifecycle" of the Cigéo disposal facility, as required by the French Environment Code (Article L. 542-10-1). This approach is reinforced by the regulatory requirement to produce and update every five years, *"in consultation with all stakeholders and the public*," a Master Plan for Operations (PDE) (Article L. 542-10-1). This collaborative update of the "Master Plan for Operations" (54) is carried out in parallel with periodic reversibility reviews and periodic safety reviews (Article L. 593-18 of the French Environment Code). Following the consultations conducted on the industrial pilot phase in 2021/22 (53) and 2024 (58), Andra also published a report on the governance aspect of the criteria and success objectives for the industrial pilot phase, submitted under the PNGMDR (action HA MA-VL 6)[23] in 2025 (57). Andra has published a summary following the consultation it conducted in 2025 on reversibility reviews to gather the expectations of the public and stakeholders regarding their organisation and objectives (59).

From an environmental impact perspective, the industrial pilot phase does not entail any specific or additional impacts compared to those of the initial construction phase and the operational phase, within which it is temporally situated. In this environmental impact assessment, the industrial pilot phase is therefore not subject to a separate impact assessment. Its impacts are addressed in the impact assessments for the initial construction and operational phases (see Volume IV of this environmental impact assessment).

KEY DECISION-MAKING MILESTONES OF THE INDUSTRIAL PILOT PHASE

The timeline of the industrial pilot phase proposed by Andra is marked by four main decision-making milestones:

- authorisation to establish the Cigéo disposal facility, after which the Phipil phase begins. This authorisation is granted by a government decree following an opinion from the Council of State;
- the commissioning license, issued by the ASNR, which authorises the reception of waste packages at the disposal facility and their disposal;
- the Act passed by Parliament that establishes the conditions for continuing disposal and may modify the conditions for its reversibility;
- authorisation for the next phase of disposal operations, regardless of its nature.

[21] Article 8 of the decision of February 21, 2020, by the Minister for Ecological and Solidarity Transition and the President of the Nuclear Safety Authority following the public debate in preparation for the fifth edition of the French National Plan for the Management of Radioactive Materials and Waste (71), which states: *"The PNGMDR will specify the conditions for implementing the reversibility of disposal, particularly regarding the retrievability of packages, the decision-making milestones of the Cigéo project, and the governance framework to be implemented in order to be able to re-evaluate the choices made*."

[22] Article 36 of the Order of December 9, 2022, issued pursuant to Decree No. 2022-1547 of December 9, 2022, as provided for in Article L. 542-1-2 of the French Environment Code, and establishing the requirements of the French National Plan for the Management of Radioactive Materials and Waste (55).

[23] Article 36 of the Order of December 9, 2022, issued pursuant to Decree No. 2022-1547 of December 9, 2022, as provided for in Article L. 542-1-2 of the French Environment Code, and establishing the requirements of the French National Plan for the Management of Radioactive Materials and Waste (55).

2.4.3 The reversibility of disposal

2.4.3.1 The ethical concern regarding reversibility

The ethical concern regarding reversibility stems from the timescale involved in the management of high-level (HLW) and intermediate-level long-lived (ILW-LL) radioactive waste. The facilities of a deep geological repository are deployed gradually, in successive stages, over a period exceeding a century, given the existing quantities of HLW and ILW-LL, those yet to be produced by the foreseeable operation of current nuclear facilities, and the physical characteristics of this waste.

Approximately five successive generations are expected to operate the Cigéo disposal facility. It is the responsibility of the current generation—which benefits from nuclear activities (national defence, nuclear power, research), to design and pass down to these following generations a safe facility that they will be able to modify and improve according to their own objectives, knowledge and constraints, or even to supplement or replace it with other waste management facilities, should other options emerge, particularly in connection with technical progress. This approach leaves ample room for considering studies and research on other waste management pathways, as well as technological advances that could be applied to the facilities of the Cigéo disposal facility itself.

The current generation therefore has a duty to launch the disposal facility project, which will ultimately enable the permanent and safe disposal of high-level (HLW) and intermediate-level long-lived (ILW-LL) waste, without, however, locking future generations into choices made at the project's inception. It is with this in mind that Andra is developing the Cigéo disposal facility to make it a reversible disposal facility.

2.4.3.2 The legal definition of reversibility

Article L. 542-10-1 of the French Environment Code states that *"reversibility is the ability of future generations either to continue the construction and subsequent operation of successive phases of a disposal facility, or to reassess previously made decisions and adapt management solutions"*. Reversibility is achieved *"through the phased nature of construction, the adaptability of the design, and the operational flexibility of a deep geological repository for radioactive waste, enabling the integration of technological progress and adaptation to possible changes in the waste inventory resulting, in particular, from shifts in energy policy"*. Reversibility includes *"the possibility of retrieving waste packages already emplaced under conditions and for a duration consistent with the disposal facility's operation and closure strategy"*. This definition of reversibility is consistent with the 2011 European Directive (16), which states that "reversibility and retrievability, as elements of operation and design, may serve to guide the technical development of a disposal system".

The French Environment Code requires that deep geological disposal be carried out *"in an underground facility specially designed for this purpose, in accordance with the principle of reversibility"* (Article L. 542-1-1). The disposal facility's ability to evolve in the future to support and facilitate decisions regarding radioactive waste management will therefore be subject to technical review during the examination of the licence application for the Cigéo disposal facility (DAC) and will constitute, along with safety and environmental impact, one of the fundamental conditions for the issuance of this authorisation.

2.4.3.3 Integrating reversibility into the design of the disposal facility

The Cigéo disposal facility is designed to offer future generations choices regarding the management of high-level and intermediate-level long-lived radioactive waste and to avoid locking them into design choices made at the project's inception.

The disposal of radioactive waste in deep geological formations is carried out *"in accordance with the principle of reversibility*[24] ."

From a technical point of view, reversibility is organised around the following four key aspects:

- the gradual construction of the disposal facility, which involves a cautious sequence of construction operations and the successive commissioning of parts of the facility throughout its operational lifespan. This primarily allows for accelerating, delaying or modifying the order of construction and commissioning of these extensions. It offers future generations the possibility of adapting the structures that will be built during the disposal facility's operational phase to potential changes in inventory;
- the operational flexibility of the disposal facility, which corresponds to its ability, once constructed, to accommodate variations in its operational schedule (schedule for receiving packages, reception flows, dates for sealing disposal cells or areas) without modifying existing infrastructure or equipment and without constructing new structures. It offers future generations the possibility of shifting or accelerating (within certain limits) the flow of received waste packages and of emplacing packages in a range of varying shapes, dimensions and masses;
- the adaptability of the disposal facility's installations, which refers to the ability to modify them to account for new design assumptions. Subject to prior authorisations, this primarily allows the disposal facility to be adapted to potential changes in the waste inventory for which it was designed. Depending on the volumes and types of waste involved, their disposal would present different technical challenges for the Cigéo disposal facility, ranging from simple adjustments to its design and operation to significant modifications to its architecture. As a precaution, Andra has been studying the feasibility of emplacing a portion of LLW-LL waste and spent fuel in the Callovian-Oxfordian clay formation since the early stages of the project in the 2000s;
- retrievability refers to the ability to remove packages from the disposal facility after they have been emplaced there. The Cigéo disposal facility is designed so that, throughout the entire period from its commissioning to its permanent closure, the emplaced packages can be retrieved. The retrieval process proceeds in reverse order, from the disposal cell to the surface. The Cigéo repository thus offers future generations, for more than 100 years, functions analogous to those of a centralised disposal facility (monitoring, potential retrieval, potential re-shipping). Retrieving from disposal waste packages that were initially stored there without the intention of a later retrieval implies a reorientation of the initial decision. The implementation of retrievability would therefore be linked to the emergence of a purpose offering an advantage over the initial decision, including in terms of safety, during operation or after closure. It can therefore only be exercised in conjunction with other decisions made within the framework of the overall management of radioactive waste.

The Cigéo disposal facility is designed to offer future generations choices regarding the management of HLW and ILW-LL and to avoid locking them into design choices made at the project's inception.

The disposal of radioactive waste in deep geological formations is carried out *"in accordance with the principle of reversibility*[25] ."

The French Environment Code states that reversibility reviews must be conducted every 5 years (Article L. 542-10-1). A multi-stakeholder consultation (72) was conducted in 2025 by Andra to better define their role, their deliverables and their coordination with waste management decisions. The summary of this consultation was published in February 2026 (59).

REVERSIBILITY IN ASN GUIDE NO. 1 OF 2008

The ASN's 2008 safety guide (33) on the final disposal of radioactive waste in deep geological formations states that:

- *"Reversibility of disposal requires appropriate operational resources, as well as means for monitoring the* facility";
- *"Measures taken to ensure the reversibility of disposal must not compromise the operational safety and post-closure safety of the disposal facility.*"

[24] Pursuant to Article L. 542-1-1 of the French Environment Code

[25] Pursuant to Article L. 542-1-1 of the French Environment Code

2.5 The main works and their implementation procedures

2.5.1 Work during the preliminary development phase

2.5.1.1 Work related to the Cigéo disposal facility

Work carried out within the Cigéo disposal facility's perimeter during the preliminary development phase will be conducted over a period of 5 to 7 years.

The purpose of this work is to prepare the sites for the Cigéo disposal facility prior to the start of construction work on the buildings and structures.

The main works performed both for the ramp zone and the shaft zone consist of:

- securing the sites (installation of perimeter security fencing, access gates and guard posts);
- developing and organising the sites to accommodate the first construction contractors, including:
  - ✓ laying the internal utility networks (water, electricity, telecommunications) required for the construction site facilities and connecting them to external networks;
  - ✓ constructing temporary construction access roads.
- installing water management infrastructure, namely:
  - ✓ basins and stormwater drainage structures during the first years of construction prior to the commissioning of the permanent facilities;
  - ✓ sewage treatment facilities for the construction site, pending the commissioning of the permanent facilities planned for the operation of the Cigéo disposal facility.
- levelling the platforms necessary for utility service (water, electricity, telecommunications), then gradually all surface areas (ramp zone, shaft zone, inter-site link, connected terminal);
- constructing certain surface support structures and facilities, including, for example:
  - ✓ on the utility service platforms, the conventional industrial waste disposal facility, and the 90/20 kV substation and distribution stations;
  - ✓ in the ramp zone, the rail terminal to subsequently enable the transport of materials, equipment and various supplies by rail;
  - ✓ the parking lots required during the early stages of the initial construction phase.

During this phase, geotechnical, hydrogeological, geological and seismic investigation campaigns are conducted.

In addition to these works in common, the work carried out specifically in the ramp zone during the preliminary development phase also includes the performance of voluntary supplementary archaeological surveys and archaeological excavations conducted as part of the first environmental characterisation and monitoring operations—referred to as DR0—prescribed following the archaeological surveys conducted by INRAP in 2015-2016 (73, 74).

In addition to the works in common, the work carried out specifically in the shaft zone during the preliminary development phase also includes:

- the conduct of archaeological surveys and any resulting preventive excavations in the event of the discovery of remains of interest;
- initial clearing operations corresponding to the footprint of the surface facilities in the shaft zone and the first management zone for excavated Callovo-Oxfordian deposits, including:
  - ✓ clearing of the forested area (felling, delimbing and skidding);
  - ✓ stump removal followed by stump grinding (temporary storage of the ground material for later reuse).
- the preparation of the first platform for managing excavated Callovo-Oxfordian deposits, to handle excavated materials from the initial construction phase (it will be expanded later in conjunction with the gradual extension of the underground facility).

In terms of work procedures, the following scenarios are considered at this stage of the studies:

- For the ramp zone and the shaft zone, two main methods of earthwork are considered, following the removal of topsoil using a scraper, excavator and loader or trax:
  - ✓ the surface layers (clay and limestone gravel) and the highly fractured, fractured and sound limestone are extracted using traditional methods, in bulk, with excavators and dump trucks, loaded directly or *via* a wheel loader, as well as a bulldozer (for the slopes);
  - ✓ the hard layers (limestone) are extracted using high-powered excavators, supplemented by a secondary operation involving breaking (fragmenting large blocks followed by crushing) or blasting (longwall blasting or pre-cutting blasts requiring the use of explosives).
- For the ramp zone:
  - ✓ A plant for producing the asphalt mix needed to waterproof the roadways is set up during the preliminary work; it is then kept in operation until the end of the initial construction phase.

Screening and crushing are necessary before backfilling with materials, in order to reduce the coarsest fractions of the extracted materials. To this end, mobile crushers may be installed as soon as earthworks begin (in the ramp zone and the shaft zone); they are used in conjunction with excavators and wheel loaders, which are necessary for their operation.

In the work zones, material storage areas are planned during the preliminary development phase; materials are transported there by dump trucks after being loaded using excavators.

Work carried out during the preliminary development phase at the Cigéo disposal facility also includes the construction of the inter-site link and the connected terminal. However, this work is on a smaller scale than that carried out in the ramp zone and the shaft zone.

Some of the work, which will have begun during the preliminary development phase, will be completed during the initial construction phase, particularly the earthwork for the platforms.

To carry out these operations, temporary construction facilities specific to the preliminary development phase are set up.

2.5.1.2 Work outside the Cigéo disposal facility

Other work related to the Cigéo overall project is carried out during the preliminary development phase, outside the boundaries of the Cigéo disposal facility.

These works relate to:

- the power supply operation (see Chapter 2.3.2.1 of this non-technical summary), notably:
  - ✓ construction of temporary access roads to the pylons;
  - ✓ work to secure the metal structures of the pylons;
  - ✓ work to reinforce the foundations of certain pylons;
  - ✓ work to replace pylon supports;
  - ✓ replacement of the current ground wire with an optical ground wire;
  - ✓ connection of the 400 kV substation, built for the Cigéo disposal facility, to the 400 kV transmission line;
  - ✓ construction of the 400 kV substation, built for the disposal facility, and its underground power lines.
- the drinking water supply project (see Chapter 2.3.2.2 of this non-technical summary):
  - ✓ water supply works by the Échenay Water Syndicate;
  - ✓ supply works by the Haut-Ornain Water Syndicate.

- the upgrading of the 027000 railway line between Nançois-Tronville and Gondrecourt-le-Château, also known as the 027000 line modernisation project (see Chapter 2.3.2.3 of this non-technical summary);
- the deviation project of the D60/960 departmental road (see Chapter 2.3.2.4 of this non-technical summary).

Work necessary for environmental characterisation, environmental monitoring and the follow-up of environmental measures—including drilling, environmental measurements in the natural environment and ecological inventories—is also carried out (see Chapter 2.3.2.6 of this non-technical summary).

2.5.1.3 The first environmental characterisation and monitoring operations, known as “DR0 operations”

The first environmental characterisation and monitoring operations, known as “DR0 operations”, were the subject of an application for environmental and urban planning permits, with the relevant documents submitted on March 6, 2024. Following review by government agencies and a public hearing, they were authorised in July 2025. The file submitted during the public inquiry is available in French on the Andra website[26] .

These operations are themselves part of a broader set of activities known as “environmental characterisation and monitoring operations”. These operations are divided into work phases, each of which will be subject to the necessary permit applications under the legislation applicable to the work in question.

The DR0 operations include:

- preventive archaeology operations (surveys and excavations) spread across several areas;
- geological, hydrogeological (groundwater study) and geotechnical (soil study for construction purposes) investigations;
- the development of storage areas and field camps for the various works.

The purpose of the DR0 operations is to provide additional information on the characterisation and monitoring of the environment of the Cigéo overall project from geological, geotechnical, hydrogeological, and heritage perspectives, in order to refine and strengthen the project design and comply with the provisions of the French Heritage Code regarding preventive archaeology. The DR0 operations are described in detail in “Document DAE1 – General Section” (75) of the previous environmental and urban planning authorisation application available in French on the Andra website[27] .

This is the first phase of work to be carried out on-site, preceding future phases of work that will involve different activities (clearing, earthworks, site development, etc.).

2.5.2 Work during the initial construction phase

2.5.2.1 Work related to the Cigéo disposal facility

The main work carried out during the initial construction phase consists of building the structures and facilities necessary for the commissioning of the Cigéo basic nuclear installation (the reception of the first shipments of radioactive waste).

This includes the construction of surface facilities and the excavation of the first underground structures.

The main structures built and equipped during this phase are:

- the facility for receiving and preparing radioactive waste packages in the ramp zone (surface nuclear building EP1) and all other surface buildings related to the operation of the Cigéo basic nuclear installation;
- the surface-underground connections (ramps and shafts) and the underground logistics support areas;
- the underground structures in the high-level waste (HLW) pilot area and the first structures in the long-lived intermediate-level waste (ILW-LL) disposal area;
- the groundwater rise protection structure designed to protect, in particular, the EP1 surface nuclear building and the nuclear rail terminal from rising groundwater.

[26] https://www.andra.fr/cigeo/les-documents-de-reference (2).

To carry out these operations, temporary construction facilities are set up. They are deployed in two phases:

- the first phase involves managing access (parking lots and service roads), setting up base camps (offices), and establishing the first temporary equipment yards;
- the second phase involves the installation of industrial facilities (concrete batching plants, crushers, asphalt mixing plants, prefabrication areas for structural elements, maintenance, storage, equipment servicing, and cleaning areas, as well as lifting equipment and job site lighting).

At the end of the construction projects, the areas housing the temporary construction facilities will be restored to their original condition.

Like the preliminary work, the initial construction may involve geotechnical investigations.

At the time of this update to the environmental impact assessment, the specific methods for carrying out this work have not been finalised, as they will be determined by the contractors selected to perform the work.

2.5.3 Work during the operational phase

A preventive maintenance programme (appropriate periodic inspections and tests) is implemented to ensure that the expected functional characteristics of the structures and equipment are maintained over time. A renewal (replacement) programme is defined at intervals appropriate to the equipment and structures to anticipate their ageing and/or obsolescence.

Potential demolition/construction work on surface buildings and structures may be necessary, including:

- construction of the horizontal unloading transport container reception building (ETH surface nuclear building - *Ouvrage de déchargement des emballages de transport à déchargement horizontal*);
- construction of the EP2 surface nuclear building;
- demolition and construction of certain surface buildings and structures.

Furthermore, during the operational phase, work to expand the underground structures is carried out:

- excavation of additional ILW-LL cells;
- progressive excavation of the HLW disposal area.

The work to progressively expand the underground facility, in successive phases, is organised according to future needs and the issuance of the associated permits.

The Callovian-Oxfordian rock excavated during the initial construction phase is managed as the underground facility is progressively deployed. The procedures for managing excavated materials will be extended to the operational phase.

During the operational phase, the excavated material stream includes:

- excavated material, associated with the construction of the ILW-LL blocks and HLW disposal structures, which is transported to the deposits area in the shaft zone *via* an underground conveyor dedicated to excavated argillite;
- closure material, used for the closure of the HLW pilot area and subsequently the closure of the ILW-LL disposal area, which is transported via the surface conveyor to the ramp zone and then down the service ramp.

The total area of the platforms in the excavated materials deposit zone and the platforms for soil storage and flow management, including water management basins, is approximately 108 ha (Z1 and Z2). The total volume of Callovian-Oxfordian material deposited or transiting through these platforms is approximately 11 million m³.

A third zone (Z3), covering approximately 39 hectares, could be considered for the final expansion of disposal facilities by 2070–2080, should the availability of external recycling channels be called into question.

[27] https://www.andra.fr/cigeo/les-documents-de-reference

2.5.4 Work during the decommissioning and closure phase

At the end of the operational phase, all facilities at the Cigéo disposal facility will be permanently shut down and decommissioned. The underground facility will also be gradually closed.

The decommissioning and closure phase begins upon issuance of the decree authorising the decommissioning of the Cigéo disposal facility's nuclear installation and ends with the decision authorising closure and transition to the monitoring phase.

The purpose of the decommissioning phase is to remove all hazardous or radioactive substances from the Cigéo disposal facility and to cut up and dismantle the equipment. This is followed by a phase involving the demolition of surface facilities, roads, and utility networks, etc., that are not necessary for subsequent post-closure monitoring activities or for preserving the site's memory.

Dismantling operations mainly comprise two types of activities:

- the decommissioning of activated or contaminated equipment (equipment located in areas where nuclear waste may be produced (ZppDN[28]) and the management of the corresponding waste streams (collection, radiological measurements, sorting, treatment, and packaging for disposal at appropriate facilities);
- the remediation of activated or contaminated concrete structures. The objectives of this phase, for each site, are the final remediation of the site in question with a view to decommissioning the premises as a non-regulated zone with conventional waste zoning, and the disposal of waste generated during remediation operations.

With regard to the demolition of surface buildings, this involves demolishing:

- civil engineering and finishing work: cell linings, portholes, metal hatches, reinforced doors, staircases, support structures, access doors, rails…;
- any handling equipment retained for demolition purposes;
- utility networks: electrical systems, fluid and utility networks, and, where applicable, underground networks;
- nuclear ventilation.

Equipment currently commonly used for decommissioning operations includes excavators, hydraulic rock breakers, hydraulic jackhammers, concrete shears, and hydraulic demolition and sorting grapples.

The technologies used for decommissioning will likely have evolved by the time dismantling is authorised following the operational phase.

The main operations for closing the underground facility are the sealing of the ILW-LL cells and closure of the ILW-LL disposal area, the backfilling of the HLW access drift, the operating and construction logistics support areas, and the surface-underground connections.

The impact assessment takes into account the project's evolution over time and its various phases, *i.e.,* the preliminary development, initial construction, and operational phases. For the periods corresponding to the decommissioning of the facilities and the post-closure phase, which will not occur for several decades (long-term operating period), the main expected impacts are presented separately (see Chapter 3.17 of this non-technical summary).

[28] "Areas with potential nuclear waste generation" (ZppDN) are areas where contaminated, activated, or potentially contaminated waste is produced. Waste produced in these areas must be subject to specific and enhanced management within dedicated, authorized waste management systems.

2.6 Estimation of resource consumption and expected emissions and residues

2.6.1 Resource consumption

The main energy sources used for the Cigéo overall project are:

- hydrocarbons during the preliminary development phase, with consumption of 1,000 to 4,000 m³/year for equipment operation;
- electricity for the operation of disposal facility equipment (drilling tools, ramp transfer system, material-handling equipment, fans, etc.), with an estimated maximum consumption of approximately 200 GWh/year and a projected power requirement that evolves across the three successive phases—"pre-development", "initial construction", and "operation"—with:
  - ✓ a peak power of approximately 80 to 90 MVA during the preliminary development and initial construction phases;
  - ✓ a power requirement of approximately 45 to 60 MVA during the operation phase.

2.6.2 Expected emissions and residues

2.6.2.1 Excavated soil and materials

Approximately 12.5 million cubic metres of excavated material are generated during the preliminary development, initial construction, and operation phases of the Cigéo repository. To avoid the need to import soil from outside sources, the spatial layout of the Cigéo repository takes into account the existing topography and maximises the reuse of excavated soil.

The volumes of Callovian-Oxfordian rock extracted during the excavation of the underground facility amount to approximately 11 million cubic metres produced over more than 100 years. About 40% will be reused for backfilling the underground facility upon its final closure. Reuse solutions are being sought for the remaining 60%.

2.6.2.2 Air Emissions

Air emissions during the preliminary construction phase are primarily caused by earthwork operations carried out at the Cigéo repository. The pollutants emitted will consist of dust and combustion gases (nitrogen dioxide, carbon monoxide, hydrocarbons, particularly volatile organic compounds, etc.).

During the initial construction phase, most of the earthworks have been completed; emissions are therefore mainly linked to construction vehicle traffic and the excavation of surface-underground connections currently underway.

During the operational phase, the main sources of emissions are external traffic (inter-site and off-site connections) and emissions from surface facilities and the underground facility, including radionuclides (tritium, carbon-14 and krypton-85) in gaseous or particulate form. These releases are very low and have no impact on the environment or human health.

2.6.2.3 Liquid emissions

Conventional liquid effluents are produced primarily by the Cigéo disposal facility within the Cigéo overall project. The drinking water requirements during the preliminary development phase and the liquid effluents produced by other operations of the Cigéo overall project are very low in volume compared to those emitted by the Cigéo disposal facility.

The Cigéo disposal facility implements, starting from the initial construction phase, a treatment system tailored to the nature of the water in question (wastewater and industrial surface and groundwater), followed by its recycling. This both reduces the Cigéo disposal facility's consumption of drinking water and ensures the supply of non-potable water for certain uses at the Cigéo disposal facility (irrigation, equipment washing, tunnel boring machine operations, etc.). The surplus is returned to the natural environment via storage basins that regulate the discharge flow rates to ensure that downstream flood risks are not exacerbated.

The Cigéo disposal facility is designed to discharge no unconventional liquid effluent; that is, no water produced in certain areas of the nuclear facility known as "areas with potential nuclear waste generation" is discharged.

2.6.2.4 Emissions into the soil and subsoil

No liquid emissions into the soil and subsoil are expected during normal operation of the facilities, particularly since no water infiltration or sludge spreading is carried out as part of the project. Atmospheric emissions do not result in deposits likely to pollute the soil or subsoil.

The only potential emissions would be related to accidental soil contamination. Preventive measures are implemented, particularly at construction sites and in storage areas for polluting products, to prevent this type of emission, such as the use of retention tanks, double-shell tanks, and spill containment kits.

2.6.2.5 Emissions that may affect the living environment

The Cigéo disposal facility and, to a lesser extent, the operations of other project owners generate emissions of noise, vibrations, odours, light, and electric and magnetic fields. These noise emissions and vibrations are most significant during the construction phase, particularly during initial construction. Light emissions are lower during the preliminary development phase compared to other phases. Local residents will be affected only by light and noise emissions, with the latter complying with regulatory thresholds for the various operations of the Cigéo overall project.

The power supply facilities are designed and operated in accordance with regulations. The presence of an outer coaxial metal shield connected to ground on the 90-kV underground cables significantly reduces electric and magnetic fields. Given the 500-metre depth of the Cigéo disposal facility and the power sources used, the magnetic field generated at the surface is in fact very weak, particularly when compared to the natural magnetic field or that generated by surface power sources.

2.6.2.6 Ionising radiation

To be transported on public roads, radioactive waste is conditioned (solidified and, where necessary, immobilised in a non-dispersible form) and placed in a container, then packed in transport containers appropriate to its hazard level and transport conditions. For the Cigéo overall project, rail transport is the preferred mode of transport.

To ensure the public's radiation protection, regulations on the transport of hazardous materials impose limits on the dose rate: 2 mSv/h at the vehicle walls, 0.1 mSv/h at a distance of 2 metres from the vehicle walls. If these limits are reached, this means that a person can remain 2 metres from the vehicle for 10 hours before reaching the annual dose limit for the public of 1 mSv.

Packaging and means of transport on public roads are designed to meet protection criteria against ionising radiation; in particular, contamination of accessible surfaces of the transport packaging and the means of transport must not exceed 4 Bq/cm² for beta- and gamma-emitting radioactive elements and 0.4 Bq/cm² for alpha-emitting radioactive materials.

The design of the packaging ensures compliance with these thresholds, thereby limiting the exposure of workers and the public, even during prolonged proximity.

2.6.2.7 Waste

The estimated quantity of conventional waste is in the range of several hundred tons spread over five years during preliminary work and 250,000 tons during initial construction. The first phase of site clearing is expected to generate 20 000 m³ to 25,000 m³ of wood waste. During the operational phase, the production of various types of waste (excluding waste from plant renewal and excess soil) is estimated at 5,100 tons per year.

This consists mainly of inert waste and, to a lesser extent, non-hazardous and hazardous waste. Priority is given to recovery, and local waste management channels are favoured.

Radioactive waste is produced during the operational phase of the Cigéo repository. This consists of very low-level, low-level and medium-level waste, primarily short-lived, which is sent to authorised disposal channels. The quantities have been estimated at a maximum of 40 tons per year of very low-level solid waste, one ton per year of low- or intermediate-level solid waste—primarily short-lived—and approximately 90 tons per year of non-conventional liquid effluents from the first decades of the BNI's operation through 2080.

The decommissioning and closure of the facilities, primarily the demolition of surface buildings, generates a significant amount of materials (mainly civil engineering concrete rubble and metal waste) and equipment.

The decommissioning of the surface facility premises that housed radioactive waste packages results in the generation of radioactive waste (removal of a few millimetres of civil engineering concrete, equipment used to handle radioactive waste packages, etc.). Equipment and areas through which radioactive waste packages have been transported may be superficially contaminated. This waste may range from very low to medium activity.

This decommissioning and closure phase generates a significant amount of waste, estimated at this stage to be around 1.5 million tons, including 8,000 tons of radioactive waste.

3

Initial state of the environment, main impacts of the Cigéo overall project, associated measures, and methods

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3.1 Methods

3.1.1 The general method

For clarity, this third section provides, for each environmental factor:

- a summary of the baseline conditions;
- a summary of the impacts of the Cigéo overall project on this factor and the planned avoidance, reduction, and compensation measures, as well as methodological details.

3.1.1.1 Initial state

The impact of a project on its environment is assessed by considering its effects relative to the situation as it exists prior to the project's implementation. The environmental impact assessment therefore includes a description of the relevant aspects of the initial state at the planning stage and their evolution should the project be implemented.

» ENVIRONMENTAL ISSUE

The environmental issue is the intrinsic environmental value assigned to the various affected environments (human, physical, ecological, etc.) based on their current state and their dynamics of change, including both natural evolution and changes resulting from external pressures.

This environmental issue also depends on society's interest in the various environmental factors, based on the benefits and resources extracted from said environment and the issues it associates with them (climate change, biodiversity, health, etc.). The environmental issue of the territory or habitat is independent of the project. Within a territory, areas with different environmental issue can be identified.

The analysis of the initial state of the environment involves assessing the existing conditions and the overall dynamics of the territory where the Cigéo project is to be implemented. The initial state addresses all environmental themes and factors, to provide the necessary and sufficient data for evaluating the project's environmental impacts.

The baseline assessment is based on existing knowledge, bibliographic references, and field investigations.

The data collected and the studies conducted make it possible to describe, and even quantify, the state of the environment for the specific environmental factor under study and, where possible, to assess its evolving dynamics in order to highlight the territorial challenges.

The environmental issues have been prioritised. The scale of values used in this environmental impact assessment comprises five levels, as presented below. The more a factor generates significant societal interest, the greater its importance. The presence of a high-quality environment or a significant resource constitutes a moderate to high-level issue. Very high-level issues stem from the presence of elements that are highly exceptional and rare on the planet.

Very High-Level Issues
High-level issues
Moderate issues
Low level issues
Very low level issues

3.1.1.2 Impacts and measures

The impact assessment for the Cigéo overall project incorporates the ARC sequence "Avoid, Reduce, Compensate": depending on the identified impact levels, measures are proposed that first aim to avoid these impacts during the design phase or, otherwise, reduce them during the design phase or through specific construction methods.

Impact levels are assessed by considering the direct, indirect, temporary, or permanent effects induced during the project's life cycle phases and the impacts associated with the relevant environmental factors. When residual impacts remain that could not be avoided or sufficiently reduced, compensation measures are implemented if possible, particularly to meet the goal of zero biodiversity loss.

The impact assessment takes into account the project's evolution over time and its various life cycle phases: the preliminary development, initial construction, and operational phases. For the decommissioning and post-closure phases, which will not occur before several decades (secular operational period), the main expected impacts are presented separately in chapter 3.17 of this non-technical summary.

The impact assessment depends on the phenomena directly related to the nature of the operations under consideration (emissions, land use, etc.), as well as their magnitude, duration, and the stakes associated with the various environmental factors.

The characterisation of the following impact levels "very high," "high," "moderate," "low," "very low," or "positive" on the various factors is based on the assessment criteria presented in the table 3-1. Given the specific characteristics of the environment, certain impacts of the Cigéo overall project may have a positive or negative effect.

The various assessment criteria for impact levels are summarised in the table 3-1 and are used as a "guiding principle" to assess the level of impact.

Table 3-1 Factors for assessing the level of impact (indicative guidance grid)

Level of impact	Assessment criteria
Positive	Direct or indirect improvement of the factor through the implementation of the project
Very low	No effect No or only marginal alteration of an environmental factor
Low	Slight alteration of an environmental factor that does not affect its functions Effect barely noticeable over a small geographic area and for a limited or one-time duration
Moderate	Perceptible change in an environmental factor that is localised or limited in time Significant disruption or degradation of factors of low importance
High	Significant change in an environmental factor over a long period or permanently Significant disturbance or degradation of factors of moderate to high importance
Very high	Very significant change in an environmental factor over a long period or permanently Destruction of an environmental factor of high significance or degradation of an environmental factor of very high significance

The French Environment Code does not provide a definition of what constitutes a significant impact, as addressed in Article R. 122-5, which sets forth the content of an environmental impact assessment. Therefore, on a five-level scale of negative impacts, this environmental impact assessment has chosen to consider the three highest negative levels (moderate, high, and very high) corresponding to significant negative impacts.

THE AVOID/REDUCE/COMPENSATE SEQUENCE

The **"Avoid, Reduce, Compensate" sequence,** known as the ARC sequence, was introduced into the methodology of environmental studies as early as the 1990s. Gradually incorporated into the French Environment Code, the ARC sequence has been integrated into regulations and applied across the board to environmental procedures.

It guides project leaders to identify and implement measures aimed at avoiding adverse impacts (negative effects) on the environment and human health, reducing those that could not be sufficiently avoided, and, if necessary and where possible, offsetting significant negative impacts that could not be avoided or sufficiently reduced, as presented on the figure 3-1.

Article L. 110-1 II 2° of the French Environment Code states that the principle of preventive action and correction, of environmental damage is to be primarily dealt with at the source and *"must aim for a net zero loss of biodiversity, or even strive towards a gain in biodiversity*." This principle is reiterated in Article L. 163-1 of the French Environment Code, which specifies that *"Measures to compensate for damage to biodiversity aim for a net zero loss, or even a gain in biodiversity*."

Avoidance measures aim to eliminate negative effects on the environment or human health. They involve either planning decision that prevents the impact from occurring in the first place by preserving critical areas, or changes in technological choices or implementation timelines that completely eliminate these impacts.

Reduction measures are defined when impacts cannot be completely avoided during the project's design phase. They aim to reduce the project's permanent or temporary negative effects on the environment and human health during its construction or operational phases. They may work by reducing either the duration of the impact, its intensity or a combination of these factors.

The definition of **residual impacts** aims to identify the specific impacts of the Cigéo overall project that could not be avoided or reduced; it specifies the level of impact according to the assessment grid of the table 3-1 and then concludes on the potential need for compensation measures.

The purpose of **compensation measures** is to provide a counterbalance to the significant residual negative impacts of the project that could neither be avoided nor sufficiently reduced, in accordance with the regulatory objectives established for each factor. They are implemented primarily on or near the damaged site to ensure its long-term functionality. They must make it possible to maintain, and if possible, improve the overall environmental quality of the habitats.

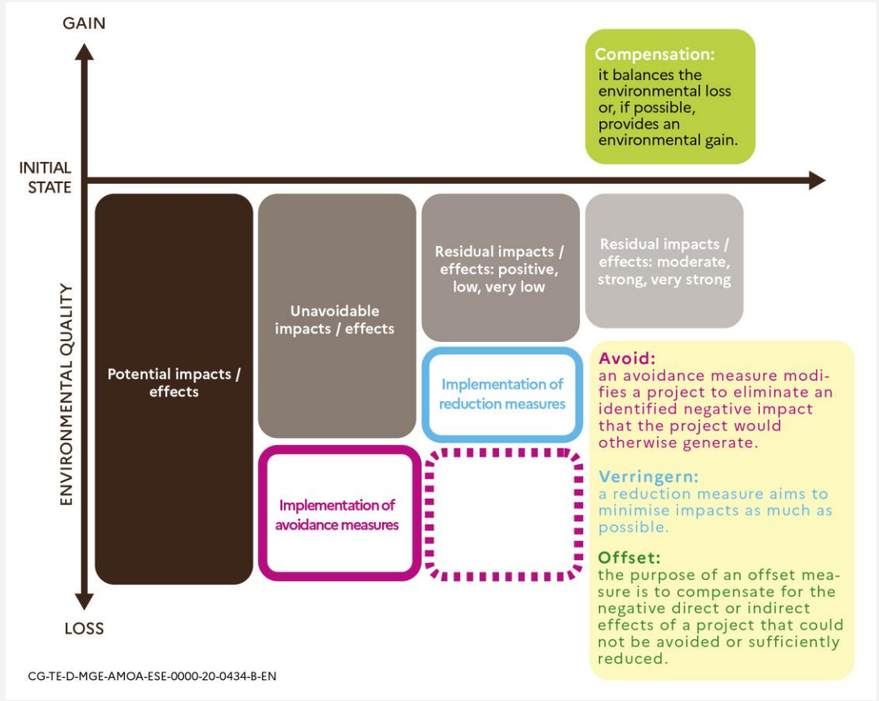


Figure 3-1 Avoid-Reduce-Compensate Approach

3.1.2 Definition of study areas

The characterisation of the initial state of the environment, the assessment of its likely evolution in the absence of the project, and the evaluation of the project's impacts are carried out across various study areas, within which environmental factors are likely to be affected by the project in a positive or negative manner, directly or indirectly, temporarily or permanently, cumulatively where applicable, and in the short, medium, and long term.

The study areas have been defined for each factor in accordance with the principle of proportionality between the content of the environmental impact assessment on the one hand and the environmental sensitivity of the area likely to be affected by the project, the scale and nature of the works, facilities, and structures, and their foreseeable impacts on the environment or human health on the other hand. The study area is the zone from which information is gathered to identify any significant impacts. It is within this area that the location of the zone likely to be affected by the project is specified.

Three categories of study areas are defined based on the types of potential effects considered:

- **The immediate study area** corresponds to the geographic zone used to assess the direct impacts of the footprints of the structures and facilities of the Cigéo overall project, as well as major disturbances related to construction work and activities (see Figure 3-2).

  An immediate study area (under this specific terminology) is common to many environmental factors; it extends up to 500 metres on either side of the potential intervention zone of the Cigéo disposal facility and the operations of other project owners within the overall project whose locations or alternative locations are known.

  It thus includes the potential construction and operational zones of the Cigéo disposal facility and the following: power supply alternatives aside of the works to secure the 400 kV Houdreville-Méry power line and the construction of the 400/90 kV substation (see the specific section concerning this power line below), the revamping of the 027000 railway line and the deviation options of the D60/960 departmental road, as well as the environmental characterisation and monitoring operations.

  Immediate study areas are specific to certain themes and have a scope distinct from that presented previously—the name of the theme is then associated with the name of the immediate study area—this concerns biodiversity and agricultural and forestry activities. They are specified at the beginning of the dedicated theme chapter and/or in Volume VII;

- **The close study area,** which varies depending on environmental factors, corresponds to an expansion of the immediate study area that is better suited to assessing certain project impacts or operations that are not yet well defined.

  For example, this study area includes elements related to water supply for the water factor or factors related to the human environment;

- **The extended study area,** which varies depending on environmental factors, corresponds to the zone that allows for the assessment of all potential or remote direct and indirect secondary effects of the Cigéo overall project. This study area was defined by taking into account all potential impacts that the facilities, structures, construction works and activities could have, based on the current available knowledge. The extended study area encompasses the near and immediate study areas.

The application of this typology to each factor is described and justified in the following chapters. The study areas for each factor are defined in proportion to the significance of those factors and the potential impacts of the various operations of the Cigéo overall project for each factor.

A **specific study area** has also been defined for the works needed to secure the 400 kV transmission line, which extends 124 km from east to west. For many factors, this area lies well outside the area likely to be affected by the rest of the Cigéo overall project. For other factors, the sufficiently large extended study area includes the work to secure the 400 kV transmission line.

No potential impacts are anticipated outside of France, whether during normal operations or in the event of an accident. Thus, the Cigéo overall project is not likely to have transboundary impacts.

The study areas associated with the various environmental factors are presented in figure 3-2 to figure 3-7.

- **Physical environment (atmosphere, soil, subsoil, water)**

  To fully understand the interactions between the various environmental factors influencing the physical environment, these factors were analysed within the same study areas.

  The physical environment extended study area was defined based on the results of various tracers used to understand flow patterns within the Barrois Limestone hydrological system.

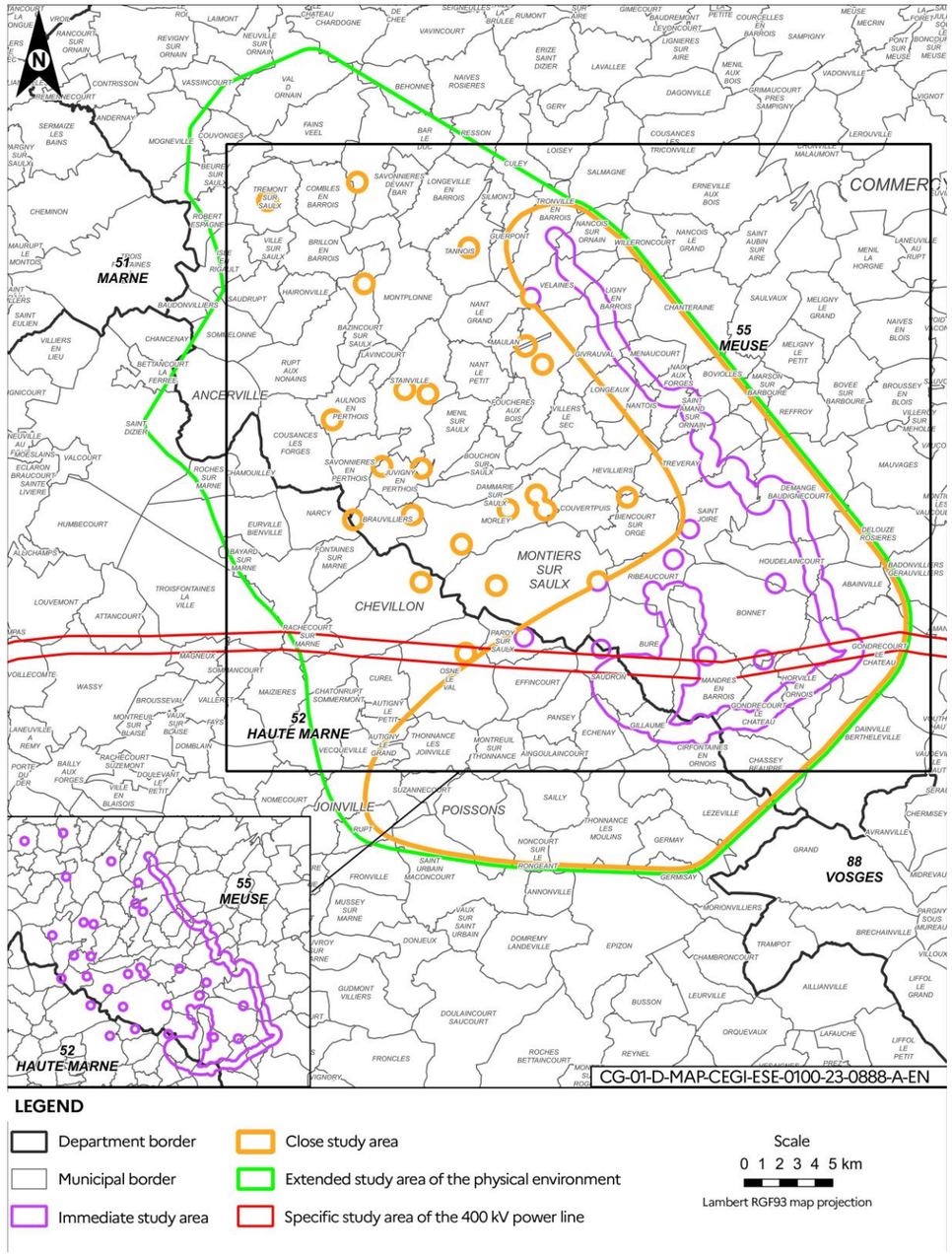


Figure 3-2 Study areas of the physical environment

- **Natural environment**

  The natural environment extended study area is defined to account for all potential impacts of the Cigéo overall project, particularly on species with large habitat areas such as birds and bats. The 30-km radius is justified by the maximum daily travel distances individuals can cover between their nesting ground and foraging areas. It is centered on the shafts zone of the Cigéo disposal facility, which is the zone with the greatest impact on these species.

  The immediate biodiversity study area corresponds to the geographic zone that allows for an understanding of the effects of the structures and facilities footprint, as well as disturbances related to construction works and activities within the potential project area and its immediate vicinity. It is used to acquire detailed knowledge of the environment through on-site inventories (natural habitats, fauna, and flora). This study area allows for an understanding of the impacts on the ecological functions of the territory, taking into account the elements necessary for the proper completion of the species' biological cycle.

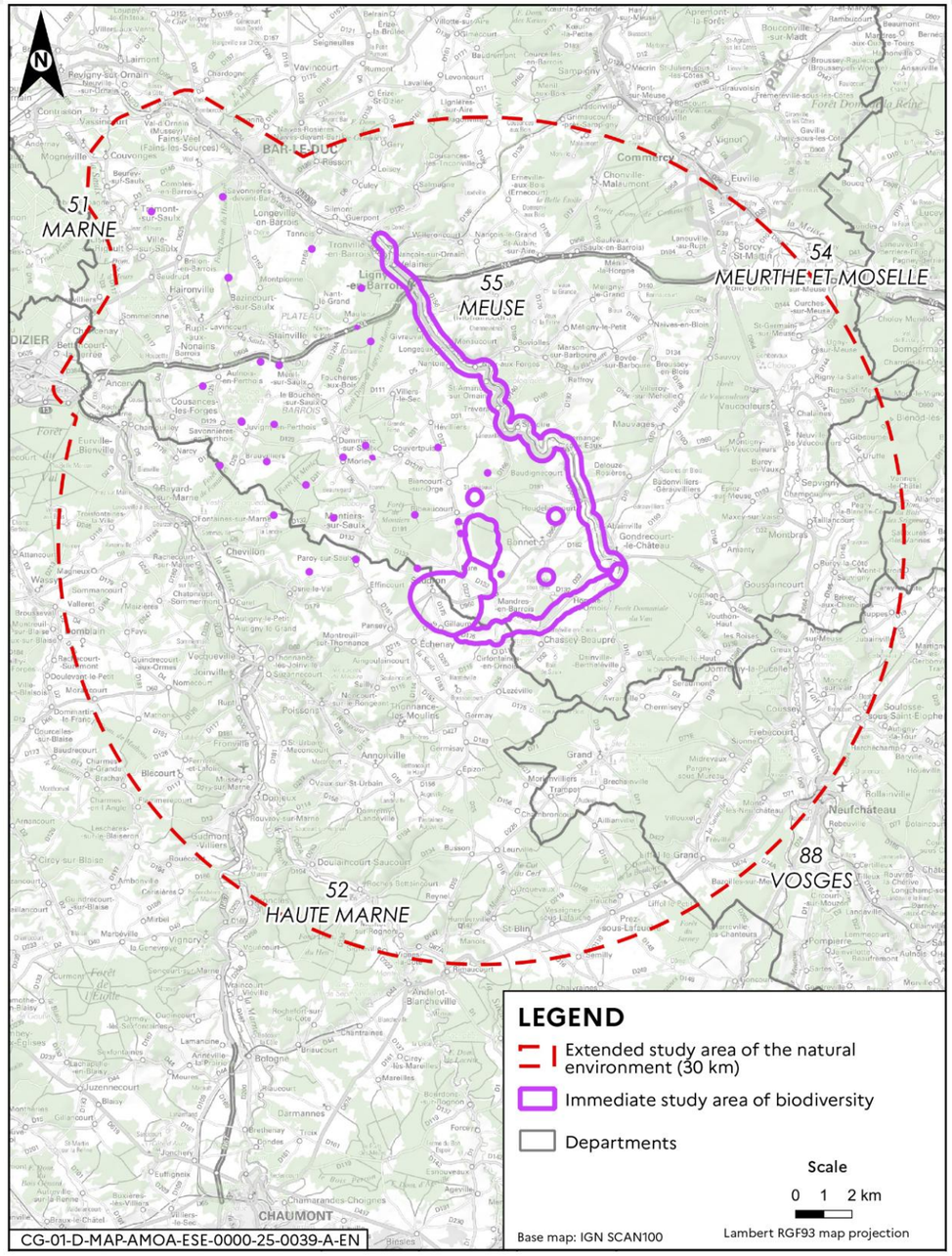


Figure 3-3 Research Areas for Biodiversity and the Natural Environment

- **Human Environment**

The study areas for the following factors contribute to the description of the human environment: population and socio-economics, networks, radioactive waste, conventional waste, technological risks and potentially contaminated sites and soils, transportation infrastructure, living environment, and land-use planning. The near study area for transportation infrastructure and the living environment corresponds to the road traffic modelling area and two specific zones at the northwestern extremity linked to two Barrois surveys.

The near study areas for population, employment, and economic activities are defined based on national statistics indicating that 90% of employees commute 50 km between their home and workplace. A 20 km study area around the disposal facility is considered; this corresponds to 60% of commutes between home and workplace at the national level. This focus specifically concerns the disposal facility. Strictly speaking, this is not a local study area.

The extended study area encompasses the entire Grand Est region. Given the scale of the Cigéo overall project, potential effects on the population, employment, and economic activities are conceivable across the entire Grand Est region, particularly regarding the region's attractiveness and the creation and structation of specific activities (business specialisation, creation of business clusters). The extended study area extends to the northern and eastern parts of France where radioactive waste shipment and transport operations take place. It allows for the assessment of impacts related to traffic generated by the transport of radioactive waste packages from the various shipment sites on the transportation infrastructures involved (rail and road networks).

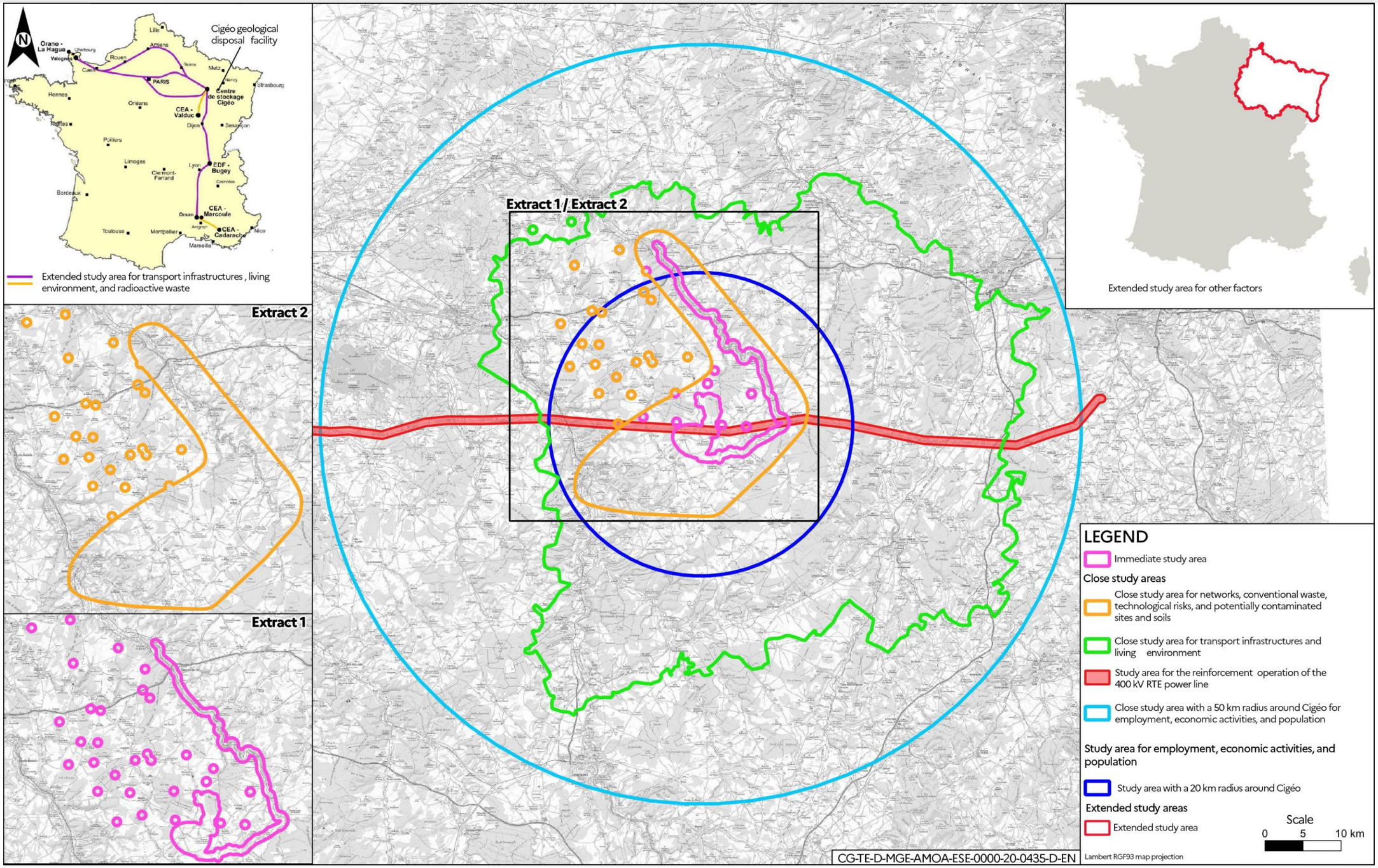


Figure 3-4 Human environment study areas

- **Agricultural and forestry activities**

  Agricultural and forestry activities are studied in a extended study area covering the administrative departments of Haute-Marne and Meuse, as the agricultural sector is organised at the departmental level.

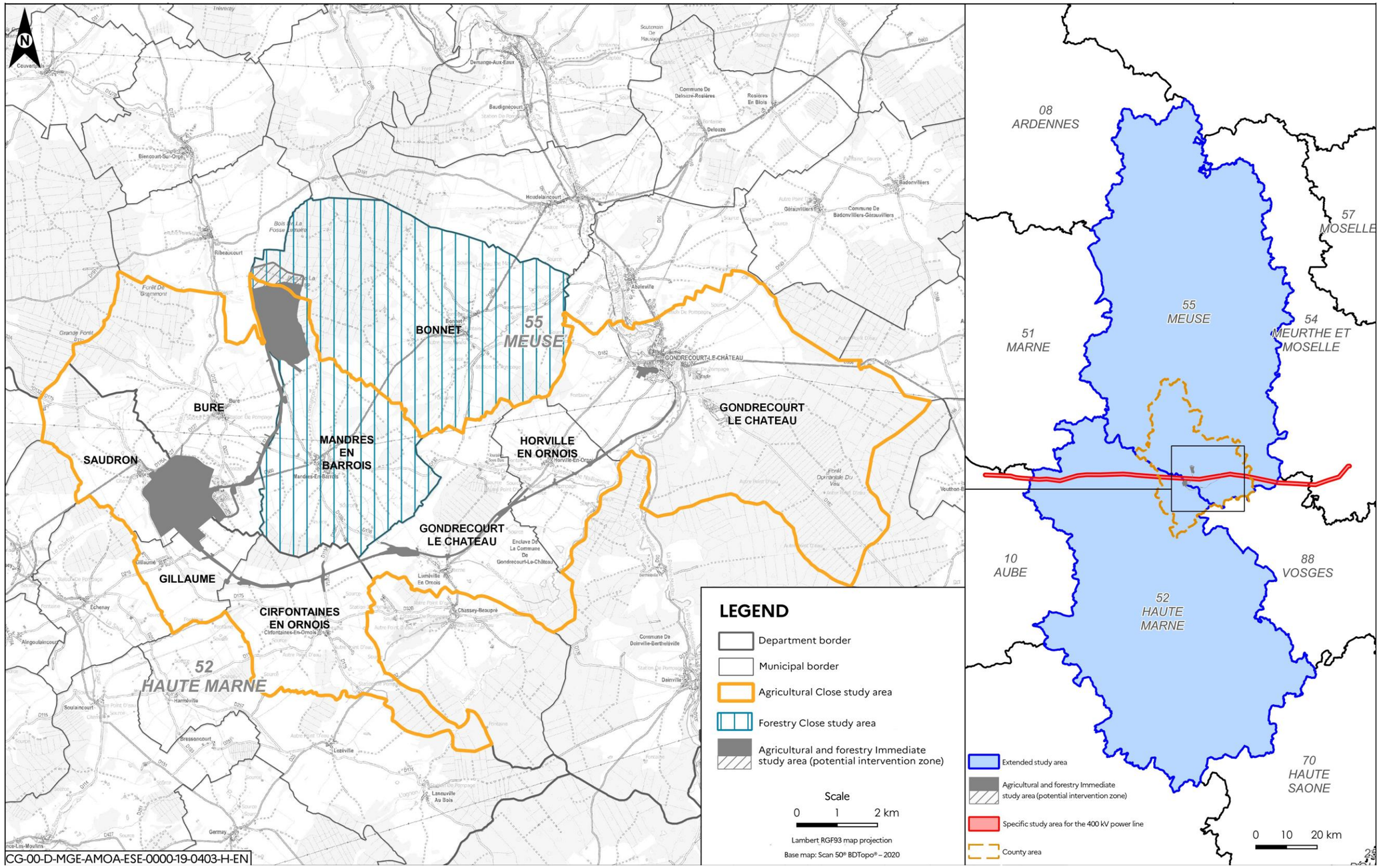


Figure 3-5 Study areas for agricultural and forestry activities

- **Landscape, cultural heritage, tourism, and recreational activities**

  The extended study area for landscape and heritage encompasses all the administrative departments involved in the Cigéo overall project, providing a comprehensive view of the landscapes within which it is situated.

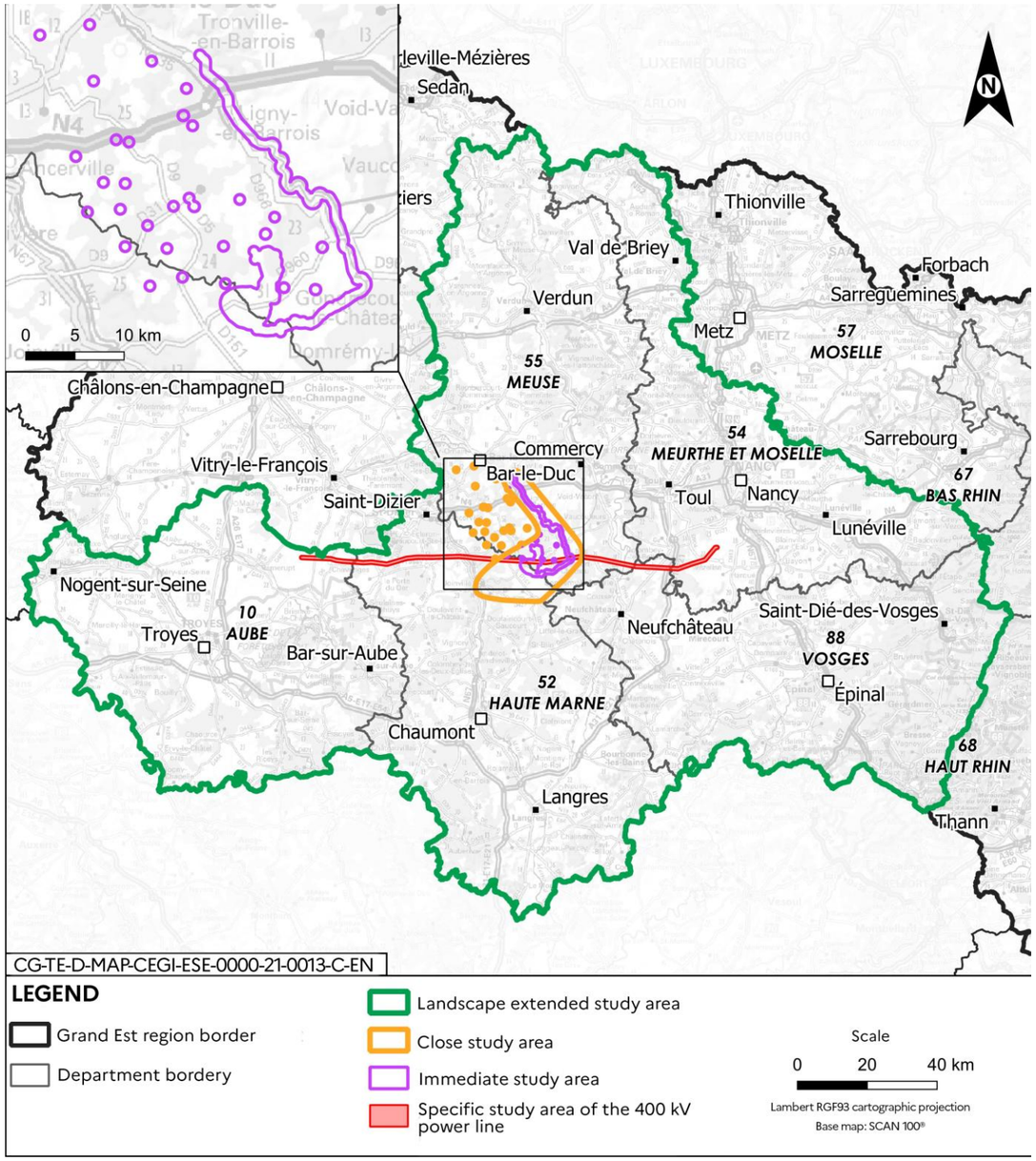


Figure 3-6 Landscape study areas

- **Interactions and ecosystem services**

  The interactions and ecosystem services are studied in the extended natural environment study area, where interactions occur between the various environments within the territory where the Cigéo overall project is located.

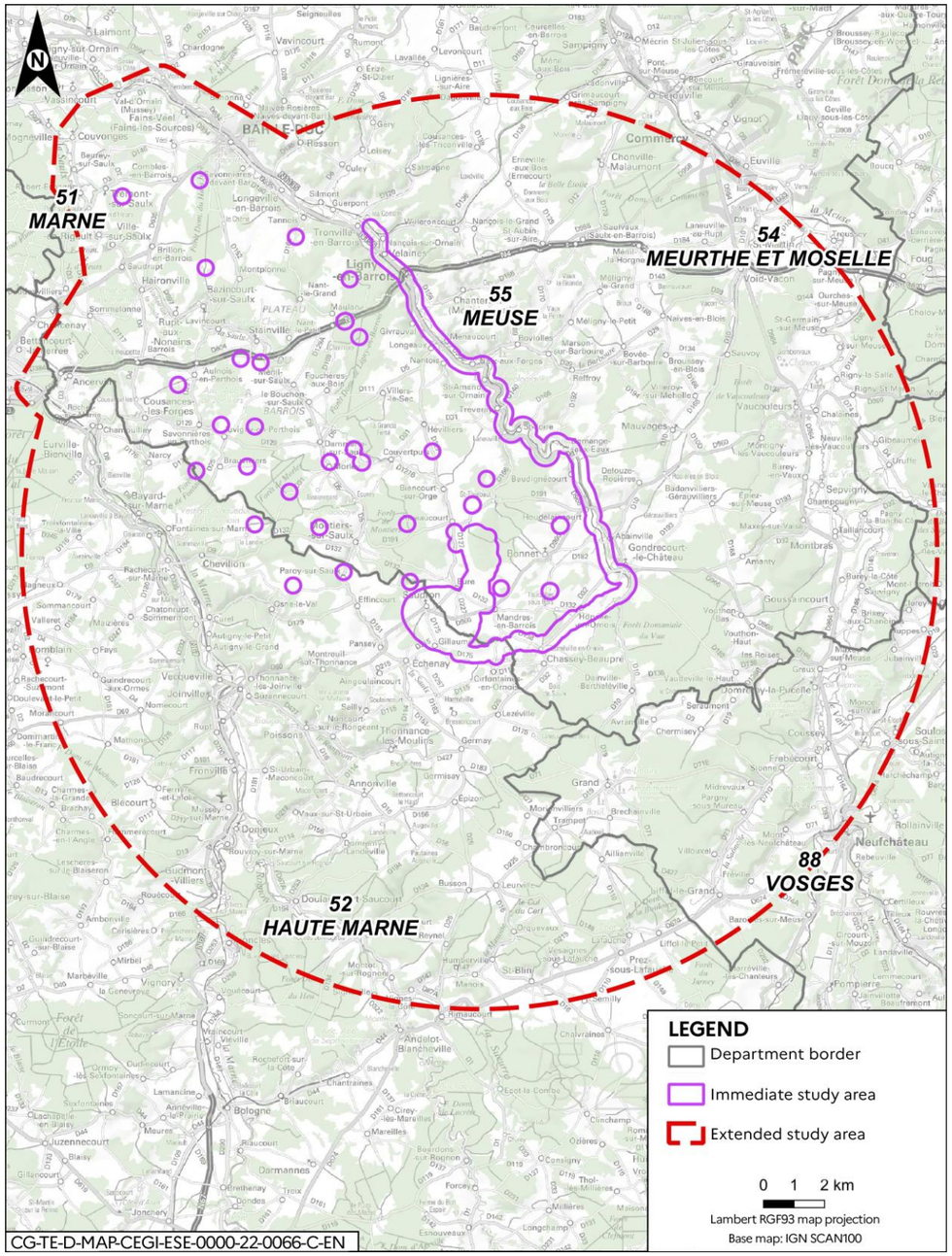


Figure 3-7 Study areas for interactions

3.2 The atmosphere

3.2.1 Local weather conditions

3.2.1.1 Initial state

Environmental issue

Local weather conditions are consistent with regional norms. They exhibit average annual and interannual variability. Exceptional events are rare.

Low level issue

The characterisation of the atmospheric environment is based on a long-term programme defined and implemented by Andra, which is integrated into major national and international networks.

Local climatology has been determined using data from three weather stations operated by Météo-France (French national weather broadcasting service) and located near the Cigéo overall project (see Figure 3-8):

- the Saint-Dizier weather station, located 35 km from the Cigéo disposal facility;
- the Houdelaincourt atmospheric station (established by Andra), located approximately 2.5 km from the 027000 railway line, approximately 10 km from the shaft zone, and approximately 15 km from the ramp zone;
- the Cirfontaines-en-Ornois weather station, located approximately 7 km from the shaft zone and 5 km south of the ramp zone.

When available, meteorological data are analysed for the period 1980–2019.

The analysis of these parameters is essential, as they determine atmospheric dispersion models, the assessment of the reference rainfall, the hydrodynamic modelling of groundwater flow, and serve as input data for the design of certain structures such as stormwater management facilities.

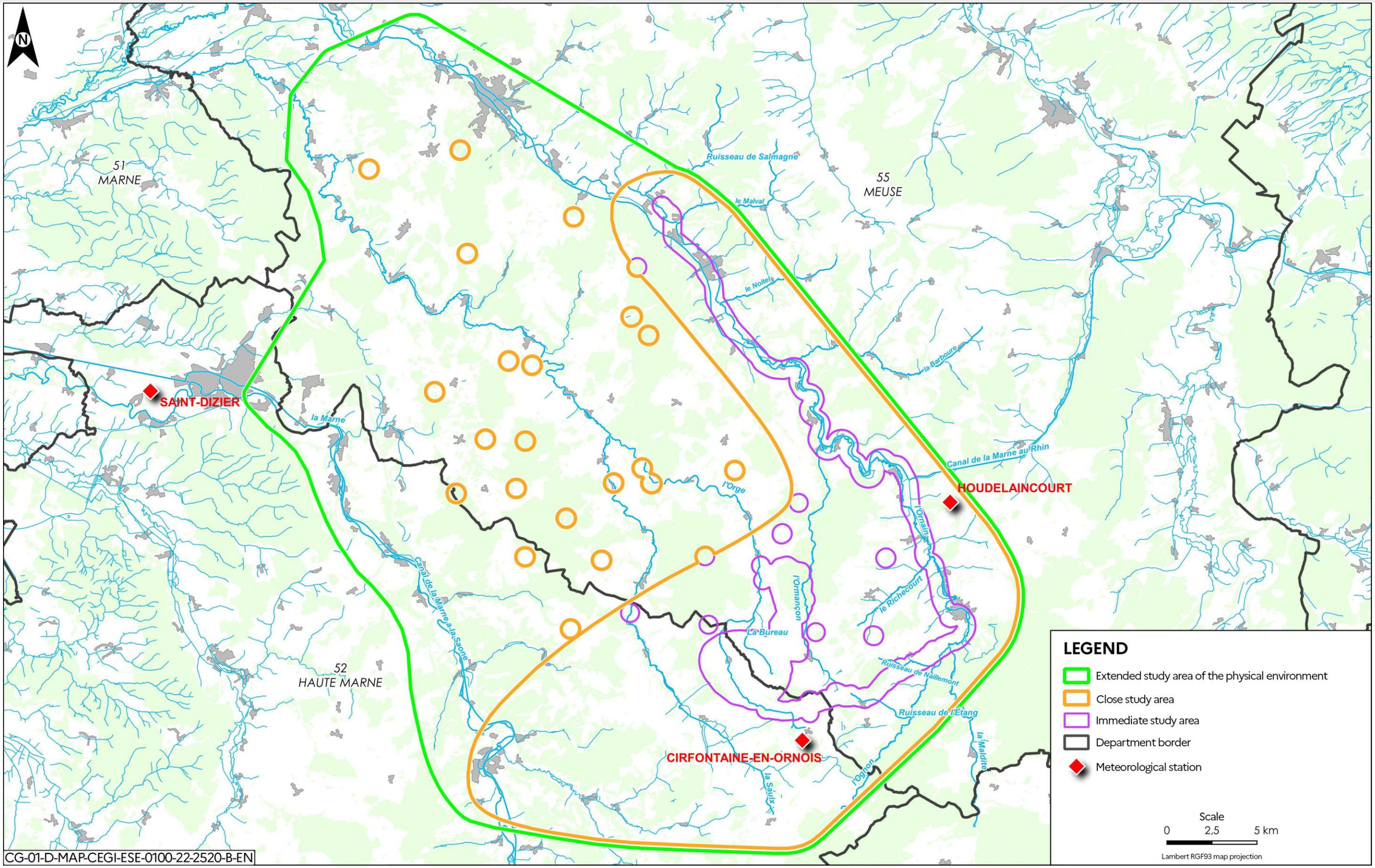


Figure 3-8 Location of the weather stations in Houdelaincourt, Saint-Dizier, and Cirfontaines-en-Ornois

Environmental issues

Several major meteorological risks have been identified in the extended study area.

The effects of climate change may exacerbate the risks assessment scenarios relevant to the Cigéo overall project, particularly through increased operating temperatures of pieces of equipment, increased fire risk, and the occurrence of extreme precipitation.

Low-level issue

The Cigéo overall project is located in a region with a continental climate characterised by mild, humid weather influenced by weather systems originating from the ocean.

The average annual precipitation is approximately 850 mm. Precipitation varies significantly from year to year, ranging from 562 mm to 1,175 mm, according to observations made at the Houdelaincourt, Saint-Dizier and Cirfontaines-en-Ornois stations between 1980 and 2019.

Fall and winter regularly experience episodes of snow (an average of 4.4 days in January) and fog (an average of 5 to 6 days per month) according to observations made at the Saint-Dizier station between 1981 and 2010.

According to observations made at the Saint-Dizier station between 1980 and 2019, the average annual temperature is 11.3 °C. The average annual temperature is 16.6 °C. Extreme temperatures range from -22.5 °C in 1956 to +41.4 °C in 2019.

According to observations made at the Houdelaincourt station between 2012 and 2019, prevailing winds come from the southwest (Westerlies), with some periods of east to northeast winds. The average wind speed is 3.9 m/s, or 13.9 km/h, with moderate winds between 3 m/s and 6 m/s being predominant.

Gusts reached a measured speed of 44 m/s (160 km/h) at the Saint-Dizier station during the December 1999 storm.

The average relative humidity is 78.1%, according to readings from the Saint-Dizier station between 1980 and 2019.

The average annual sunshine duration is 1,727 hours in Saint-Dizier, based on data collected between 1981 and 2019, and 1,797.1 hours in Houdelaincourt, based on data collected between 2012 and 2019.

Annual potential evapotranspiration is 774 mm/year, corresponding to a potential evapotranspiration of 2.1 mm per day, according to data from the Saint-Dizier station between 1980 and 2019.

3.2.1.2 Impacts and associated measures

The Cigéo overall project, which is located in a sparsely urbanised rural environment, may impact local weather conditions through changes in temperature (heat emissions), wind (obstruction of wind flow), humidity (vapor release, etc.) and local sunlight.

Several measures implemented as early as the preliminary works phase for other purposes have the added benefit of helping maintain local weather conditions. These include, for example, measures related to water management or the preservation of biodiversity, which also reduces the heat island effect: limiting impervious surfaces, revegetation of outdoor spaces and rooftops, creating water retention basins and the potential use of alternative materials.

Thus, the Cigéo overall project has no residual impact on weather conditions at any stage of the project's lifecycle (pre-construction, initial construction, operation). No significant effects on humidity, temperature, wind patterns or sunlight are expected.

The Cigéo overall project has a very low residual impact on local weather conditions.

3.2.2 Weather risks and climate change

3.2.2.1 Initial state

The meteorological risks identified in the extended study area are storms, thunderstorms and associated phenomena, heavy rain, snowfall and ice, periods of extreme cold, heat waves, and periods of drought.

Projections on climate change over the near term (2021–2050) and the long term (2050–2100) indicate that France could experience, in particular, a further rise in average temperatures, an increase in the number of heatwave days in summer (particularly in the southeastern regions), a decrease in the number of abnormally cold days in winter across mainland France (particularly in the northeastern regions).

3.2.2.2 Impacts and associated measures

The project is not likely to alter existing meteorological risks. The analysis of the Cigéo overall project's vulnerability to major meteorological risks is presented in chapter 3.11 of this non-technical summary.

The design of the Cigéo overall project takes into account extreme weather risks and their exacerbation due to climate change: storms, heat waves, extreme cold, heavy precipitation, and lightning.

Nuclear facilities and the equipment essential to their protection are designed to operate over very wide temperature ranges:

- from –15 °C to +35 °C continuously;
- from –20 °C to +42 °C for seven consecutive days;
- from –25 °C to +47 °C for 12 consecutive hours.

The high thermal inertia of reinforced concrete structures, some of which are buried, means they are not significantly affected by these extreme temperatures.

Protective measures for sensitive facilities are in place to guard against wildfires. Anticipation of global warming is also factored in through the selection of drought-resistant plant species for site greening and as part of carbon offset efforts.

Regarding the risk associated with heavy rainfall, the stormwater collection basins are designed with safety margins to collect stormwater during extreme rainfall events exceeding historical records and for 100-year return periods.

These measures ensure that the project is not vulnerable to current and future meteorological risks. The impacts of the Cigéo overall project resulting from the occurrence of such events are therefore very low. Details of the measures are presented in chapter 2.2 of Volume IV of this environmental impact assessment.

EVAPOTRANSPIRATION

Evapotranspiration is the sum of the evaporation of water contained in the soil and the water transpired by the plants. It is expressed in millimetres (mm). It is used, in particular, to determine the amount of water needed for irrigation.

Potential evapotranspiration is the maximum amount of water that can be evaporated through evapotranspiration under a given climate by a continuous vegetation cover with a good water supply.

The vulnerability of the Cigéo overall project and the impacts related to climate change are very low.

3.2.3 Energy and greenhouse gases

3.2.3.1 Initial state

Environmental issue

The extended physical environment study area lists only renewable sources of energy, primarily from wind and wood-based energy. The latter sector has significant development potential. In the immediate study area, renewable energy resources consist mainly of forests, methane deposits from agriculture, and energy recovery from local industries. The region imports fossil fuels to meet its energy needs, particularly those related to road transportation. The forest has moderate carbon sequestration capacity.

Moderate level issue

3.2.3.1.1 Energy profile

The energy profile is based on 2020 ATMO Grand Est data for the year 2018 (76) and the 2022 edition of key figures from the Climate, Air, and Energy Observatory of the Pays Barrois SCOT (2020 data) (77).

The Barrois region is characterised by high energy consumption, particularly in the residential sector and transportation. The energy consumed consists mainly of petroleum products, electricity, and natural gas.

The main energy sources in the Pays Barrois are wind power generation and wood-based energy. External electricity supplies compensate for the irregularity of wind power production. The Pays Barrois also imports the fossil fuels needed for motor vehicles.

Thus, the immediate study area differs from the Grand Est region, where energy is primarily generated from nuclear sources.

3.2.3.1.2 Renewable energy potential

The description of renewable energy potential is based on the 2022 report on key figures for renewable energy in the Grand Est region by the DREAL du Grand Est (2021 data) (78) and the 2022 edition of key figures from the Climate, Air, and Energy Observatory for the SCOT of the Pays Barrois territory (2020 data) (77).

RENEWABLE ENERGIES

Renewable energies (RE) are energies derived from natural processes that are constantly renewing themselves. There are several forms of renewable energy, including energy generated by the sun, wind, solid biomass (primarily wood-based energy), geothermal heat, water from rivers, lakes, seas and oceans, biogas, and liquid biofuels. A distinction is made between renewable electrical energy and renewable thermal energy.

Renewable electrical energy includes hydroelectric, wind, tidal, solar photovoltaic, and high-temperature geothermal power.

Thermal renewable energy includes firewood (collected or purchased), geothermal energy utilised as heat, active solar thermal energy, incinerated wood and crop residues, biogas, biofuels, and heat pumps, as well as biodegradable urban and industrial waste (regardless of type).

Wind energy accounts for 59% of the total electricity production in the Pays Barrois. Potential areas for wind energy development in the Pays Barrois are located south of Gondrecourt-le-Château and around the Seuil d'Argon.

The wood-based energy sector dominates local renewable thermal energy production, with significant prospects for development.

Sources of wood, agricultural methane, and industrial waste heat have been identified in the immediate study area.

3.2.3.1.3 Greenhouse gas emissions

GREENHOUSE GASES

Greenhouse gases (GHGs) are gases that absorb a portion of solar radiation and redistribute it as radiation within the Earth's atmosphere, a phenomenon known as the greenhouse effect. They are measured in tons of carbon dioxide equivalent (teqCO2).

In the Grand Est region, greenhouse gas emissions are primarily attributable to industry and road transport.

Due to its rural character, the Pays Barrois region is dominated by greenhouse gas emissions from the agricultural sector, road transport, and residential buildings.

3.2.3.1.4 Carbon sequestration

CARBON SEQUESTRATION

Carbon sequestration refers to all processes that remove carbone from the atmosphere and store it in a reservoir. Today, the main terrestrial carbon reservoirs are the oceans, soils (including peatlands), and plant biomass, particularly wood, whether in forests (trees and deadwood) or used as a material in construction or furniture. Globally, soils and biomass store about four times more carbon than the atmosphere contains. Their evolution are therefore critical to the climate regulation process. Sedimentary rocks are actually the largest terrestrial carbon reservoir, but this reservoir changes very little over the course of a century, which is the timescale that matters to us in the context of combating climate change.

In mainland France, 3 to 4 billion tons of carbon are stored in the top 30 centimetres of soil and 1.5 billion tons in forest biomass (Source: ATMO Grand Est (79)In mainland France, 3 to 4 billion tons of carbon are stored in the top 30 centimetres of soil and 1.5 billion tons in forest biomass (Source: ATMO Grand Est (79)).

Carbon sequestration was analysed based on:

- data from the French Assessment of Ecosystems and Ecosystem Services (EFESE) by the General Commission for Sustainable Development (national report titled "Carbon Sequestration by Ecosystems in France" (80));
- data from the National Soil Quality Monitoring Network (GIS SOL, 2011(81)) and data from the regional soil reference databases for Lorraine, Haute-Marne, and Marne (82–84) ;
- data from Corine Land Cover (2018) regarding land use (85).

Cross-referencing ecosystem carbon sequestration data with soil type data enabled the establishment of a rating (from none to very high) of the carbon sequestration capacity of ecosystems present in the remote study areas. Based on this classification, a cartographic representation of the ecosystems' carbon sequestration capacity was created by merging soil and land-use data in a GIS (QGIS v3.10 software).

Numerous parameters influence carbon sequestration capacity: climate, ecosystem type, associated management practices, and the nature of the soils on which the ecosystem is based. The carbon sequestration capacity of the remote and immediate study areas was examined using a cross-analysis of land use and the nature of the soils on which the ecosystem rests. Thus, the relatively high forest cover in the remote study area makes it appear as a zone favourable to natural carbon sequestration. However, the presence of slightly acidic forest soils combined with the predominance of shallow to moderately deep cultivated soils moderates the carbon sequestration capacity of the remote study area. Ultimately, there are few areas with very high sequestration capacity: these are exclusively forested areas at the bottom of valleys.

Figure 3-9 , shows the carbon sequestration capacity in the extended study area.

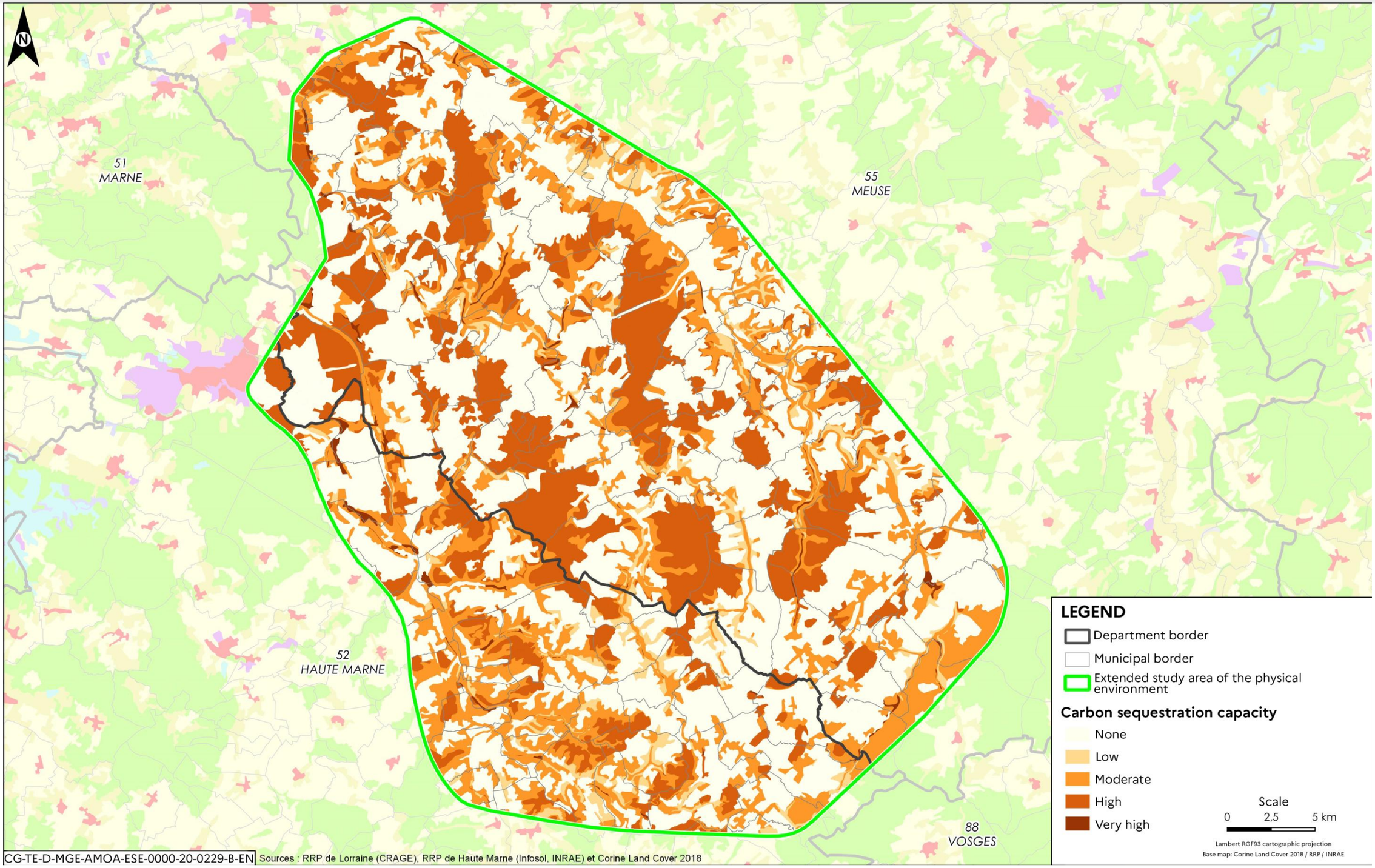


Figure 3-9 Map of carbon sequestration capacity in the extended physical environment study area

3.2.3.2 Associated impacts and measures

From the preliminary works phase through to the decommissioning of the facilities, sources of greenhouse gas emissions include energy consumption (electricity, hydrocarbons for machinery and internal freight), demand for primary raw materials (particularly concrete and steel), transportation, staff travel, and artificial surfaces (including the loss of carbon sequestration capacity in artificial or cleared soils). The initial construction and operational phases of the Cigéo disposal facility are responsible for the highest greenhouse gas emissions.

In terms of avoidance measures, the decision was made to distribute the potential site area of the Cigéo disposal facility between forested and agricultural areas. As a result, several hundred hectares of forest are untouched and retain their carbon sequestration capacity, which is far greater than that of cultivated land.

Reduction measures are implemented: continuous improvement of the carbon footprint during the upcoming design phases and throughout its operation so that the Cigéo overall project benefits from technological advancements that will be implemented within the context of a globally decarbonised economy driven by the national low-carbon strategy; rail access to the disposal facility; the maintenance and restoration of carbon sequestration capacities; reducing material requirements, using low-emission materials, rational energy use, the use of renewable energy, reducing emissions from combustion-engine machinery and vehicles, incorporating energy efficiency criteria into specifications for selecting contractors, monitoring and maintaining equipment containing refrigerants, and optimising waste management.

The estimation of the quantities of greenhouse gases (GHGs) that could be generated by the project during these various life cycle phases was carried out using the Bilan Carbone® methodology developed by the French Agency for Ecological Transition. The objective of this tool is to "challenge" the design by prioritising solutions that minimise greenhouse gas emissions.

Following these assessments, the carbon footprint is estimated at approximately 10 million teqCO_2 from the preliminary works phase through to the closure and decommissioning of the disposal facility (i.e., over a century-long period). The main sources of greenhouse gas emissions are energy consumption (electricity, natural gas, diesel, gasoline) and the production of raw materials used in the project or inputs (cement, sand, gravel, concrete, steel, asphalt), which account for more than 80% of the emissions from the Cigéo overall project. This amounts to approximately 67,000 CO_2 eq over 150 years, or about 0.02% of current annual national emissions. The carbon footprint of the Cigéo overall project can also be put into perspective relative to CO_2 emissions associated with nuclear power generation, with the Cigéo overall project accounting for 4% to 9% of these emissions.

The Cigéo overall project has a low level residual impact on greenhouse gases.

3.2.4 Air Quality

3.2.4.1 Conventional parameters

POLLUTANTS AND CONVENTIONAL PARAMETERS

The term **"pollutant"** refers to any substance present in ambient air that may have harmful effects on human health or the environment as a whole. Air quality standards, determined using methods defined by order of the Minister of the Environment, are established on a pollutant-by-pollutant basis.

Conventional parameters correspond to chemical compounds.

3.2.4.1.1 Initial state

Environmental issue

Air quality in the study area where the Cigéo project is located is good due to its rural nature, with little urbanisation or industrialisation. Furthermore, meteorological conditions are favourable for the effective atmospheric dispersion of pollutants.

High level issue

Air quality was assessed at the regional level using data from stations in the ATMO Grand Est regional network (86) and at the local level using readings from the Houdelaincourt station established by Andra. This weather station is also equipped with an atmospheric monitoring station integrated into the ATMO Grand Est air quality monitoring network.

Air quality can be affected by pollutants that may be of natural origin or anthropogenic origin, i.e., related to human activity. Air pollution has significant effects on health and the environment.

The pollutants studied are those regulated under air quality monitoring in Article R. 221-1 of the French Environment Code. These include:

- nitrogen dioxide (NO_2);
- sulfur dioxide (SO_2);
- ozone (O_3);
- carbon monoxide (CO);
- particulate matter with a diameter of less than 10 µm and 2.5 µm ($PM_{10}$and $PM_{2.5}$,respectively);
- volatile organic compounds (VOCs) equivalent to benzene, the only VOCs with a threshold value;
- polycyclic aromatic hydrocarbons (PAHs), represented by benzo(a)pyrene (B(A)P), which is itself regulated;
- heavy metals (arsenic, cadmium, nickel, and lead).

The figure 3-10 shows the air quality monitoring stations.

The study area where the Cigéo overall project is located is rural; traffic is light, as is the number of industries emitting pollutants. A summary of pollutant-emitting activities reveals that the "residential, tertiary, commercial, and institutional" sector and the agricultural sector are responsible for emissions of most pollutants.

Consequently, the concentrations of pollutants (sulfur dioxide SO_2 , nitrogen oxides NOx , carbon monoxide CO, benzene, benzo(a)pyrene, PM_{10} and $PM_{2.5}$ and trace metals) measured at the Houdelaincourt air monitoring station comply with both the limit values and virtually all the quality objectives specified in the regulations, with the exception of ozone (exceedances observed at the regional and national levels) and $PM_{2.5}$ (only under particularly unfavourable weather conditions).

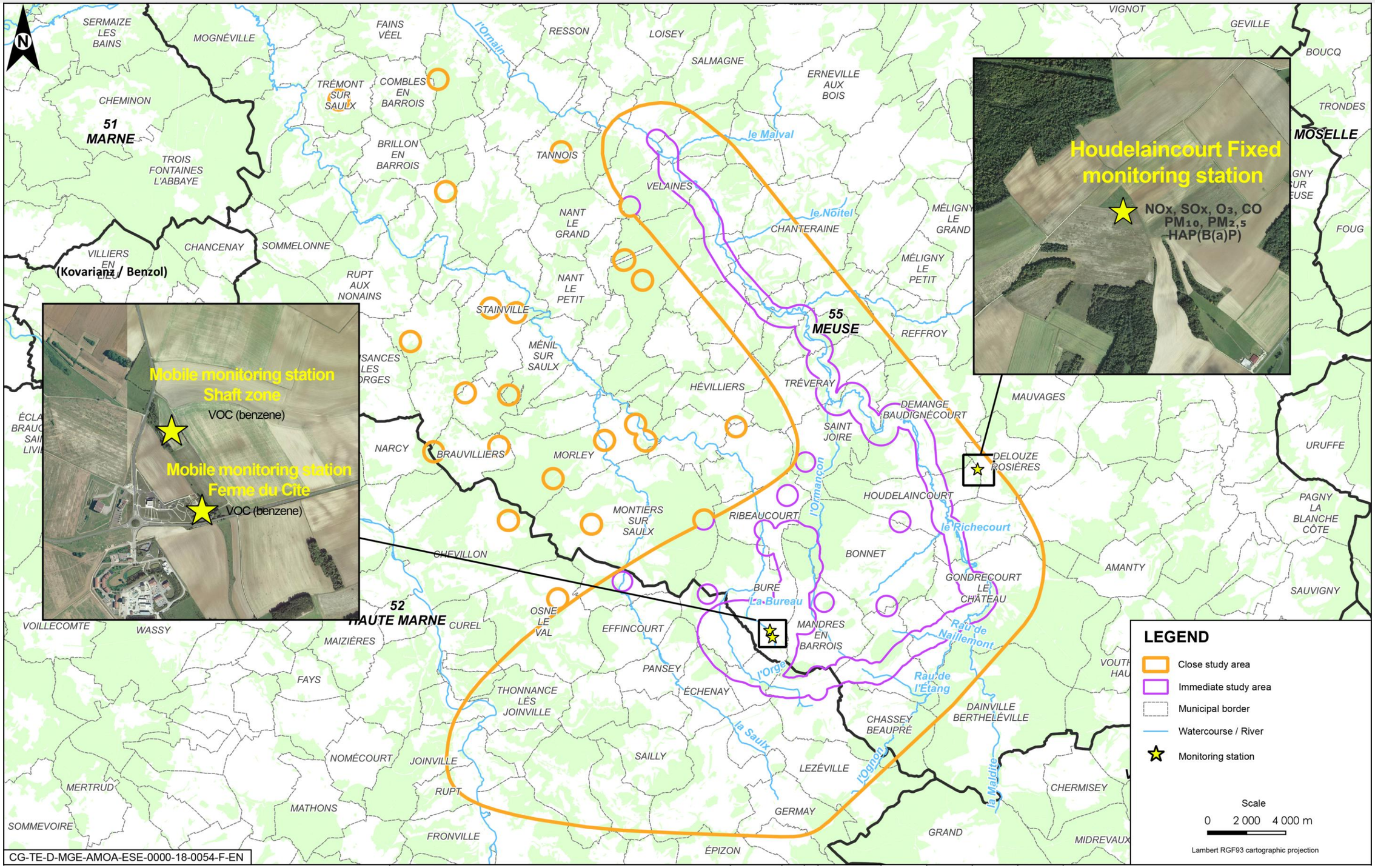


Figure 3-10 Location of air quality monitoring stations

3.2.4.1.2 Impacts and associated measures

The project's impact on air quality was studied using atmospheric dispersion modelling. The modelling was performed using the AirAdvanced® Map Standard version software. The figure 3-11 illustrates the methodology implemented by the software.

This model enables the statistical analysis of meteorological data, followed by the simulation of the dispersion of industrial or automotive air pollutants (gaseous or particulate) originating from one or more diffuse or channelled sources (Aria Technologies, 2013 (87), 2009 (88)).

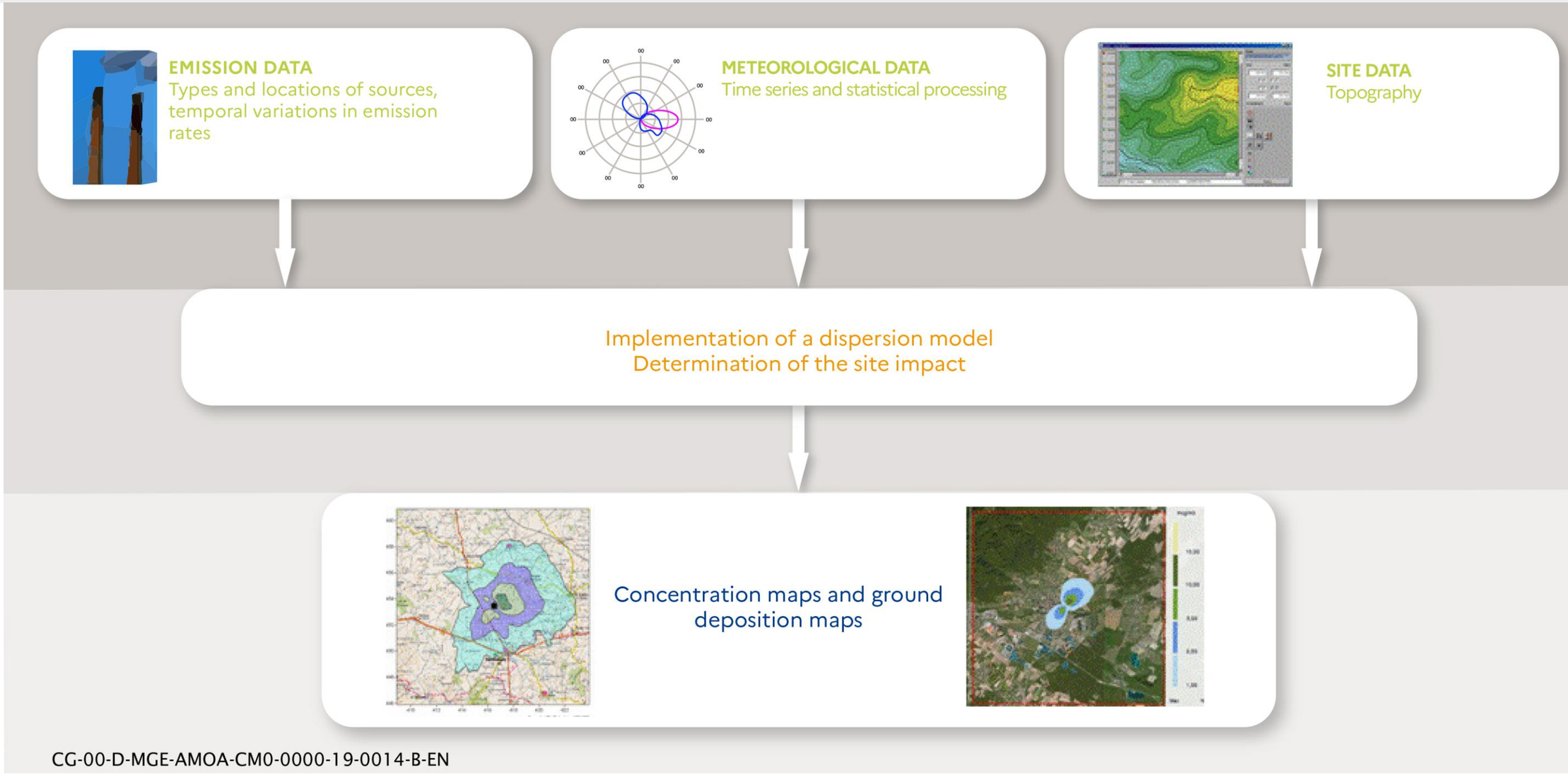


Figure 3-11 Approach implemented by the ARIA Impact™ software

The preliminary works and initial construction phases involve numerous activities such as earthworks, clearing, building construction, etc., which are the source of air pollutant emissions. These operations lead to increased traffic (*in situ*) and require the use of construction equipment, concrete plants, etc. The operational phase, meanwhile, includes vehicle and equipment traffic, material storage, and the operation of facilities such as electrical substations, boiler rooms, ventilation systems for underground facilities, and nuclear buildings.

These activities emit varying amounts of substances such as:

- dust, particularly from soil particles being resuspended during earthwork operations or from vehicle exhaust;
- VOCs (volatile organic compounds), from vehicle exhausts, construction machinery, and, very occasionally, the asphalt plant;
- nitrogen dioxide (NO_x);
- carbon monoxide (CO), from vehicle exhausts, well ventilation, and very occasionally from the use of the asphalt plant;
- sulfur dioxide (SO_x), resulting from the very occasional use of explosives for earthworks or from the asphalt plant;
- and finally benzo(a)pyrene, linked to vehicle traffic on county roads and the inter-site link.

Airborne particles or dust are classified according to size:

- PM_{10}: particles with a diameter of less than 10 microns (µm), or 0.01 mm;
- $PM_{2.5}$: particles with a diameter of less than 2.5 microns (µm), or 0.0025 mm.

To limit these impacts, Andra is committed to implementing avoidance and reduction measures. Among the avoidance measures planned are: the use of a semi-underground conveyor to transport waste rock and materials between the shaft and ramp zones; the disposal of waste rock in the shaft zone near the extraction site, which avoids the need for lorry trips; and the reuse of existing infrastructure, which helps minimise the amount of dust suspended in the air during construction. These avoidance measures are accompanied by reduction measures typically implemented on construction sites. Among these measures, the following are implemented: misting of uncovered waste deposit areas, consideration of weather conditions during operations likely to disperse dust (such as liming), watering during dry weather, adapting equipment that may disperse dust (covering trucks as much as possible, installing hoods and suction systems on pieces of equipment where necessary), applying road surfacing, limiting vehicle speeds, and so on.

Details of the measures are presented in chapter 2.4 of Volume IV of this environmental impact assessment Together, these measures help reduce the quantities of chemical substances emitted by the Cigéo overall project.

According to atmospheric dispersion modelling, concentrations of toxic chemical compounds at facilities open to the public or near sensitive populations within the immediate study area of the Cigéo project's physical environment remain below air quality standards, except for PM2.5, for which the quality objective is already exceeded in background pollution regardless of the Cigéo project. Concentrations of particulate matter and benzene may locally exceed the quality objective at the boundary of the disposal facility in uninhabited agricultural areas, while still complying with the limit value. The Cigéo overall project does not cause a deterioration in air quality; the impact is low.

Emissions of conventional substances from the Cigéo overall project have a minor level residual impact on air quality.

3.2.4.2 Radiological parameters

3.2.4.2.1 Initial state

Environmental issue

Air quality in the study area where the Cigéo overall project is located is good due to its rural nature, with little urbanisation or industrialisation. Furthermore, meteorological conditions are favourable for good atmospheric dispersion of pollutants.

The baseline shows ambient air radioactivity levels consistent with an area far removed from any nuclear activity.

High level issue

The characteristics of radioactivity in the air (and rainwater) studied at the Houdelaincourt atmospheric station are representative of a large area. This station is part of the national air radioactivity monitoring network known as the Permanent Radioactivity Observatory (Opera) of the Institute for Radiation Protection and Nuclear Safety (IRSN).

The comprehensive initial radiological assessment conducted by Andra (carried out since 2011 at the Houdelaincourt station) shows ambient radioactivity levels consistent with an area distant from nuclear activities. Furthermore, the measured levels are generally of the same order of magnitude as the average levels measured in the air in France (89).

3.2.4.2.2 Impacts and associated measures

The assessment of the dispersion of radioactive releases into the air and associated environmental deposition is performed using modelling tools (Gascon module of the CERES platform (a code for fast environmental and health assessments developed by the CEA (90)).

The transfer and disposal of radioactive waste packages within the perimeter of the nuclear facility during the operational phase results in releases of radioactive gases such as tritium (^{3}H), carbon-14 (^{14}C), krypton-85 (^{85}Kr), and radioactive aerosols, including alpha and beta emitters. These releases are very low.

Releases from the underground facility represent the primary source by several orders of magnitude. Releases from the surface nuclear facility, located in the access tunnel area, are negligible compared to those from the underground facility's air discharge stack.

The nuclear ventilation systems are equipped with very high-efficiency filters that capture at least 99.9% of aerosols. The height of the discharge stacks is sufficient to ensure proper dispersion of gaseous emissions. Ambient dose monitoring in areas containing radioactive waste packages is continuously performed by atmospheric radiation monitors coupled with alarms (visual and audible) to alert personnel to any abnormal situation.

Atmospheric dispersion modelling shows that the maximum airborne concentrations associated with these releases of radioactive gases and aerosols are located a few hundred metres from the vent in the shaft zone, outside of inhabited zones, and are very low. They decrease significantly with distance.

The residual impacts of atmospheric radioactive emissions from the Cigéo global project on human health during the operational phase are very low level.

3.2.5 Compatibility with planning documents related to air, energy, and climate

In accordance with international agreements, France translates its policy to combat global warming and preserve air quality into laws and regulations that are implemented through planning documents at the national and local levels.

All these documents aim for a significant reduction in anthropogenic greenhouse gas emissions through:

- reducing energy consumption;
- the use of renewable energy;
- improving building insulation;
- reducing resource consumption;
- reducing waste.

They also aim to reduce air pollutant emissions through:

- technological innovation;
- changes in mobility options.

These objectives to reduce greenhouse gas emissions and other air pollutants have been integrated into the design of the Cigéo overall project and are also intended to be taken into account during its construction and operation periods.

3.3 Soil

The Cigéo overall project, due to the large areas it requires and its industrial and nuclear nature, may impact the land in various ways:

- the Cigéo disposal facility will alter land use since it is built on land that is currently primarily forested and agricultural;
- the earthworks required prior to construction and associated development across several hundred hectares will alter the topography, nature, and structure of the soil and, finally, temporarily leave the land bare;
- construction works for the entire project and industrial activity may result in the deposition of pollutants on the soil surface.

3.3.1 Relief, geomorphology, and topography

3.3.1.1 Initial state

Environmental issue

The extended physical environment study area features a cuesta relief typical of the edge of the Paris Basin. The soils are of average quality.

Moderate level issue

Located in the eastern part of the Paris Basin, the remote study area consists of a succession of limestone cuestas and clay depressions, as shown on figure 3-12.

The 400 kV transmission line crosses several morphological units in a straight line: the Saintois region (a vast, undulating clay plain), the southern tip of the Haye Plateau, the Meuse slopes, the Meuse Valley, the Barrois limestone plateau, and the Pays du Der.

In the immediate study area, elevations range from 215 m to 428 m. The proposed Cigéo disposal facility is located on the front and back slopes of the Côte des Bars, at elevations between 300 m and 400 m. The connected terminal and railway line 027000 run between 370 m and 215 m in elevation, following the Ognon and Ornain valleys.

Drinking water sources are located in the valleys at altitudes between 200 m and 300 m.

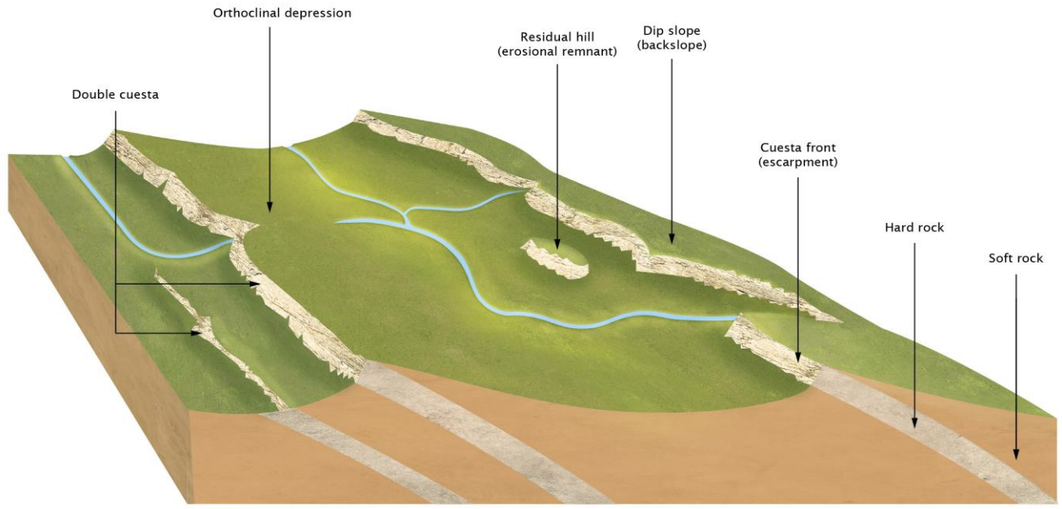


Figure 3-12 Sloping terrain or cuesta

3.3.1.2 Impact of earthworks

The construction of the Cigéo overall project involves adapting the site's topography to ensure optimal foundation for the structures and to meet both technical and operational safety requirements. Earthwork operations will generate significant earth movements and require the temporary storage of excavated material (removal of material) at certain locations on the site pending its reuse as backfill (addition of material).

3.3.1.2.1 The Cigéo disposal facility

Several mitigation measures are implemented to limit earth movements to or from the outside:

- taking the natural topography into account for the site's spatial layout;
- a project design aimed at balancing the backfill/excavated material balance: 12.5 million cubic metres of excavated soil and materials will be used as backfill *in situ*;
- site organisation based on the management of materials excavated on-site and their reuse according to their characteristics;
- Landscaping work begins immediately after the completion of the preliminary construction to ensure that stockpiled materials (tailings, embankments, etc.) blend into the landscape.

Upon completion of the work, the ramp zone is levelled, and the topography of the shaft zone is accentuated. However, the new contours are in keeping with the proportions of the existing terrain: the Excavated materials heaps do not exceed 20 metres in height, like the Chaufour mound; the access tunnel area accentuates the flat area on the backside of the slope where it is located.

Changes to the site's topography primarily concern the excavated materials deposit zone. Due to the nature of the project, which involves the extraction of materials resulting from the excavation of underground tunnels, the total volume of excavated materials deposited and transported through the excavated materials management platform located north of the shaft zone amounts to approximately 11 million cubic metres. The maximum area affected by land reclamation is approximately 147 ha (taking into account a third zone that could potentially be utilised by 2070–2080 if waste recycling streams were compromised).

The excavated materials management area is optimised: it allows for the retention of excavated material used for backfilling, which account for approximately 40% of the total volume of excavated materials, and for the management of unused materials flows, which are transported off-site for reuse.

Several reduction measures limit the impact of the excavated materials management area, within the perimeter of the nuclear facility, on the topography and landscape, notably its arrangement in a stepped pyramid with a maximum height of 20 metres. This design reinforces the existing relief without creating a new hill. The areas surrounding the shaft and the excavated materials management zones are reforested, blending them into a forested landscape. In addition, the excavated materials deposits will be gradually vegetated. After backfilling, the platforms will undergo ecological restoration to re-establish a natural habitat that integrates into the environment. Details of the measures are presented in chapter 3.4 of the Volume IV of this environmental impact assessment.

The residual impact after reduction measures is classified as low. No compensatory measures are necessary.

3.3.1.2.2 Other operations

Compared to the earthworks in the shaft and ramp zones, those required for other facilities and operations are minor in scale and consist mainly of:

- terracing the platform for the 400/90 kV substation near the ramp zone;
- digging trenches several metres wide for the underground electrical connections between the shaft and ramp zones;
- digging trenches several metres wide for water supply lines from the three water collection points;
- selective reinforcement of railroad crossings engineering structures along the 027000 railway line;
- terracing the platform for the deviation of the D60/960 departmental road near the ramp zone and, if necessary, construct watercourse crossings depending on the selected route option.

Their specific impact on the relief will be presented during subsequent updates of this environmental impact assessment associated with the necessary permits for these operations. However, for these operations, changes to the topography are limited to the occasional presence of mounds of earth on-site. The installation of the substation requires the terracing of 6 hectares of land. One variant of the D60/960 departmental road deviation requires earthworks to cross the Orge Valley. For the operations to secure the 400 kV transmission line, the water supply, and the upgrading of the 027000 railway line, no additional changes to the topography and/or earthworks are expected.

The impact of the other operations is classified as low for the deviation of the D60/960 departmental road and the electrical connection. It is very low for the water supply and the upgrading of the 027000 railway line. No compensatory measures are necessary.

The Cigéo overall project has a low level residual impact on topography.

3.3.2 Land use

3.3.2.1 Initial conditions

Environmental issue

The land is mainly used for crops and forests.

Moderate level issue

Land use reflects a distinctly rural charactertic, with agricultural areas accounting for 57.58% of land use and forested areas for 38.5%. The proportion of urbanised land is 3.8%, compared to 9.3% in metropolitan France. The largest urbanised areas are grouped into four sectors in the extended study area: in the Joinville sector in the southwest, in the Ligny-en-Barrois sector in the northeast, in the Saint-Dizier sector in the northwest, and in the Bar-le-Duc sector in the northeast. The other urbanised sectors consist of villages and a few industrial zones or quarries scattered throughout this rural territory.

Land use within the extended physical environment study area is presented in figure 3-13.

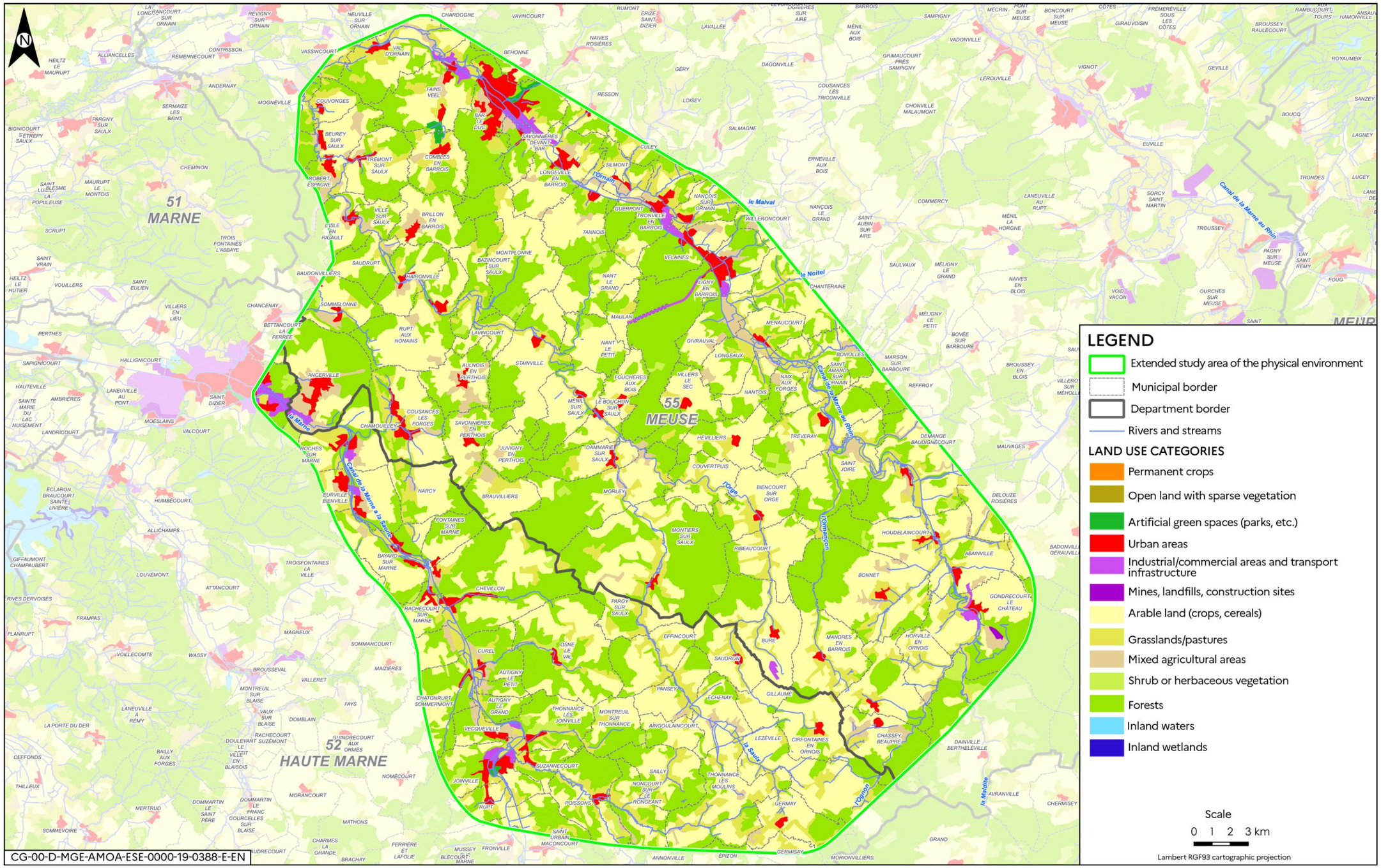


Figure 3-13 Land cover (Corine Land Cover, 2018 (85))

3.3.2.2 Impacts on land use and associated measures

In terms of land use, the choices made by Andra early on make it possible to avoid an overconsumption of agricultural land or natural areas while ensuring the necessary space for the project to proceed smoothly:

- by reusing existing rail infrastructure: the 027000 railway line between Nançois-Tronville and Gondrecourt-le-Château and the rail platform of the former Gondrecourt-le-Château/Joinville railway line over a distance of 10 km;
- by storing on-site only the excavated materials (Callovian-Oxfordian claystones), which are reused for backfilling the underground structures. Consequently, various options for utilising the excess excavated materials are currently being studied.

The project will result in changes to land use as soon as construction begins. For certain project operations, such as drinking water supply lines and underground power lines, the changes to land use are temporary, as trenches are systematically backfilled as work progresses. Certain construction site facilities positioned along the transportation infrastructure also temporarily alter land use.

For the other components of the project, the change in land use is permanent (disposal facility, electrical substation, deviation of the D60/960 departmental road). The potential project areas for the Cigéo disposal facility cover 721 hectares. For operations carried out by other project owners, the potential land requirements cover approximately 62 hectares.

For the Cigéo project as a whole, land-use changes are estimated over the entire project duration to be:

- approximately 587 ha for land artificialisation (including, but not limited to, soil sealing);
- approximately 192 ha to 231 ha for deforestation, depending on the utilisation of excavated materials, primarily in the shaft area and, to a lesser extent, in the ramp zone and part of the connected railway terminal. Deforestation will be gradual and dependent on the timeline for management of the excavated materials deposits;
- Approximately 347 to 415 ha of fields cleared for the ramp zone , the inter-site link, the connected railway terminal, the electrical substation, the water supply, the railway line revamping, and the deviation of the D60/960 departmental road.

Several measures are implemented to reduce the footprint of the Cigéo overall project:

- power supply via underground power lines;
- optimisation of the disposal facility's footprint through the installation of a multistorey car park in the shaft zone and the sharing of certain facilities between the shaft zone and the ramp zone; the creation of an inter-site link combining side-by-side lanes for heavy-duty and light vehicles and a conveyor, and the location of construction facilities for the shaft and ramp zones within the potential intervention area.

Other measures to reduce land use help minimise the area of artificial surfaces:

- potential work zones for components of the overall project located outside the disposal facility perimiter will be restored to their original condition upon completion works;
- green spaces will be created within the disposal facility;
- the gradual revegetation of theexcavated material deposits.

Apart from work related to the project's water and energy supply, work related to the Cigéo overall project impacts large areas (approximately 783 ha). The disposal facility, the 400 kV substation, and the deviation of the D60/960 departmental road are largely situated on agricultural land and natural habitats.

The residual impact, after the implementation of avoidance and reduction measures, is significant; therefore, measures to compensate for this are implemented. These concern the natural environment as well as agricultural and forestry activities:

- ecological compensation in forested areas, grasslands, and cultivated areas. Regardless of the habitat involved, these measures aim to diversify the environments to increase biodiversity by creating feeding, resting, nesting, and hibernation areas, as well as to restore ecosystem balance;
- financial contributions to the development of agricultural and forestry sectors and the reforestation of twice the area cleared.

The residual impacts of the Cigéo overall project on land use are moderate following the implementation of compensatory measures.

3.3.3 Contaminated or potentially contaminated sites and soils

» SOURCES AND METHODOLOGY

Polluted or potentially polluted sites

The inventory of polluted sites and soils was compiled using the BASIAS database (database of former industrial sites and service activities, whether active or not), the BASOL database on polluted (or potentially polluted) sites and soils requiring government action, whether preventive or remedial, and the Soil Information Sectors (SIS), which identify land where the government is aware of soil pollution justifying, particularly in the event of a change in land use, the conduct of soil studies and the implementation of pollution management measures to protect public health and the environment.

» CONTAMINATED SITE

A contaminated site is a site that, due to past disposal of waste or infiltration of pollutants, is contaminated in a way that may cause a nuisance or a long-term risk to people or the environment.

These situations are often due to past unscrupulous waste disposal practices, but also to accidental or intentional leaks or spills of chemicals. Contamination also exists around certain sites due to atmospheric emissions that have accumulated over the years or even decades.

3.3.3.1 Initial state

Environmental issue

No confirmed soil contamination has been identified in the northern part of the immediate study area. Industrial sites and service activities that may have impacted soil and groundwater quality have been identified in the southern part of the immediate study area.

Moderate issue

The BASOL databases (database provided by the Ministry of the Environment, on polluted or potentially polluted sites requiring government action) and the SIS soil information sectors (sites where the government is aware of soil contamination justifying the implementation of management measures)R list a former foundry where soil is contaminated in Joinville, within the close study area. However, a soil study has shown that it has no impact on the soil and groundwater in the immediate study area.

Industrial sites and service activities from the CASIAS database that may have impacted soil and groundwater quality are identified within the close study area. Within the immediate study area, these sites are primarily located along the 027000 railway line. Several sites are located in Gondrecourt-le-Château (a former landfill along the connected terminal, decontaminated and rehabilitated by Andra in 2019; a former furniture manufacturing site near the logistics hub); however, they are not or are no longer contaminated. The Andra Underground Laboratory runs alongside the access tunnel area, but no pollution has occurred on the site, either during construction or during operation. Other potential sources of pollution may be present in the immediate study area (fuel tanks, pesticides, creosotes, etc.).

3.3.3.2 Impacts on soil pollution and associated measures

» PROCEDURE TO BE FOLLOWED IN THE EVENT OF AN INCIDENT WITH AN ENVIRONMENTAL IMPACT

The relevant government agencies and/or the French Nuclear Safety and Radiation Protection Authority must be notified as soon as possible if an incident is detected that has caused an environmental contamination.

An incident may have several causes: an act of malice (vandalism, arson, etc.) or the detection of an anomaly during the interpretation of monitoring results for various environmental components (air, water, biodiversity, etc.) and their comparison with the initial state, or baseline.

An analysis of the incident's impact on the various environmental components is conducted to determine the necessary action plan to address it.

3.3.3.2.1 During preliminary development and initial construction phases

During the preliminary works and initial construction phases, small-scale accidental pollution incidents may occur. To limit this risk, storage facilities suitable for hazardous materials and waste will be established in potential work zones, and the construction site will be organised accordingly (traffic plan, use of eco-friendly products, material quality control, petrol stations, signage, pollution control kits, etc.).

To limit the risk of dust emissions, the paths used by construction vehicles will be paved as soon as possible. Weather conditions will be taken into account to adjust procedures, such as watering the paths during dry weather. Equipment and trucks will be equipped with tarpaulins and covers.

Details of the measures are presented in chapter 3.5 of Volume IV of this environmental impact assessment.

3.3.3.2.2 During the operational phase

Environmental issue

The study area, which is remote from the surrounding environment, exhibits high tectonic and stratigraphic stability. The characteristics of the Callovian-Oxfordian formation are effective for the retention of radioactive elements.

Low level issue

During the operational phase, soil contamination may result from the deposition on the ground of radioactive elements released into the air and from incidental contamination such as fuel leaks from lorries or construction equipment.

This pollution is classified as incidental, as opposed to accidental pollution, which is not addressed here but is covered in the "Risks" section of the "3.11" chapter of this non-technical summary.

The main sources of pollution identified during the operational phase are fuel leaks from construction machinery and heavy-duty vehicles, as well as accidental pollution. The risk of fuel leakage onto the ground is limited by the fact that machinery and heavy vehicles operate on impervious surfaces, from which runoff is collected and treated before being discharged into the natural environment. Several avoidance and mitigation measures related to runoff management and waste management are planned.

Modelling results show that the accumulation of potential ground deposits of radioactive elements released into the air under normal conditions is extremely low. These amounts are on a scale that cannot be detected by current measurement techniques.

The Cigéo overall project has a very low level residual impact on soil contamination.

3.4 The subsoil

Within the Cigéo overall project, it is primarily the Cigéo disposal facility that could potentially impact the subsoil, as it is built around an underground facility excavated 500 metres below ground. The other facilities and operations of the Cigéo overall project are likely to affect only the few metres of subsoil closest to the surface. Furthermore, the facilities of the Cigéo overall project may be subject to ground movements and seismic risks.

3.4.1 Geological characteristics favourable to the disposal of HLW and ILW-LL

3.4.1.1 Initial state

3.4.1.1.1 Tectonics

» TECTONICS

Tectonics is the study of geological structures on a scale of kilometres and larger (mountain ranges, sedimentary basins) and the mechanisms responsible for them. This discipline is directly linked to plate tectonics. Originally called continental drift, plate tectonics is related to mantle dynamics (convective movements) and their mechanical and thermal effects at the surface (earthquakes, volcanoes, the formation of oceans and mountain ranges, etc.). The **lithosphere**, the Earth's outer layer comprising the crust and part of the upper mantle, is divided into rigid, mobile plates—tectonic plates—that "float" and move over the asthenosphere, the upper part of the Earth's mantle, which is more ductile and viscous. **Tectonic plates**, also known as lithospheric plates, are about 100 kilometres thick and are fragments of the lithosphere resulting from its fragmentation due to movements in the mantle, which manifests as a system of faults, ridges, rifts, and subduction zones. Lithospheric plates move a few centimetres per year in different directions, leading to the formation of divergence, subduction, collision, and strike-slip zones. It is in the narrow zones where they meet that deformations are concentrated (oceanic rifts where they diverge, formation of mountain ranges where they converge) and where most earthquakes occur.

The extended study area of the physical environment, is located east of the Paris Basin, which is a remarkably stable zone.

Three fault zones, inactive for at least 2 million years and likely 25 million years, are present to the west and south of the study area:

- the Marne basement faults trending north-northwest/south-southeast and the Joinville Trench cover faults trending northeast/southwest;
- the "ponytail" cluster of medium-sized faults trending northwest/southeast, forming the southern extension of the Marne fault system and constituting the so-called "diffuse fracturing" zone on the western edge of the transposition zone (ZT);
- the cover faults of the Gondrecourt-le-Château trending northeast/southwest.

At the heart of the near study area, the transposition zone (see Figure 3-14) where the Cigéo disposal facility is to be located is free of detectable faults.

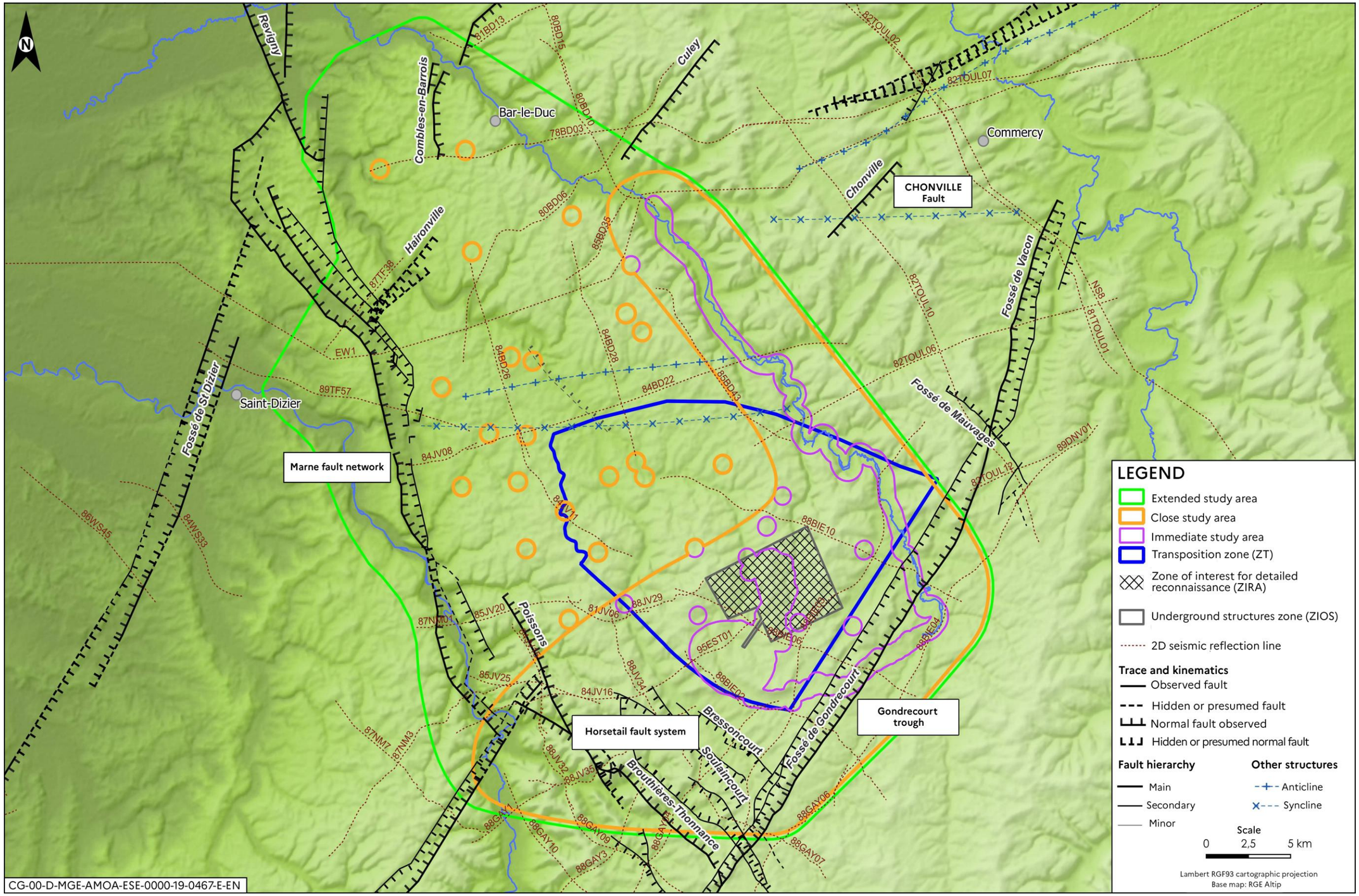


Figure 3-14 Local tectonic context

3.4.1.1.2 Stratigraphy

» STRATIGRAPHY

The study of the spatial and temporal arrangement of geological layers or strata is called **stratigraphy**.

The stratigraphic context is based on bibliographic analyses supplemented by numerous investigative campaigns. Several 2D and 3D seismic surveys were conducted, as well as more than forty boreholes going several hundred metres deep. The core samples extracted from the boreholes underwent numerous analyses: sedimentology, chemical composition, mineralogical quantification, microscopic observations, porosity measurements, permeability and tracer diffusion measurements, and geomechanical testing.

These operations made it possible to clarify the geometry of the layers comprising the subsurface, to confirm the homogeneity of the Callovian-Oxfordian claystone layer, and to confirm the absence of faults within it. Knowledge regarding the behaviour of argillites (particularly their containment capacity and the suitability of underground structures) was expanded through experiments and investigations conducted at the Meuse/Haute-Marne Underground Research Laboratory .

The extended physical environment study area is located on the eastern edge of the Paris Basin, consisting of alternating predominantly clayey and limestone sedimentary formations deposited between 250 million and 135 million years ago, as shown on the figure 3-15.

The path of the 400 kV Houdreville–Méry line crosses the geological formations that constitute the outer edges of the Paris Basin. From east to west, the following formations are encountered: the predominantly marly Lias formations, the Dogger limestone formations, the Upper Jurassic formations, and finally the softer Cretaceous formations.

The geological formations present in the subsurface of the physical environment extended study area are, from the most recent at the surface to the oldest at depth:

- Quaternary formations, mainly in the Ornain valley;
- the Late Jurassic and undifferentiated Cretaceous formations (lower part of the Valanginian formation at a few high points);
- the Barrois Limestones, approximately 40 metres thick around the Meuse/Haute-Marne Underground Research Laboratory and exhibiting diffuse karstification in this same area;
- the Kimmeridgian Marls, approximately 110 metres thick beneath the shaft zone;
- the carbonate Oxfordian, approximately 280 metres thick around the Meuse/Haute-Marne Underground Research Laboratory;
- the Callovian-Oxfordian at depths ranging from 443 metres to 594 metres below the shaft zone. This predominantly clayey layer is laterally homogeneous over 350 km²; its mineral structure gives it very low permeability, and the clay minerals provide it with a high capacity to retain radioactive elements, which is a key factor in its selection for the underground disposal facility;
- the Dogger Limestone, more than 200 metres thick.

These formations have a general dip towards the centre of the Paris Basin of approximately 1.5° to the northwest. The limestone strata serve as pathways for water flows.

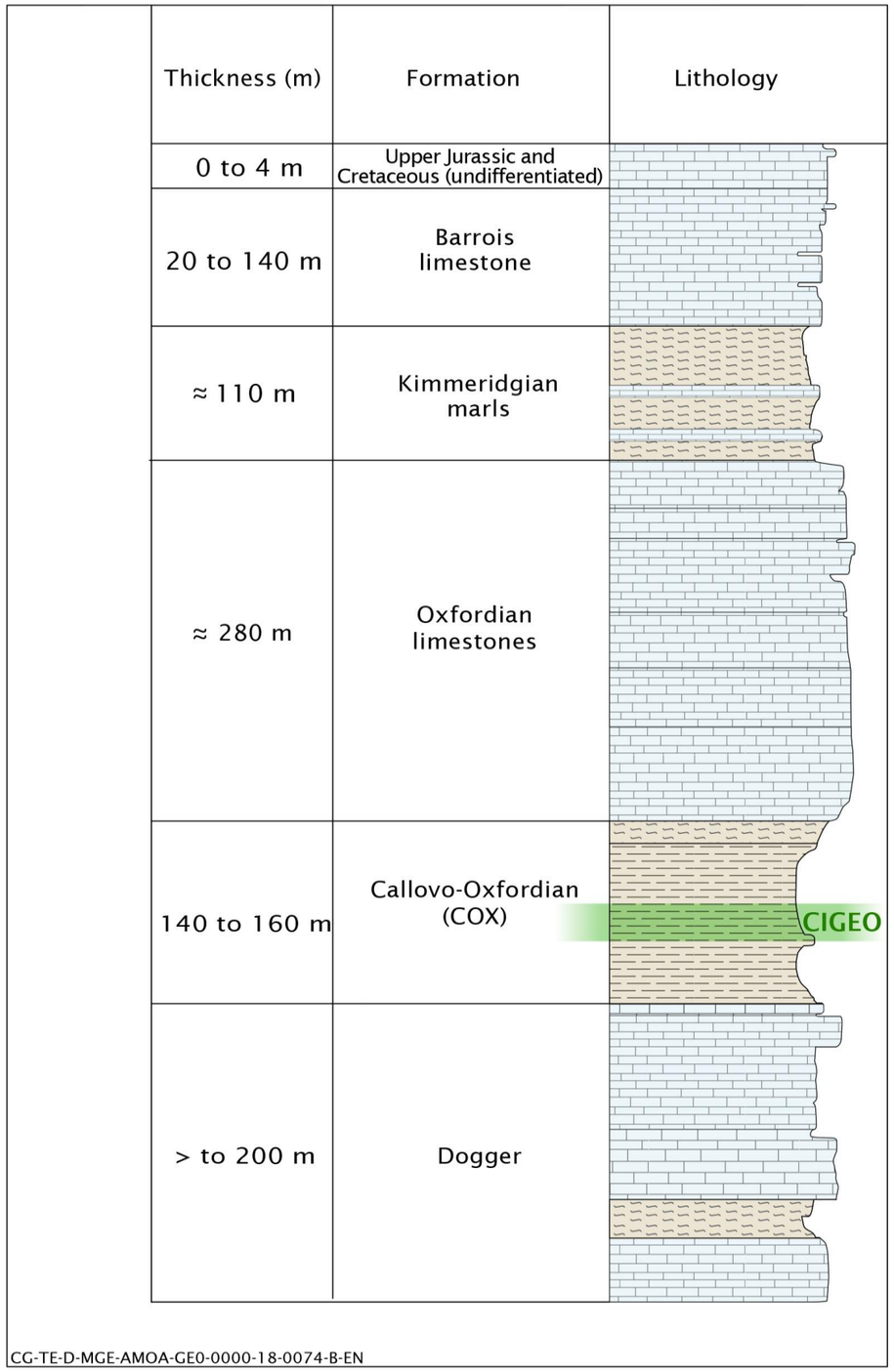


Figure 3-15 Schematic sequence of geological formations in the extended study area

3.4.1.1.3 Radiological characteristics of the subsurface

Data on the radiological characteristics of the subsurface are derived from the analysis of rock samples collected during the drilling campaigns described above. Samples corresponding to material extracted from the Callovian-Oxfordian argillite layer during the excavation of the underground galleries of the Underground Laboratory were also studied.

The radioactive elements present in the geological formations of the subsurface are exclusively of natural origin. Radioactivity levels are low and are within the range expected in these types of geological formations. The level of natural radioactivity measured in degassed water from the Callovian-Oxfordian is low (approximately 1 Bq/L).

3.4.1.2 Impact and measures

Waste packages are stored in the hard claystone layer of the Callovian-Oxfordian, which was deposited approximately 160 million years ago and lies at a depth of about 500 metres. Consequently, the disposal facility is protected from human activities and natural events at the surface over the very long term.

The selection of this site was the result of several decades of research to ensure the protection of people and the environment. The Cigéo overall project is located in the eastern part of the Paris Basin, which is one of the most geologically stable areas in France. The phased construction of the Cigéo disposal facility involves a careful sequence of construction operations and the successive commissioning of parts of the disposal facility throughout its operational lifespan.

The Callovian-Oxfordian layer is primarily composed of *"clays*," hence its common name *"argillites*." All experiments conducted on this rock, particularly at the Meuse-Haute-Marne Underground Laboratory, have demonstrated that it possesses the necessary properties for the containment of radioactive waste:

- the Callovo-Oxfordian formation has very low permeability, and water flow is very limited;
- due to this very low permeability, radioactive elements move primarily by diffusion within the rock, and this diffusion is very slow;
- Callovo-Oxfordian argillites possess high retention capacities for most radioactive elements and contain a significant proportion of clay minerals, which bind these elements to their surface;
- the chemical composition of the water in the rock results in very low solubility for most radioactive elements.

Cigéo's disposal cells and underground structures will be located in the middle of the formation, allowing for maximum clay content and a significant, uniform thickness from the top to the bottom.

Long-term safety is ensured passively, meaning that human health and the environment are protected from the radioactive elements and toxic chemicals contained in the radioactive waste without the need for intervention.

Long-term protection of human health and the environment relies on the Callovian-Oxfordian layer, which plays a central role in this protection, supplemented by structural measures such as the sealing of the facilities and the packaging of the waste.

For example, of the 144 radionuclides contained in the HLW and ILW-LL waste packages, only iodine-129 (^{129}I), chlorine-36 (^{36}Cl), and selenium-79 (^{79}Se)—which are not retained by the clay—will very slowly migrate as solutes and to a limited extent (by diffusion) into the Callovian-Oxfordian layer.

The Cigéo disposal facility accepts only primary waste packages that meet all the criteria defined in the acceptance specifications. The conditioning of radioactive waste destined for the Cigéo disposal facility consists of immobilising the radionuclides in a non-dispersible form within a container (stainless steel container, concrete shell, etc.).

The design of the underground facility ensures that the characteristics of the Callovian-Oxfordian formation are preserved: the disposal cells are designed to minimise any risk of collapse during excavation and during the operational phase. They are also designed to limit the migration of radionuclides after the disposal facility is closed. Finally, waste disposal operations and cell excavation are geographically separated within the perimeter of the basic nuclear facility during the operational phase to limit chemical and thermal interactions between waste categories.

A protection zone, as provided for in Article L. 542-10-1 of the French Environment Code, has been defined. Its purpose is to protect the facilities and activities of the Cigéo disposal facility from the effects of activities or work carried out by third parties on the surface or underground during the operational and monitoring phases.

Accidental physicochemical contamination of the subsoil

During the three phases of preliminary works, initial construction, and operation, the main risk of subsoil pollution concerns accidental contamination linked to construction equipment and runoffs that could reach exposed geological layers. This risk is minimal, and the overall impact of the work on the subsoil is very low.

The Cigéo overall project has a very low residual impact on people and the environment.

3.4.2 Major risks related to geology

MAJOR RISKS

Major risks are the potential serious consequences for populations, property, and economic activity caused by exceptional natural phenomena. The concept of "major risks" is defined in particular in the departmental major risk files (DDRM) for Meuse and Haute-Marne (91, 92), with Article L. 125-2 of the French Environment Code requiring the State to inform all persons of the major risks to which they are exposed in certain areas of the territory. Land movements are more or less abrupt gravitational displacements of the soil or subsoil caused by natural stresses (snowmelt, rainfall, earthquakes, dissolution due to water infiltration, etc.) or anthropogenic stresses (earthworks, vibrations, deforestation, mining of materials or aquifers, etc.).

Shrinkage of clay soils due to drying (or swelling and shrinkage of clays) during a severe and/or prolonged drought causes deformations of the soil surface (differential settlement). This may be followed by swelling as initial moisture conditions are restored, or, more rarely, by creep accompanied by softening.

The risks of ground movement are addressed by consulting the Departmental Major Risk Files, the databases of the French Geological Survey (BRGM) and the Géorisques website.

Seismic risk is assessed using bibliographic resources (scientific publications, historical earthquake records, and seismicity catalogues), drilling campaigns, seismic studies, and studies on the seismotectonics and internal geodynamics of the eastern Paris Basin conducted for Andra, as well as the characterisation of faults in the area and the seismic monitoring network.

3.4.2.1 Initial state

Environmental issue

The immediate study area is not subject to major risks related to large-scale geology.

Low level issue

A few natural cavities have been identified, particularly in the centre of the extended physical environment study area. The 400-kV Houdreville–Méry power line crosses two large areas with a high risk of surface clay shrinkage and swelling: the Saintois region and the Pays du Der region. In very specific locations, certain sectors are characterised by a high risk of clay shrinkage and swelling. The primary natural risk related to geology, identified in the study area away from the physical environment, is that of collapse of karst cavities in the Barrois limestones, and it is classified as low.

Clay outcrops are subject to the risk of clay shrinkage and swelling. The high risk is rarely present in the extended study area. It is low on the Chaufour hill and in the Lejuc woods, and it is moderate in certain valleys: the Orge, the Ornain, and their affluent, including the Ormançon.

The entire extended study area and the specific study area of the 400 kV transmission line are located in seismic zone 1, meaning they exhibit seismic activity classified as “very low.” Any tectonic activity capable of triggering earthquakes along neighbouring faults is ruled out.

The injection of gas into the Cerville underground gas storage facility, located 70 km to the east, and the Trois-Fontaines-l’Abbaye site, located more than 40 km to the north-northwest, causes induced seismicity characterised by events of very low magnitude.

Despite very low, if not non-existent, seismic activity, seismic monitoring has been conducted since 2001 to obtain precise data on seismic activity. Andra has established a high-performance seismic monitoring network on the surface and within the Underground Laboratory, enabling highly detailed measurement of seismic activity and the ability to distinguish its origin (natural or human).

3.4.2.2 Impacts and measures

3.4.2.2.1 Vulnerability to natural and human-induced seismic risk

The selection of the site for the Cigéo disposal facility was the result of several decades of research to ensure the long-term safety of the repository. This was a lengthy decision-making process that led, first, to the selection of clay-based disposal and, second, to the identification of the underground structures zone (ZIOS) within a geological zone of very low seismic activity, where the seismotectonic context currently prevailing in the region is expected to persist for the next million years. Details of the measures are presented in chapter 4.3 of Volume IV of this environmental impact assessment.

The Cigéo disposal facility is constructed, designed, and operated in accordance with the specific regulations applicable to nuclear facilities, so that in the event of an earthquake, the facilities remain in a “safe” state and the event does not result in any adverse effects on human health or the environment.

The Cigéo overall project’s vulnerability to seismic risk is very low.

3.4.2.2.2 The risk of clay swelling and shrinkage, cavities, and subsidence

Among the natural hazards identified, the risk of clay shrinkage and swelling constitutes the primary natural hazard identified in the vicinity of the Cigéo overall project. Certain sections of the project are subject to a low hazard level, such as in the shaft zone and, in isolated instances, in the Orge valley near the new platform of the connected terminal . Another sector is subject to moderate risk: the 027000 railway line. Certain sections of power supply lines cut accross areas classified as of high to very high risk, particularly in the humid Champagne region.

Regarding the risk of cave-ins, karstification of the Barrois limestones outcropping around the disposal facility is diffuse. The dissolution zones are therefore small. The risk of dissolution is low in the project area where the activities are projected to take place.

To mitigate natural hazards, excavation methods are adapted to the characteristics of the encountered terrain. Furthermore, thanks to geotechnical studies, the foundations of buildings and structures are adapted to the geotechnical context, thereby reducing damage associated with natural hazards.

The Cigéo overall project’s vulnerability to risks of clay shrinkage and swelling, cavities, and settlement is very low.

The potential accidental collapse of an underground structure (tunnel), or even the entire underground facility, would have a mechanical ripple effect limited to a few metres, or at most a dozen metres, in the vicinity of the collapsed structures, and would have no perceptible impact on the surface.

The impact of the Cigéo overall project, and in particular the BNI, on the risk of ground movement (collapse) is very low.

3.4.3 Subsurface resources

DATA ON NATURAL RESOURCES

Data on natural resources are derived from studies that form the foundation of Cigéo’s scientific and technical knowledge, as well as from the quarry plans of the Haute-Marne and Meuse administrative departments (93).

3.4.3.1 Initial state

Environmental stake

The immediate study area does not contain any particular or exceptional geological resources.

Low-level stake

No specific or exceptional deposits of natural resources—whether quarry materials, minerals, hydrocarbons, or geothermal resources—are present in the extended study area.

Outside the extended study area, the former Forcelles oil field in Meurthe-et-Moselle and the Trois-Fontaines-l’Abbaye gas field, converted into a storage site in 2010 near Saint-Dizier, are located approximately 54 km to the east-southeast and 39 km to the northwest, respectively.

3.4.3.2 Impacts and measures

3.4.3.2.1 Resource exploitation

While selecting a site capable of hosting radioactive waste storage, areas with exceptional or unique characteristics in terms of underground resources were avoided, as recommended by the French Nuclear Safety Authority’s (ASN) safety guide on the final disposal of radioactive waste in deep geological formations (33).

No quarries are currently in operation within the potential project area of the Cigéo overall project. The Cigéo disposal facility is located at a site that does not contain any geological or geothermal resources of an exceptional nature.

The Cigéo overall project has a very low level residual impact on the exploitation of subsurface resources.

3.4.3.2.2 The need for construction materials

Within the Cigéo overall project, the construction of the disposal facility generates the greatest need for construction materials. To align the storage facility with France’s policy guidelines and ensure its operational safety, the underground facility is deployed in phases. This approach avoids unnecessary excavation. In peak years, the demand for construction materials can reach up to 180,000 tons of cement, 720,000 tons of gravel, and more than 570,000 tons of sand.

The Grand Est region is home to cement plants and crushing facilities with a total annual production of just under 3.2 million tons. This production therefore more than covers the projected needs for the Cigéo disposal facility, which account for less than 6% of the region’s capacity.

At its peak, during the initial construction phase, the Cigéo disposal facility’s annual consumption of sand and gravel will reach just under 1.3 million tons, or about 1.5% of the Grand Est region’s annual production. Quarries in the Grand Est region are therefore likely to meet all of the Cigéo disposal facility’s sand and gravel needs.

Given the quantities involved, Andra is exploring the implementation of several practices aimed at reducing this need: precise sizing, extruded structures, recovery of concrete waste, reuse of limestone extracted during the excavation of surface-underground connections underground connections, use of recycled materials, reuse of fresh concrete slurry, and recovery of hardened concrete slurry, subject to compliance with specific concrete mix designs. Details of these measures are presented in chapter 4.5 of Volume IV of this environmental impact assessment.

The Cigéo overall project has a low residual impact on the use of subsurface resources.

3.4.4 Compatibility with the Grand Est regional quarry plan

Due to its industrial and nuclear nature, the construction of the Cigéo overall project requires, on the one hand, the use of significant quantities of materials (aggregates, cement, sand) and, on the other hand, very specific concrete mixes for certain surface structures as well as for the tunnels that will be used to store radioactive waste. To limit demand on natural resources, the use of recycled materials is prioritised for site works and construction, provided that the performance of the materials and of the concrete is met. The recovery of excavated materials (reused for drifts backfilling, quarry backfilling, and use as a base component in cement manufacturing) also helps limit the overall demand on natural resources. Thus, the Cigéo overall project is compatible with the regional quarry plan for the Grand Est region (94).

The Cigéo overall project is compatible with the departmental quarry plans for Haute-Marne and Meuse.

3.5 Water

Water circulates on Earth in various forms: clouds, rain, rivers, and oceans. It moves from the sea to the atmosphere, then from the land to the sea, following a cycle that repeats indefinitely through several stages (see Figure 3-16):

- evaporation and evapotranspiration: part of the seawater turns into water vapor under the sun's heat, just as water from plants and animals does through evapotranspiration;
- condensation: clouds form in the sky;
- precipitation: clouds aggregate and then turn into rain, snow, or hail;
- infiltration: some of the rainwater seeps into **the groundwater**;
- runoff: another portion of the water flows into **surface water bodies**: streams, rivers, lakes, etc.;
- storage: water is stored in natural reservoirs (groundwater and surface water) for varying lengths of time (e.g., 8 days in the atmosphere, 17 years in lakes, 2,500 years in the oceans…);
- return to the sea: water from natural reservoirs evaporates under the sun's heat and then returns to the seas and oceans.

Surface water encompasses all flowing or stagnant bodies of water in direct contact with the atmosphere. These waters can be fresh, brackish, or even salty depending on their location. Within the Cigéo site area, surface waters are made of freshwater found primarily in rivers, lakes, and wetlands.

A watercourse flows from its source, located at its highest elevation (the headwaters), and extends to its outlet, at its lowest point (the tailwaters). The entire area that collects water flowing towards a single point (the outlet) constitutes its watershed (learn more about watersheds). From the source to the outlet, a watercourse is fed by other watercourses (its affluents), runoffs from precipitation, and groundwaters. Within the same basin, all aquatic environments (lakes, rivers, the sea, groundwater, etc.) are interdependent.

Groundwater refers to all water reserves found underground. Water is stored in zones called aquifers, composed of porous and/or fractured rock. Water can accumulate in these voids to form aquifers, which occupy all or part of the aquifer. The depth of aquifers varies: the deepest ones can be found several hundred metres below the surface.

Groundwater originates from the process of infiltration. Following rainfall, some of the water seeps into the pores and cracks in the soil. Drawn by gravity, it passes through the soil and infiltrates the subsurface until it is blocked by a compact, impermeable layer. The water then accumulates in all the empty spaces of the aquifer, forming a groundwater table.

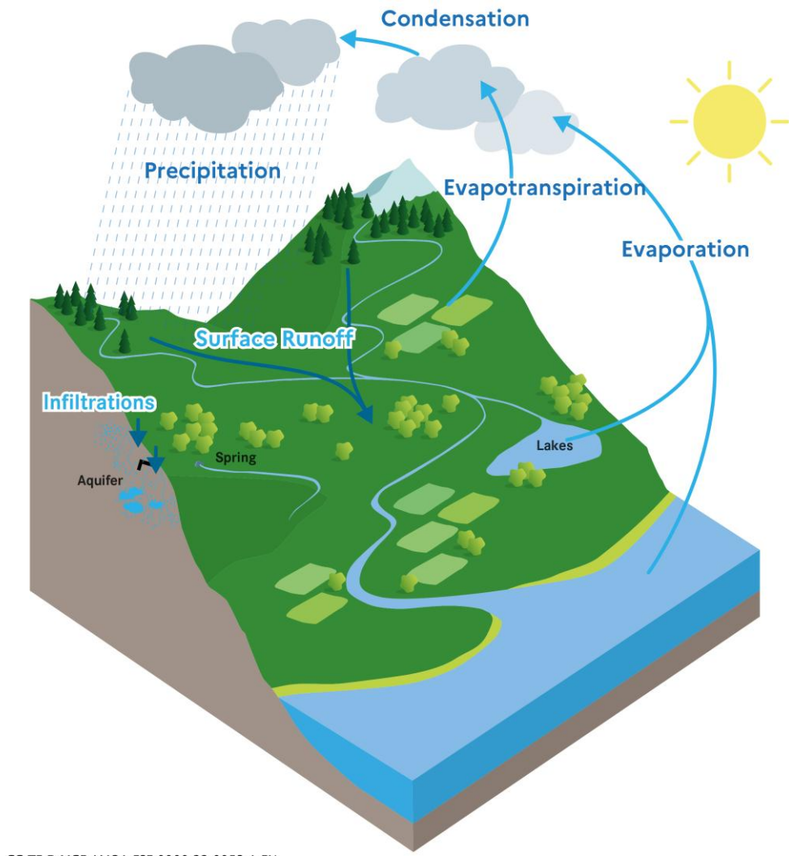


Figure 3-16 Water Cycle

Groundwater interacts with other aquatic environments. Freshwater ecosystems are in fact likely to be fed by groundwater, particularly during low-flow periods when it ensures the maintenance of minimum flow rates. And during floods, aquatic environments—particularly rivers—can contribute to the replenishment of groundwater tables.

In France, as in other European Union member states, water "management plans" are governed by EU law as set forth in the 2000 Water Framework Directive (WFD) (95).

These are the Water Development and Management Master Plans (SDAGE). Established by the 1992 Water Act (96), these planning documents have evolved in accordance with the European Water Framework Directive (WFD). They set out six-year guidelines to achieve the expected objectives regarding "good water status" within a single major river basin.

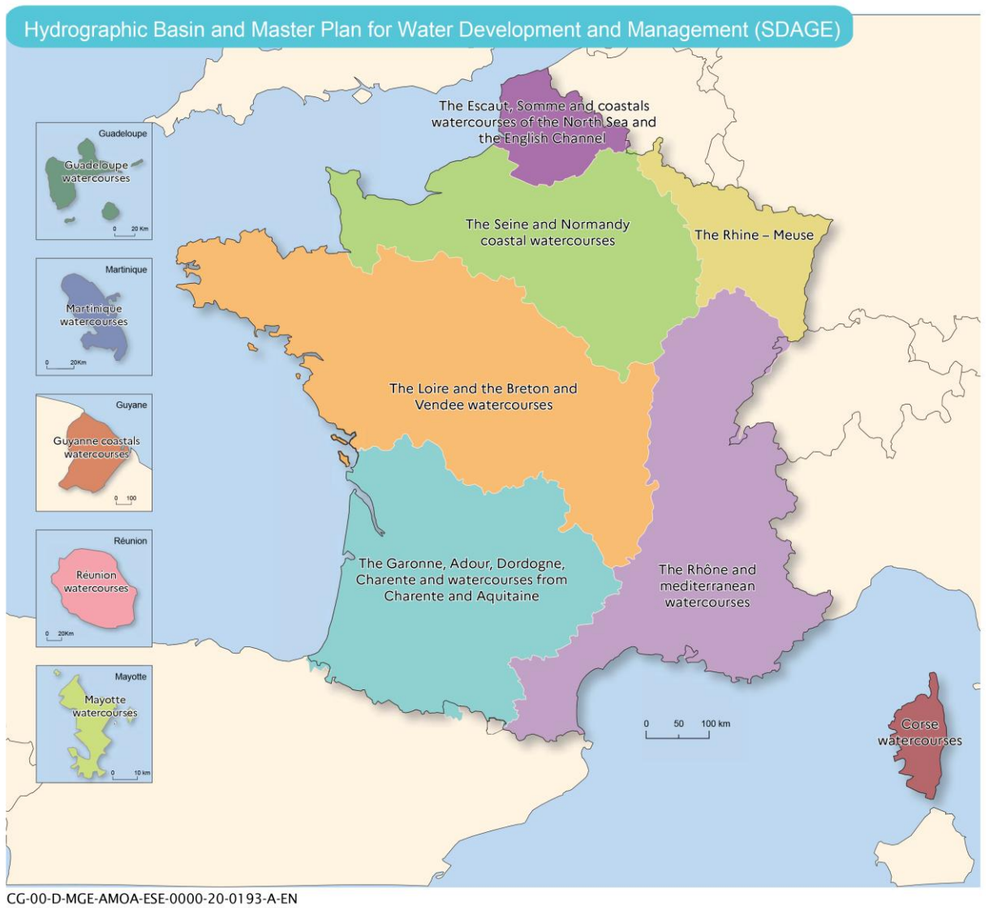
To assess the potential impacts of the Cigéo overall project on water bodies, it is therefore important to characterise the initial condition of surface waters (rivers, lakes, and wetlands) as well as groundwater. This assessment is based on quantitative and qualitative indicators, as well as a description of the "pressures" exerted on aquatic environments within the region.

The objective is to demonstrate the project's compatibility with the SDAGE water management planning documents.

» DRAINAGE BASIN

A drainage basin corresponds to the entire area that receives water flowing towards a single watercourse or a single groundwater aquifer.

It is bounded by drainage divide between different basins. These divides are natural boundaries that correspond to ridgelines. Rain falling on one side or the other of this divide will feed two adjacent drainage basins. A river's drainage basin is composed of the sub-basins of its tributaries.



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Figure 3-17 Water Development and Management Master Plans (SDAGE) in France

3.5.1 Initial state

3.5.1.1 Water management planning tools

The Cigéo overall project is subject to two types of water management planning tools in effect within the extended study area and the specific area of the 400 kV transmission line: the SDAGEs for the Seine basin and the Normandy coastal waterways (97) and the Rhine-Meuse (98–102), and the SRADDET Grand Est (103). There is no SAGE in the extended physical environment study area, nor within the specific study area of the 400 kV transmission line.

No river-type environmental contract exists within the immediate study area of the Cigéo overall project.

3.5.1.1.1 The water development and management master plan (SDAGE) applicable to the Cigéo overall project

The Cigéo overall project is covered by two water development and management master plans, namely:

- the 2022–2027 SDAGE for the Seine basin and Normandy's coastal waterways, adopted by the basin committee on March 23, 2022 (97). The SDAGE is structured around five fundamental priorities identified at the basin level, specifically to reduce pollution, revitalise rivers, wetlands, and water-related biodiversity, address climate change, balance economic activities with the preservation of coastal and littoral environments, and strengthen basin governance and solidarity;
- The Rhine-Meuse SDAGE 2022–2027, adopted by the Rhine-Meuse basin committee and approved by the basin coordinating prefect on March 18, 2022 (98–102), at the eastern end of the 400 kV transmission line from Gondrecourt-le-Château to Houdreville. The SDAGE is structured around six major water-related themes: health, pollution, biodiversity, water scarcity, land use planning, and governance.

3.5.1.1.2 The regional plan for land use and sustainable development (SRADDET) for the Grand Est region

The Grand Est region's SRADDET, adopted on November 22, 2019, and approved on January 24, 2020 (103), provides the region and its territories with a strategic tool to realise a collective ambition and address the three challenges identified in the SRADDET's territorial assessment:

- building the region at every level and strengthening cooperation;
- to transcend borders to expand the influence of the Grand Est region;
- successfully managing territorial transitions.

The objectives related to the "water" component of the Grand Est SRADDET are:

- Objective 6: Protect and enhance the natural heritage, the functionality of ecosystems, and the landscapes;
- Objective 7: Preserve and restore the green and blue infrastructure;
- Objective 10: Improve the qualitative and quantitative management of water resources.

These three objectives are broken down into four guidelines applicable to the Cigéo overall project.

In the extended study area, several municipalities (six in Haute-Marne and two in Meuse) are affected by nitrate vulnerability zones and a vulnerable water intake. In the municipalities closest to the Cigéo overall project, only the Échenay water intake is classified as vulnerable under the nitrates directive (104), and a programme of agri-environmental and climate measures is implemented in the water intake's catchment area. There is no groundwater distribution zone in the remote physical environment study area, nor within the specific study area of the 400 kV transmission line. The Albian-Neocenian confined aquifer (FRHG218) is nevertheless affected by the Albian aquifer distribution zone (No. 03001).

Six watercourses are identified within the immediate study area of the Cigéo overall project as biological reservoirs. Two watercourses within the specific study area of the 400 kV transmission line are also identified as corridor reservoirs.

The extended physical environment study area and the specific study area for the 400 kV transmission line are covered by two flood risk management plans.

Environmental issues related to water management planning tools

The Cigéo overall project is located in a region facing significant challenges regarding both groundwater and surface water.

Compliance with the five fundamental guidelines of the 2022-2027 Seine-Normandy SDAGE applicable to the extended physical environment study area and compliance with the six themes of the 2022-2027 Rhine-Meuse SDAGE, which applies to the eastern end of the 400 kV transmission line beyond Gondrecourt-le-Château, are a major challenge for the Cigéo overall project.

Finally, compliance with the rules established to achieve the three objectives related to the water component of the Grand Est SRADDET is a major challenge for the Cigéo overall project.

High level issue

3.5.1.2 Surface water

SOURCES AND METHODOLOGY

The hydrographic network was determined using data from the current Seine-Normandy and Rhine-Meuse basin water development and management plans (97, 100) and information and maps available on the website of the national water data and reference system administration (Sandre). The departments of Meuse and Haute-Marne also include a prefectural list of watercourses considered to be rivers.

The determination of watercourse flows is based on data from stations in the France water network (Banque Hydro). Additional data from the continuous and spot monitoring stations of the *Observatoire Pérenne de l'Environnemen*t (permanent environmental observatory) provide a better understanding of how the surface water function and their condition.

The determination of the water quality status of watercourses is based on the 2019 status report by the Seine-Normandy water agency (105) and on the current water development and management plans for the Seine-Normandy and Rhine-Meuse basins. Additional data from the area surrounding the Cigéo disposal facility, obtained from the network of the *Observatoire Pérenne de l'Environnement*, is also used.

Under the European Water Framework Directive (EWFD), a surface water body is in good status when it has achieved both good ecological status (which includes hydromorphological, biological, and physico-chemical status) and good chemical status, which corresponds to compliance with European standards.

The inventory of land uses was conducted based on documentary evidence as well as through a survey.

The flood risk analysis was based on all relevant administrative documents (atlas of flood-prone areas, flood risk prevention plans, etc.) and the use of numerical models.

The baseline status of surface water bodies therefore aims to describe: the hydrology, hydromorphology, and chemical and ecological conditions of the various watercourses. To facilitate understanding, it will be presented by hydrographic sub-sector affected by the disposal facility's operations.

3.5.1.2.1 Surface water bodies (watercourses and bodies of water)

The Cigéo overall project is primarily located within the large Seine-Normandy drainage basin. At the eastern end of the 400 kV transmission line, the project also overlaps with part of the Rhine-Meuse drainage basin between Gondrecourt-le-Château and Houdreville.

The Cigéo overall project is therefore covered by the SDAGE for the Seine basin and Normandy coastal waterways (2022-2027) (97) and the Rhine-Meuse basin (98-101) (2022-2027).

The remote study area falls within two hydrographic units:

- the Marne-Blaise, specifically the Marne watershed from the confluence of the Rognon to the confluence of the Blaise;
- the Saulx-Ornain unit, comprising the Saulx watershed from its source to the confluence with the Ornain and the Ornain watershed from its source to the confluence with the Saulx.

The 400 kV transmission line also intersects the Aube, Meuse, and Moselle hydrographic units, specifically the Aube, Voire, and Blaise drainage basins within the Seine-Normandy basin.

Thus, within the Seine-Normandy drainage basin, 22 rivers and streams and one navigable waterway are included in the study area affected by the Cigéo overall project and by the work to secure the 400 kV transmission line. The immediate study area primarily intersects the Saulx and Ornain watersheds, and to a lesser extent, the Marne watershed. The main watercourses affected by the project's operations are:

- the Orge and the Bureau in the Saulx drainage basin;
- the Ormancon, the Ornain, and certain small tributaries (the Étang Stream, the Naillemont Stream, etc.) in the Ornain drainage basin.

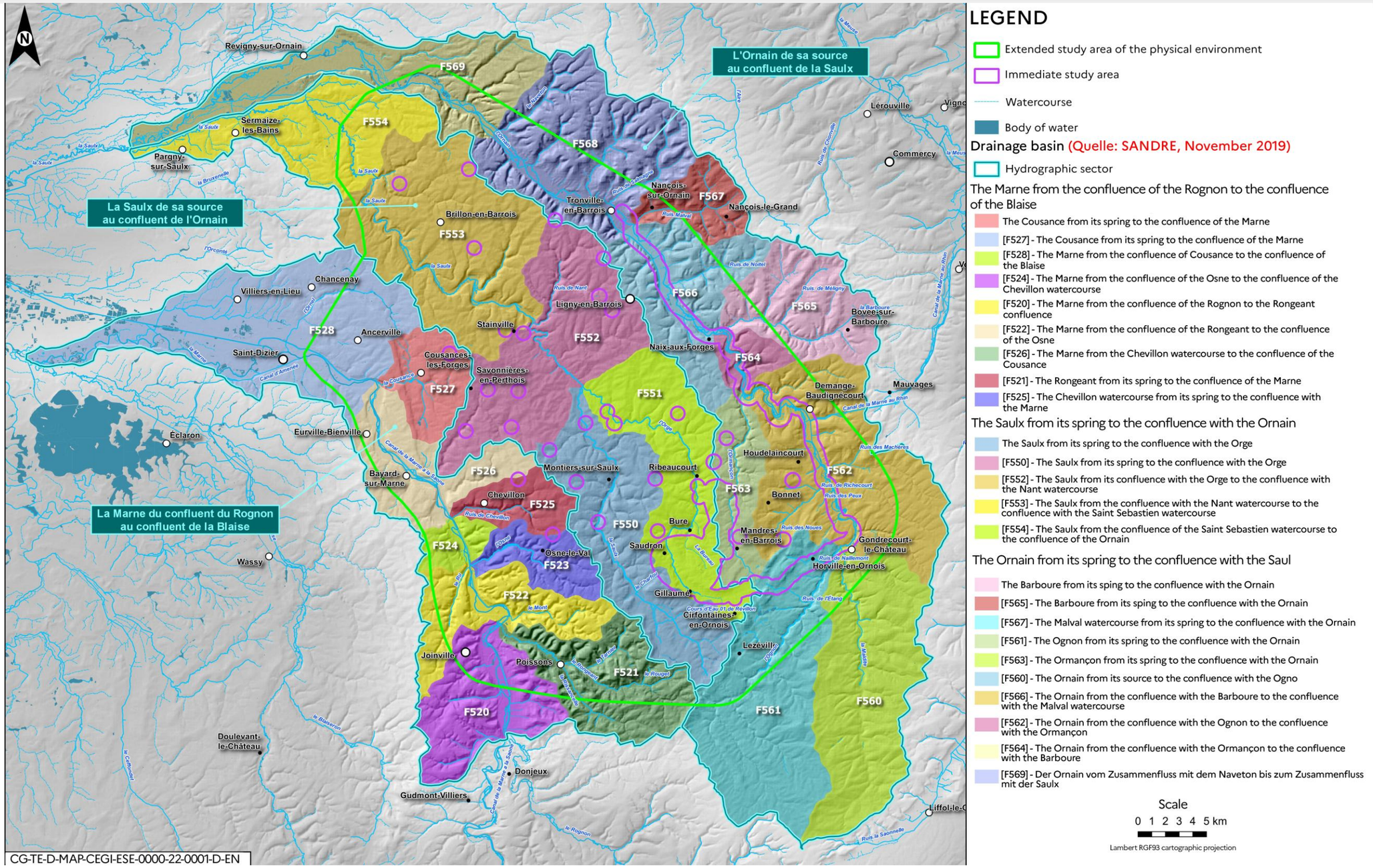
In the Rhine-Meuse drainage basin, eight rivers and streams are affected by the securing works on the 400 kV transmission line.

The figure 3-18 presents these various drainage basins.

There are no bodies of water within the potential project areas of the Cigéo overall project (apart from the bodies of water already crossed by the 400 kV transmission line).

However, certain operations of the Cigéo overall project are located near bodies of water (immediate study area) and downstream, notably:

- Cigéo disposal facility – connected terminal (ITE) connected to:
  - ✓ the Gillaumé body of water on the Orge river between the Quiloup Woods and Departmental Road D215;
  - ✓ the La Balastière water body in the municipality of Gondrecourt-le-Château.
- revamping of the railway line 027000 involving:
  - ✓ the Pâquis water body and neighboring water bodies located between the downstream passage under the railway line and the Ornain river (in the municipality of Abainville);
  - ✓ the water body of the Preuille spring (in the municipality of Houdelaincourt);
  - ✓ the Banvoie Sablière 1 and 2 ponds (in the municipality of Givrauval) and the Bellay water body (in the municipality of Ligny-en-Barrois) located between the Marne-Rhine Canal and Departmental Road D966 between the municipalities of Saint-Joire and Guerpont;
  - ✓ the Ragère pond in the municipality of Nançois-sur-Ornain.



LEGEND

- Extended study area of the physical environment
- Immediate study area
- Watercourse
- Body of water

Drainage basin (Quelle: SANDRE, November 2019)

- Hydrographic sector

The Marne from the confluence of the Rognon to the confluence of the Blaise

- The Cousance from its spring to the confluence of the Marne
- [F527] - The Cousance from its spring to the confluence of the Marne
- [F528] - The Marne from the confluence of Cousance to the confluence of the Blaise
- [F524] - The Marne from the confluence of the Osne to the confluence of the Chevillon watercourse
- [F520] - The Marne from the confluence of the Rognon to the Rongeant confluence
- [F522] - The Marne from the confluence of the Rongeant to the confluence of the Osne
- [F526] - The Marne from the Chevillon watercourse to the confluence of the Cousance
- [F521] - The Rongeant from its spring to the confluence of the Marne
- [F525] - The Chevillon watercourse from its spring to the confluence with the Marne

The Saulx from its spring to the confluence with the Ornain

- The Saulx from its spring to the confluence with the Orge
- [F550] - The Saulx from its spring to the confluence with the Orge
- [F552] - The Saulx from its confluence with the Orge to the confluence with the Nant watercourse
- [F553] - The Saulx from the confluence with the Nant watercourse to the confluence with the Saint Sebastien watercourse
- [F554] - The Saulx from the confluence of the Saint Sebastien watercourse to the confluence of the Ornain

The Ornain from its spring to the confluence with the Saul

- The Barboure from its sping to the confluence with the Ornain
- [F565] - The Barboure from its sping to the confluence with the Ornain
- [F567] - The Malval watercourse from its spring to the confluence with the Ornain
- [F561] - The Ognon from its spring to the confluence with the Ornain
- [F563] - The Ormançon from its spring to the confluence with the Ornain
- [F560] - The Ornain from its source to the confluence with the Ogno
- [F566] - The Ornain from the confluence with the Barboure to the confluence with the Malval watercourse
- [F562] - The Ornain from the confluence with the Ognon to the confluence with the Ormançon
- [F564] - The Ornain from the confluence with the Ormançon to the confluence with the Barboure
- [F569] - Der Ornain vom Zusammenfluss mit dem Naveton bis zum Zusammenfluss mit der Saulx

Scale
0 1 2 3 4 5 km
Lambert RGF93 cartographic projection

Figure 3-18 Map of hydrographic sub-sectors and hydrographic zones within the study area, excluding the physical environment (source: Sandre, November 2019)

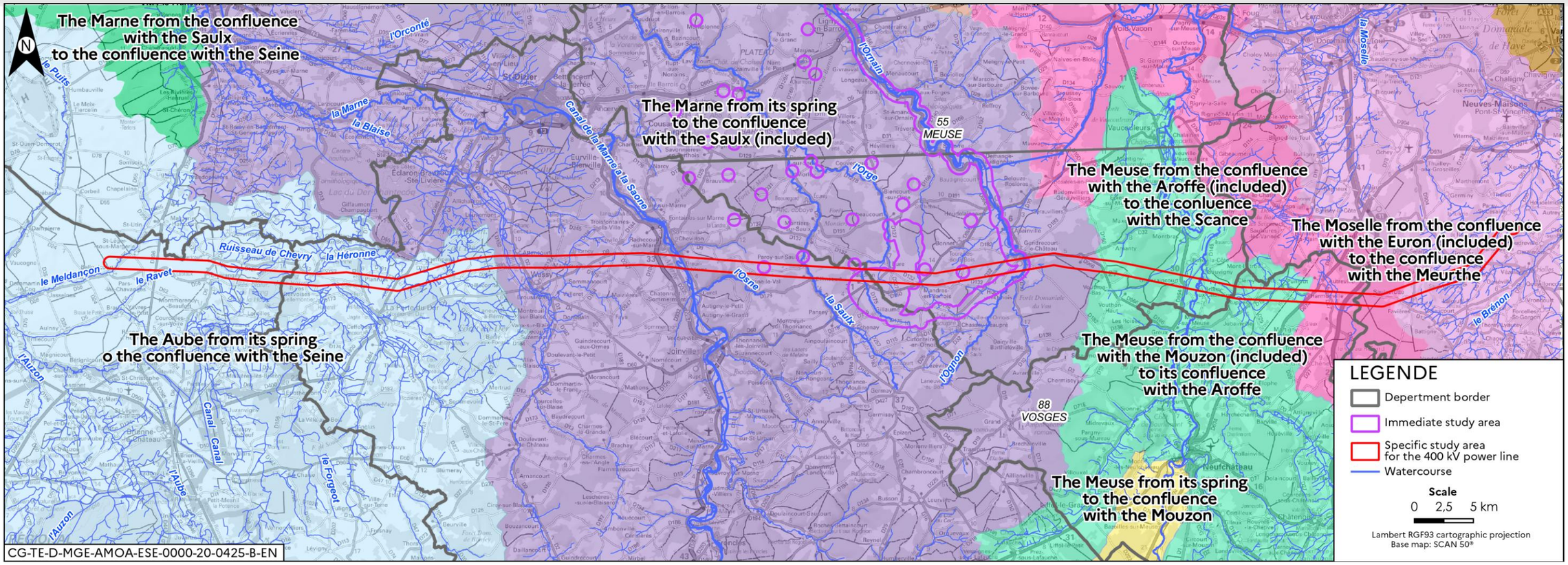


Figure 3-19 *Hydrographic units crossed by the 400 kV transmission line*

3.5.1.2.2 Surface waters of the Marne hydrographic sector

The Marne Blaise hydrographic unit spans the Marne drainage basin downstream of the confluence with the Rognon and the Blaise basin to the confluence with the Saulx at Vitry-le-François. It spans three departments (Haute-Marne, Marne, and Meuse), with a total drainage basin area of 1,378 km². In the extended study area, the upper Marne Valley cuts through a plateau whose maximum elevation ranges from over 516 metres in the south to 385 metres in the north. The valley floor, meanwhile, lies at an elevation between 195 m and 160 m.

This hydrographic unit is characterised by a high proportion of forests and grasslands (48% of land cover), a low population density (74 inhabitants/km²), a significant erosion risk on the Blaise river (contamination by suspended solids), and the presence of small watercourses.

Pressures related to livestock farming and crop cultivation, as well as the presence of hydraulic structures on certain rivers, are risk factors for achieving good status. Furthermore, this river basin contains numerous industrial facilities, generating specific pressures. The Marne and Blaise rivers are hydrologically influenced by the lake Der. There are numerous aggregate material extraction sites between Saint-Dizier and Vitry-le-François. Despite these pressures, the majority of the watercourses in this river basin are classified as being in good condition. Surface water bodies (e.g., the Cousance Stream, the Pisancelle Stream, etc.) that are degraded are primarily affected by several biological and physico-chemical parameters (see Figure 3-20).

The main rivers in this hydrographic unit, which is located within the study area but distant from the Cigéo overall project, are the Marne, the Mont, the Rongeant, and the Osne.

The Atlas of Flood Prone Areas in Champagne-Ardenne (DIREN, 2008) indicates that the Marne river in the study area—located away from the Cigéo overall project and along the route of the 400-kV transmission line—is included in the mapping of the 'highest known water levels' (PHEC). The Blaise river, at the point where the 400 kV transmission line crosses, is covered by the Atlas of Flood Prone Areas in Champagne-Ardenne (106) but lacks a flood risk prevention plan at the point where the 400 kV transmission line crosses the area. The Flood Risk Prevention Plan for the Middle Marne was approved on January 14, 2014 (107). Located along the Marne river, the regulated zones indicated in this flood risk prevention plan are included in the study area, which is distant from but not in close proximity to the facilities of the Cigéo overall project, except for the 400 kV transmission line in the municipalities of Rachecourt-sur-Marne, Chevillon, and Curel.

» ATLAS OF FLOOD-PRONE AREAS (AZI)

Flood prone areas atlases are cartographic documents providing knowledge and information on areas prone to flooding due to river overflow.

Developed by governmental agencies at the level of each drainage basin, flood prone areas atlases aim to highlight the existence and consequences of historical events and to illustrate the characteristics of flood hazards for the selected reference flood, which is the highest known flood, or the 100-year flood whichever is highest.

The atlas of flood prone areas is not legally binding. It nevertheless serves as a reference for the development of plans to prevent foreseeable natural risks and for providing citizens with preventive information on major risks.

3.5.1.2.3 Surface waters of the Saulx-Ornain river basin unit

The Saulx-Ornain river basin is located within the limestone plateaus of the eastern Paris Basin (between the Marne and Meuse rivers), subdivided into several regions (Hautpays, Ornois, Barrois, Perthois) where flow conditions and water potential vary. The karst-influenced morphostructural context governs groundwater-river exchanges and determines underground flows between adjacent basins, a characteristic of active recharge.

Due to the local geological context, the hydraulic behaviour of watercourses depends, in certain sections, more on fluctuations in groundwater levels than on runoffs within their own watershed. These watercourses experience significant periods of dryness and are characterised as intermittent streams (Orge, Bureau, Ormançon…).

This hydrographic unit is characterised by the presence of forests and grasslands in the headwaters (51% of land use), low population density, moderate erosion risk, and the presence of numerous small watercourses with high ecological potential (the Saulx and Ornain mobility corridors). Pressures related to agriculture (45% of land use), in a context of grassland conversion, the presence of hydraulic structures (industrial legacy), and the influence of the Marne-Rhine Canal are the main risk factors for water quality deterioration.

a) Hydrographic sub-sector of the Saulx at its confluence with the Ornain

The main watercourses in this sector affected by the Cigéo overall project are the Saulx, the Orge, and the Bureau. The Orge is an intermittent watercourse subject to long periods of dryness, and the Bureau has a hydrological regime comparable to that of a ditch, also with long periods of dryness. The low flows observed on the Orge and the Bureau are mainly due to their location at the head of the drainage basin as well as the karstic environment, which causes rapid and large-amplitude flow variations. The Saulx is a perennial watercourse. The Saulx Valley has been subject to several floods during the 20th century (1910–1947/1948–1982/1983). Based on the hydrological characteristics of this watercourse, these floods can be classified as plain floods (the river slowly overflows its channel and may flood the floodplain for a relatively long period. The river occupies its medium-flow channel and possibly its floodplain). A natural risk prevention plan—Flooding of the Saulx and Orge Valleys—was approved by the Meuse Prefecture on June 29, 2018 (Decree No. 2018-1544 (108)). In the extended study area, the atlas of flood prone areas in Lorraine/Rhine-Meuse Basin provided by Géorisques covers the Orge from the far north of the municipality of Saudron to its confluence with the Saulx. The flood prone area depicted corresponds to the maximum flooding area defined by the study of fluvial hydrosystems. The delineated zone includes the river's channel, floodplain, and exceptional floodplain. It corresponds to the inundation area for exceptional floods. In addition, a flood risk prevention plan for the Saulx and Orge valleys was approved on June 29, 2018. It covers the territory of the municipalities of Biencourt-sur-Orge, Bazincourt-sur-Saulx, Couvertpuis, Dammarie-sur-Saulx, Lavincourt, Le Bouchon-sur-Saulx, Ménil-sur-Saulx, Montiers-sur-Saulx, Morley, Ribeaucourt, Rupt-aux-Nonains, and Stainville (109). In addition to these "administrative" flood risk management tools, hydrological simulations were conducted on the Orge and Bureau rivers, upstream of the engineering structures. The areas flooded by overflow from these two rivers are limited to their existing floodplains. No facilities of the Cigéo overall project are affected by the regulatory zoning. However, since the Cigéo disposal facility's installations are located upstream of the flood risk prevention plan, the challenge will be to contribute to flood risk management downstream of the project.

From an ecological and chemical standpoint, the Saulx and Orge rivers are regularly degraded by physicochemical factors. The qualitative status of the Bureau River was not assessed during the 2019 site survey. It can be considered comparable to that of the Orge River (see Figure 3-21).

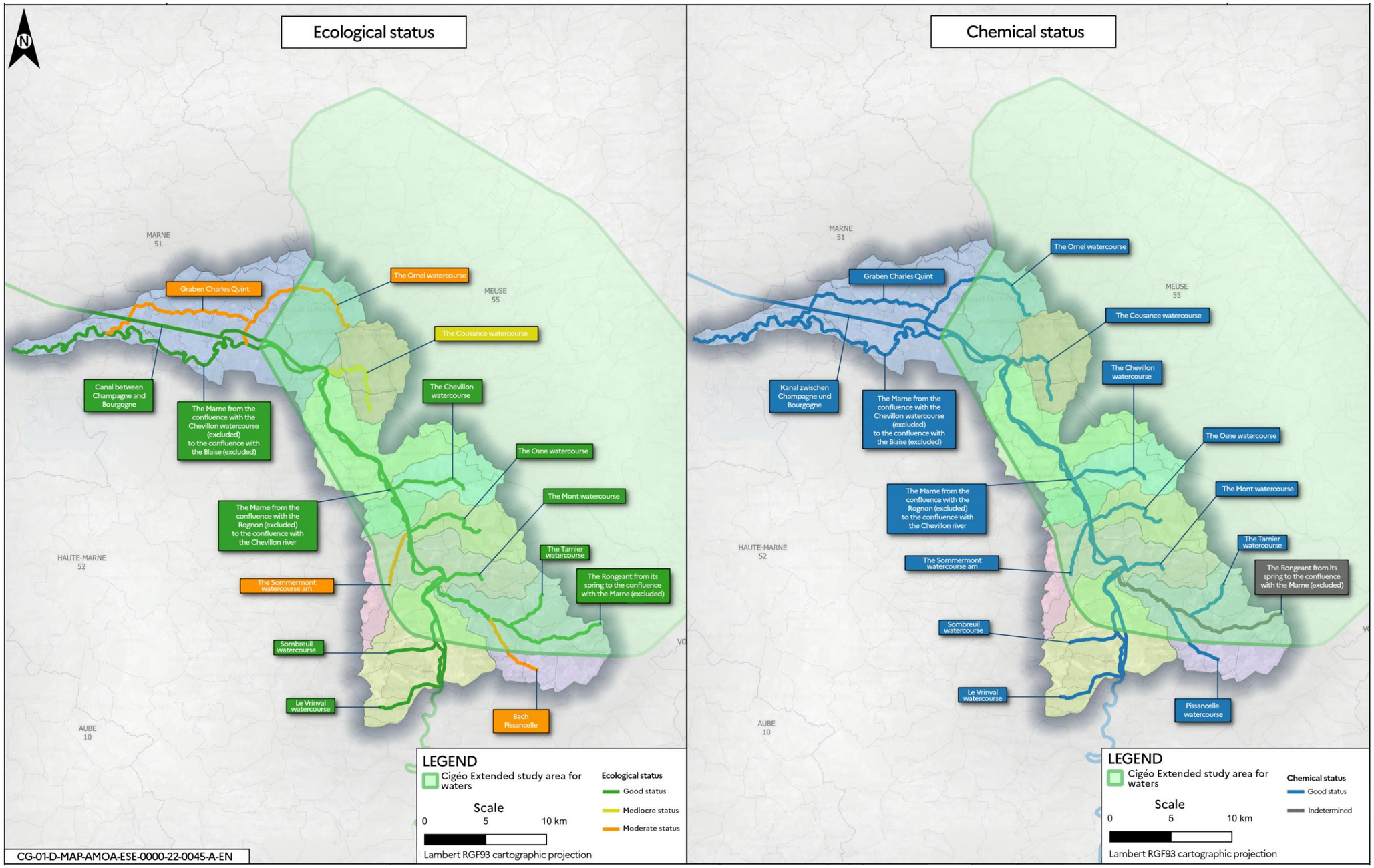


Figure 3-20 *Status of surface water bodies in the Marne Blaise hydrographic sub-sector (AESN 2019 inventory (105))*

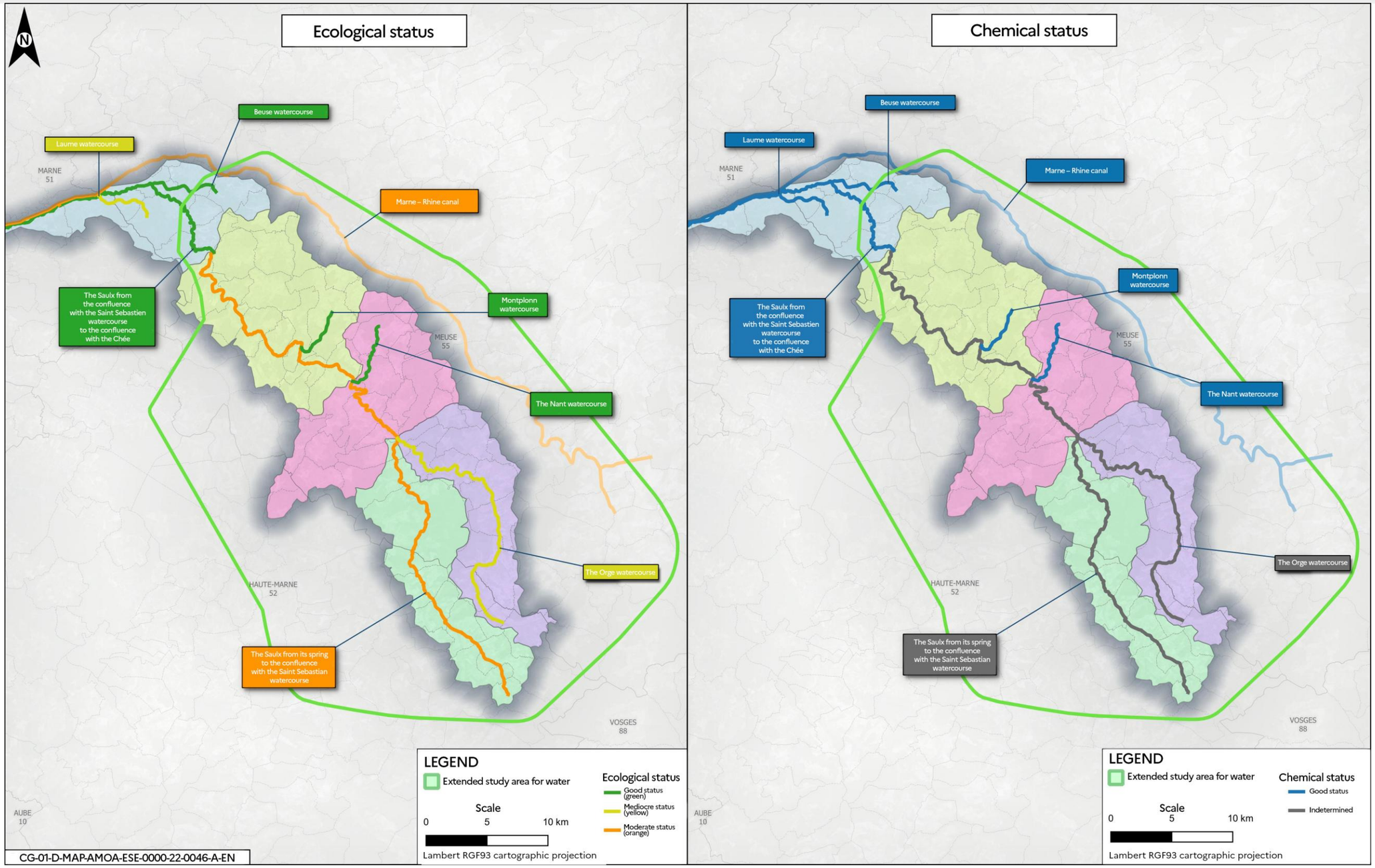


Figure 3-21 *Status of surface water bodies in the Saulx river sub-basin from its source to its confluence with the Ornain (AESN 2019 baseline assessment (105))*

b) Ornain river sub-basin from its source to the confluence with the Saulx

The mapping in the Atlas of Flood-Prone Areas of Lorraine and the Rhine-Meuse Basin administrative district, derived from Géorisques, indicates that the immediate study area includes a flood-risk zone with a modelled 100-year flood along the Ornain in the municipalities of Demange-Baudignécourt, Saint-Joire, and Tréveray—municipalities located downstream of the various components of the Cigéo overall project. This zone represents the area exposed to the theoretical flood calculated based on an analysis of past floods, which has a one-in-a-hundred chance of occurring each year. A Flood Risk Prevention Plan along the Ornain River was also adopted on April 16, 2010 (110, 111). It covers the immediate study area in the municipalities of Abainville, Houdelaincourt, Demange-Baudignécourt, Gondrecourt-le-Château, Saint-Joire, Longeaux, Givrauval, Ligny-en-Barrois, Velaines, Tronville-en-Barrois, and Nançois-sur-Ornain. It concerns the upgrading of railway line 027000 and the ITE. Railway line 027000, which predates the implementation of the flood risk prevention plan, is built on an elevated platform above the natural terrain. It crosses floodplain areas but is excluded from high-risk zones. The highest known water levels (PHEC) indicate that the connected terminal is located outside flood-prone areas. In addition to these "administrative" flood risk management tools, as with the Orge and the Bureau, hydrological simulations were conducted upstream of the engineering structures. The areas flooded by overflow from the Ormançon are limited to the existing floodplains of these watercourses (see Figure 3-22).

3.5.1.2.4 The hydrographic units crossed by the RTE 400 kV transmission line

The 400 kV transmission line runs from Balignicourt to Gondrecourt-le-Château (covering approximately two-thirds of its route) within the Seine-Normandy drainage basin, and more specifically within the Upper Seine hydrographic unit, crossing, from west to east, the Aube river basin from its source to the confluence of the Seine and the Marne, and the upper Marne from its source to the confluence with La Saulx (inclusive).

The Aube hydrographic unit basin includes numerous small tributaries upstream and in the Voire basin, as well as five major bodies of water (the Der-Chantecoq, Amance, and Auzon-Temple reservoir dams, and the Horre and Landres ponds). 71% of watercourses have disturbed morphology (recalibrated or dredged watercourses, etc.); their morphological restoration, as well as the restoration of river dynamics (downstream) and ecological continuity, are major challenges for this basin. Water withdrawals for irrigation, drinking water, and industry also significantly impact the Aube's downstream tributaries. The hydrological regimes of the Aube and some of its tributaries are disrupted by the operation of reservoir dams. Water quality is primarily degraded by pesticides and nitrates (56% of water bodies at risk) and also poses a challenge for the drinking water supply. The watercourses crossed by the line within this basin (the Heronne, the Meldançon, the Ruisseau de Chevry, and the Ruisseau de la Brie) are in good chemical condition but are experiencing a steady decline in their ecological status.

Within the Marne river basin, the 400 kV transmission line crosses the Marne, the Saulx and its tributary the Orge, and finally the Ornain and its tributary the Ormançon.

At the eastern end of the 400 kV transmission line between Gondrecourt-le-Château and Houdreville, the line crosses the Rhine-Meuse watershed within the Meuse district, specifically the hydrological sectors of the Meuse from the confluence of the Mouzon (inclusive) to the confluence of the Aroffe, the Meuse from the confluence of the Aroffe (inclusive) to the confluence of the Scance, and the Moselle from the confluence of the Euron (inclusive) to the confluence of the Meurthe. The 400 kV transmission line crosses six watercourses: the Fragne and Ruppes streams, the Noue de Burey, the Meuse, the Aroffe, and the Brenon to the east. The ecological status of the watercourses crossed by the 400 kV transmission line is rated as fair to good. Data from the 2019 baseline assessment of the Rhine-Meuse SDAGE (97) show an overall ecological status ranging from fair for the Brenon to good for the Meuse. For the three watercourses in the Rhine-Meuse basin, the SDAGE's target for good ecological status is set for 2027. Only the Brenon exhibits a degraded chemical status (see Figure 3-23).

In total, the 400 kV transmission line crosses 17 watercourses of various types along its route: rivers, streams, and ditches.

3.5.1.2.5 Use of surface water

There are no reported surface water withdrawals for public drinking water or agricultural use within the study area.

Within the immediate study area, in the Ornain drainage basin, surface water is used to supply the canal, a hydroelectric dam, and to support fish farming operations. The issue can therefore be considered significant for "industrial" uses of surface water. Fishing activities are also recorded in the perennial watercourses of the broader study area and in certain bodies of water (Gillaumé, Ligny en Barrois) within the immediate study area. No officially authorised swimming areas have been identified in the broader study area of the Cigéo overall project or in the specific study area of the 400 kV transmission line.

Issues for surface waters

The hydrographic sectors affected by the future facilities of the Cigéo overall project contain watercourses with highly contrasting hydrology:

- watercourses with very low flow rates in close proximity to groundwater, particularly where the Barrois limestone outcrops (Ormançon, Orge, etc.);
- perennial watercourses such as the Marne, the Saulx, and the Ornain, as well as the major watercourses crossed by the 400 kV transmission line, such as the Héronne, the Blaise, and the Meuse.

Due to very low flow rates, or even recurring periods of dryness, small watercourses are highly susceptible to deterioration in their ecological and/or chemical quality. Furthermore, an increase in flow rates or a decline in water quality could have downstream repercussions on watercourses that are specifically subject to a flood risk prevention plan. The challenges facing surface waters vary from one watercourse to another and even within the same watercourse.

The quantitative challenge is generally significant due to low-flow watercourses that experience active losses even during periods of high water (Orge and Ormançon).

The qualitative risk is generally high due to the need, depending on the watercourse, to preserve current capacity or to ensure that the SDAGE's good status objectives are not hindered

Several industrial and recreational uses have been identified in the immediate study area. No uses for drinking water supply have been identified. The issue regarding water uses is generally significant due to the presence of these industrial uses.

The issue related to flood risk is generally significant due to flood-prone areas near villages.

In summary, and at the scale of the Cigéo overall project, the challenge is high regarding the "surface water" theme.

High level issue regarding quantitative and qualitative status and the preservation of uses

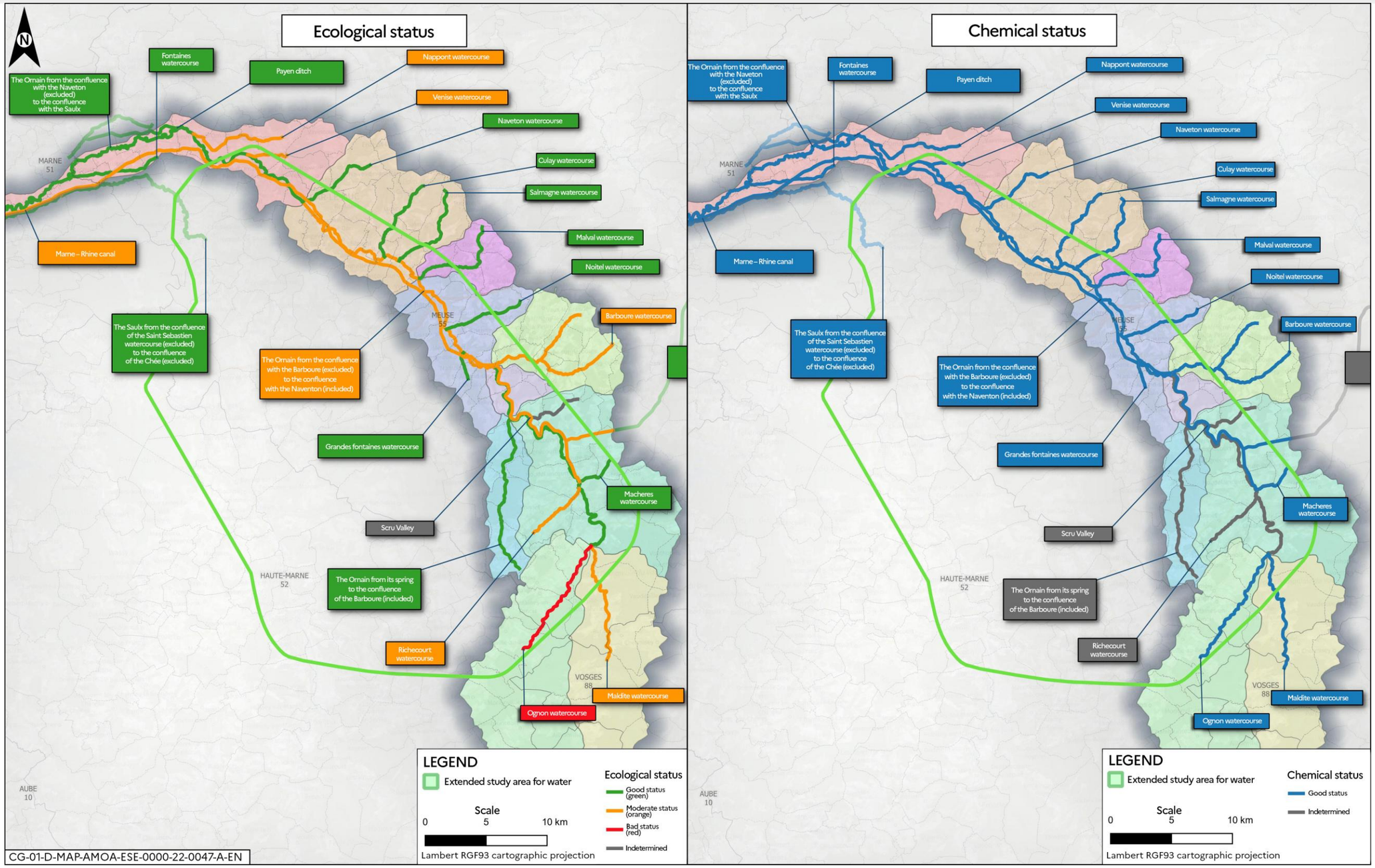


Figure 3-22 *Status of surface water bodies in the Ornain hydrographic sub-sector (AESN 2019 assessment (105))*

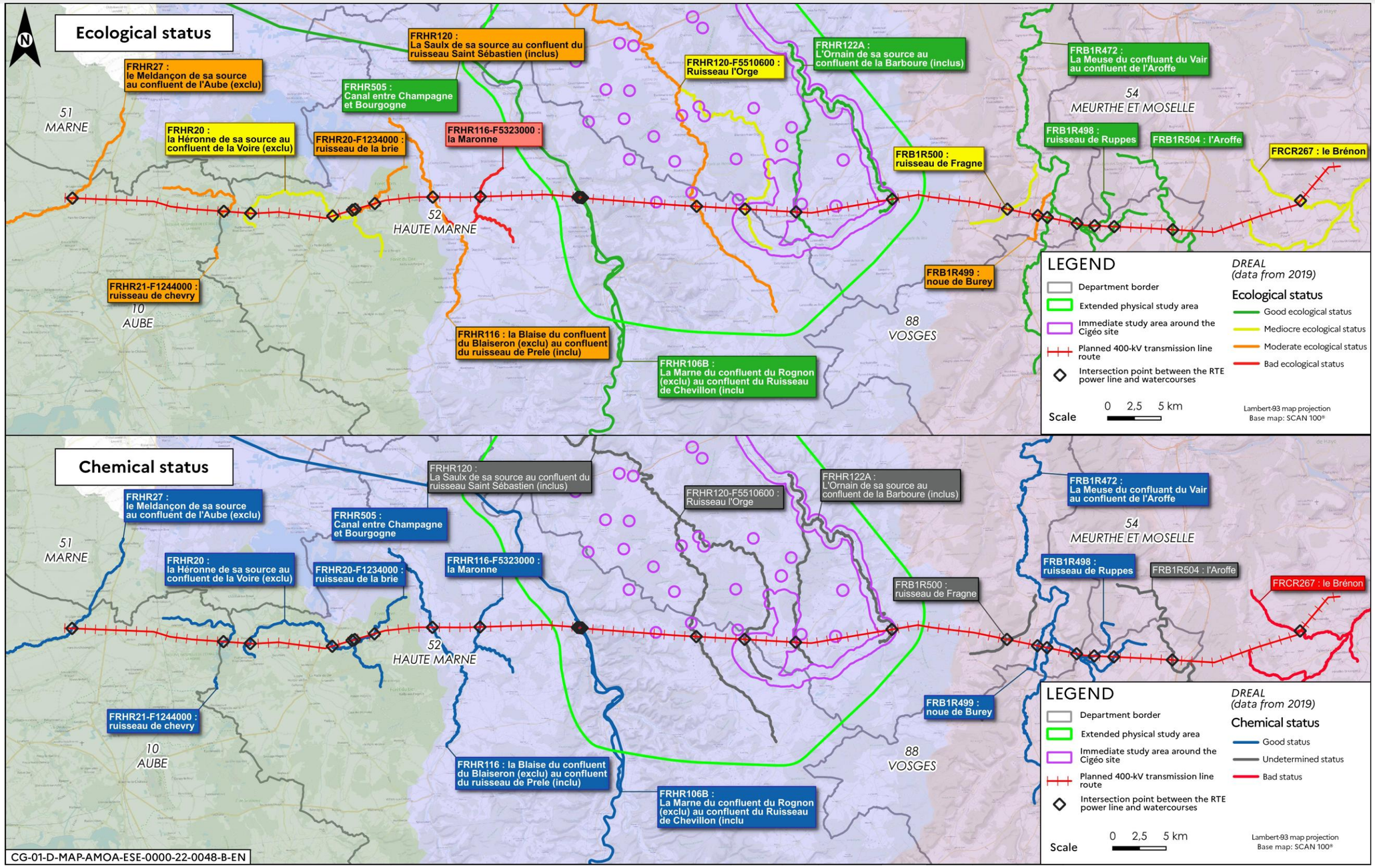


Figure 3-23 *Status of surface water bodies in the hydrographic units crossed by the RTE line*

3.5.1.3 Groundwater

SOURCES AND METHODOLOGY

Hydrogeology was determined using data from the current Water Development and Management Plans for the Seine-Normandy and Rhine-Meuse basins, as well as information and maps available on the website of the National Water Data and Reference System Administration (Sandre).

Supplementary field data (water level, water quality) provides a better understanding of the functioning and condition of the water bodies. The inventory of water uses was compiled based on documentary sources and a supplementary survey conducted by Andra in 2020.

The analysis of the risk of flooding due to groundwater rise was based on the national map of susceptibility to groundwater rises due towater bodies.

Under the European Water Framework Directive (95), the assessment of the status of groundwater bodies results from a combination of both qualitative and quantitative criteria: “the overall status of a groundwater body is determined by the worst value of its quantitative status and its chemical status.” The determination of the status of water bodies is based on the 2019 baseline assessment by the Seine-Normandy Water Agency (105) and on the current Water Development and Management Plans for the Seine-Normandy and Rhine-Meuse basins. Additional data from the area surrounding the Cigéo disposal facility, obtained from the network of the *Observatoire Pérenne de l’Environnement*, is also used.

3.5.1.3.1 Groundwater “bodies” and aquifers

GROUNDWATER BODIES AND AQUIFERS

The European Water Framework Directive (95) introduces the concept of “groundwater bodies,” which it defines as “a distinct volume of groundwater within one or more aquifers.”

Within the remote study area, various bodies of water have been identified. They are shown on the figure 3-28. These include, from the most superficial to the deepest (see Figure 3-24):

- the water bodies FRHG302 “Karstic Tithonian limestones between Ornain and the district boundary” and FRHG303 “Karstic Tithonian limestones between the Seine and Ornain,” which concern the aquifers of the Barrois Limestones;
- the water bodies FRHG305 “Kimmeridgian-Oxfordian karst limestones in the northeast of the district (between the Ornain and the district boundary)” and FRHG306 “Kimmeridgian-Oxfordian karstic limestones between the Seine and Ornain,” which concern the aquifers contained in the Kimmeridgian limestone banks and in the Oxfordian limestones;
- of the FRHG312 water body “Dogger limestones between the Seine and the district boundary,” present beneath the Callovian-Oxfordian and concerning the aquifer contained within the Dogger Formation;
- the FRHG215 water body “Unconfined Albian-Neocadian aquifer between the Seine and the Ornain,” predominantly non-alluvial sedimentary, located in the remote northwestern part of the study area.

In addition to the five water bodies listed above, there are associated aquifers or alluvial aquifers (FRHG005 and other uncoded water bodies) developed within the sedimentary formations present in the river valleys.

Superposition of groundwater bodies directly beneath the immediate study area

THICKNESS	FORMATION	LITHOLOGY	WATER BODY	LEVEL 1	LEVEL 2	LEVEL 3
0 - 4 m	Jurassic–Cretaceous undifferentiated					
20 - 140 m	Barrois limestones		**Water bodies FRHG303** Tithonian karstic limestones between the Seine and the Ornain **and FRHG302** Tithonian karstic limestones between the Ornain and the district border	131AA97	131AA	131
≈ 110 m	Kimmeridgian Marls			133AA01 133AA05 133AA04 133AA13 133AA08	133AA	133
≈ 280 m	Carbonate Oxfordian		**Water bodies FRHG306** Karstic Kimmeridgian–Oxfordian limestones between the Seine and the Ornain **and FRHG305** Karstic Kimmeridgian–Oxfordian limestones northeast of the district (between the Ornain and the district border)	135AA51 135AA61	135AA	135
140 -160 m	Callovo-Oxfordian (Cox)		Waste package storage zone CIGEO project – geological disposal facility	137AB01 137AB99	137AB	137
> 200 m	Dogger		**Water body FRHG312** Dogger limestone between the Seine and the district border	139AM01 139AM05 139AM19 139AN99 139AP99 139AP10	139AM 139AN 139AP	139

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Figure 3-24 *Overlay of groundwater bodies directly beneath the remote study area (correspondence between the BRGM groundwater body database and the BDLISA)*

Within the specific study area of the 400 kV transmission line, eight additional groundwater bodies have been identified. They are not described in detail because the nature of the work on the 400 kV transmission line is not likely to affect groundwater.

The limestone formations encountered are frequently “aquifers,” meaning they constitute natural reservoirs where groundwater can circulate “easily” due to the porosity or fissures in the rock. These are “permeable” environments where “groundwater bodies” develop. Conversely, clay or marl layers are environments where water flows very little or not at all and are classified as aquitards if they are slightly permeable and as aquicludes if they are impermeable.

These water bodies are primarily replenished by rainwater infiltration and, locally, by watercourses connected to the groundwater bodies.

a) Water bodies FRHG302 and 303: the Barrois Limestone aquifers

In Lorraine, the Tithonian (FRHG302) has a thickness exceeding 100 metres (140 to 150 metres). It consists at its base of lithographic limestones, locally overlain by “Pierre chaline,” clayey limestone with debris (corresponding to the Dommartin limestones), locally by the Bure oolite (present from southern Lorraine to Clermont-en-Argonne to the north), weathered limestones, and tubular limestones. The Tithonian limestones have a tabular, monoclinally dipping structure oriented towards the west, where they dip beneath the Lower Cretaceous formations (MESO HG214). They rest on the Upper Kimmeridgian marls and clays. Across its entire surface, MESO HG302 is represented by 13 Level 3 entities as per the French hydrogeological reference database (BDLISA), on Aquifer System Boundaries,, varying in nature and extent. Within the remote study area: only four BDLISA entities are found, including one aquifer entity: the Lower Tithonian limestones of the Paris Basin.

Table 3-2 Hydrogeological entities included in water bodies FRHG302 and 303 within the extended study area of the Cigéo overall project

BDLISA Code	Level 3 Description	Entity Type
127AG05	Wealdian (Neocenian) sands and clays, white sands, ferruginous sandstones, and Valanginian marls; marly limestones (Hauterivian) of the Paris Basin	Semi-permeable
131AA94	Tithonian dolomites of the Paris Basin	Semi-permeable
131AA95	Tithonian marly limestones in Lorraine and Champagne	Impermeable
131AA97	Lower Tithonian limestones of the Paris Basin	Aquifer

The groundwater exhibits a homogeneous facies of the calcium bicarbonate and magnesite type.

The Tithonian limestones form a **multi-layered** aquifer whose top is represented by the various formations encountered at the Cretaceous contact, which ranges from the Albian (Green Sands) to the Valanginian, and whose base is constituted by the Upper Kimmeridgian exogyre marls.

Within the FRHG302 and 303 water bodies, in the extended zone, the Barrois Limestone aquifers are found; these are the first formation encountered in the disposal facility’s sitting area. This aquifer formation consists of three aquifer levels: the weathered and spotted limestone aquifer, the Dommartin limestone aquifer, and the sublithographic limestone aquifer.

In the area where the connections between Cigéo’s surface facilities and underground disposal structures are located, the flow of the Barrois aquifers is generally directed towards the north/northwest.

This aquifer experiences significant fluctuations in water level (piezometric head) throughout the year. The aquifer is replenished in two ways:

- when the aquifer is at the surface: recharge occurs directly through rainwater infiltration via weathered, karstified, and therefore highly permeable surface soils;
- when the aquifer is unconfined: moving northward, for the Sublithographic Limestones that dip beneath the Dommartin Limestones and the impermeable layer of Pierre Châline, recharge occurs laterally either through flows coming from the south (from the outcrop zone known as the recharge area) or through slow vertical infiltration.

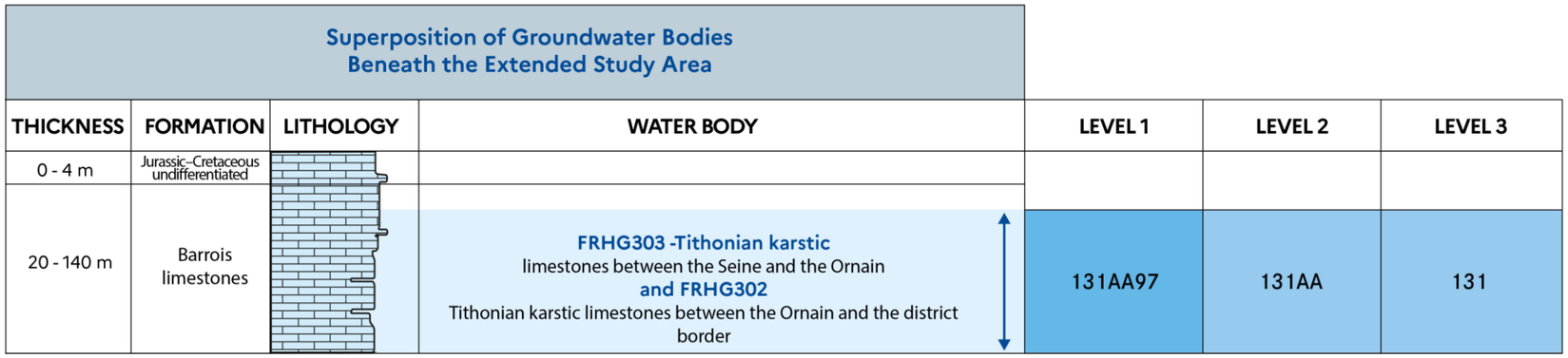


Figure 3-25 *Superimposition of groundwater bodies directly above the extended study area (correspondence between the BRGM groundwater body reference system and the BDLISA) – focus on the Barrois Limestone aquifers (Blue: aquifer; gray: impermeable)*

Furthermore, topographic maps of the Orge and Ormançon rivers, as well as the results of various available tracer studies, indicate that there may be local underground flows from the Ormançon to the Orge, particularly north of Bure in the area where the underground structures are located.

Further north, in the Orge and Saulx valleys, the surveys show the presence of flows towards the Marne valley to the west and towards springs further downstream in the Saulx valley (springs at Rupt-aux-Nonains, Haironville, Bazincourt-sur-Saulx) or further north, towards Bar-le-Duc and Fains-les-Sources.

The quantitative and qualitative status of water bodies is regularly assessed by the water agencies. Downstream of the Cigéo disposal facility site, the condition of the water in certain aquifer levels has also been subject to local characterisation.

Water body	Code	Quantitative status 2019	Chemical status 2019	Overall status 2019	Local chemical status
Tithonian karst limestones between the Seine and Ornain (Barrois Limestones)	FRHG303	Good	Good	**Good**	Poor
Tithonian karstic limestones between Ornain and the district boundary (Barrois Limestones)	FRHG302	Good	Poor	**Poor**	**Undetermined**

In 2019, local samplings indicate poor water quality. The excessive presence of suspended solids and resulting turbidity, as well as levels of 4-nonylphenol and certain organic pesticide pollutants exceeding standards, have led to a permanent downgrade of the local water quality status of this water body.

b) Water bodies FRHG305 and FRHG306: Kimmeridgian and Oxfordian Limestone water body and Kimmeridgian-Oxfordian Karst Limestone water body

Groundwater bodies HG306 and HG305 consist of Kimmeridgian-Oxfordian limestones, which include the following lithologies: Upper Kimmeridgian white limestones, Lower Kimmeridgian limestones (“Astartes limestones”), Upper Oxfordian reef limestones (Sequanian, Argovian, Rauracian), and marly limestones of the Middle Oxfordian.

The Kimmeridgian-Oxfordian limestones have a tabular, monoclinally dipping structure, with a dip directed southwest to west, where they are overlain by the marly formations of the Upper Kimmeridgian and Portlandian (HG303). The Kimmeridgian-Oxfordian aquifer system rests on the marly formations (with ferruginous ammonites) of the Lower Oxfordian and Callovian.

These water bodies contain two aquifer systems: the Kimmeridgian and Oxfordian Limestone water bodies and the Kimmeridgian-Oxfordian Karst Limestone water body.

Table 3-3 Hydrogeological entities included in water bodies FRHG305 and 306 within the extended study area from the Cigéo overall project

BDLISA Code	Description	Entity type
133AA01	Upper exogyre marls and undifferentiated Kimmeridgian marls and limestones in the Lorraine administrative region (Seine-Normandy Basin)	Impermeable
133AA05	Upper Kimmeridgian white limestones in the Lorraine administrative region (Seine-Normandy Basin)	Aquifer
133AA04	Middle exogyre marls and undifferentiated marls and limestones of the Kimmeridgian in the Lorraine administrative region (Seine-Normandy Basin)	Impermeable
133AA13	Lower white limestones of the Kimmeridgian in the Lorraine administrative region (Seine-Normandy Basin and Rhine-Meuse Basin)	Aquifer
133AA08	Lower exogyre marls and undifferentiated marls and limestones of the Kimmeridgian in the Lorraine administrative region (Seine-Normandy Basin and Rhine-Meuse Basin)	Impermeable
135AA51	Upper Oxfordian and Lower Kimmeridgian limestones of the Paris Basin, rocky limestones with pteroceras, Astartes limestones, Lamothe oolite, sublithographic limestones, and Ostrea clays	Aquifer
135AA61	Middle to upper Oxfordian coral limestone of the Paris Basin	Aquifer

- The Oxfordian limestone forms a discontinuous aquifer system. Although Kimmeridgian marls are not considered aquifers, they do contain limestone intercalations, particularly two limestone banks about fifteen metres thick, which, at outcrops where the formations are weathered, can serve as pathways for water flow, according to regional data (drinking water intake by the Échenay Water Authority). The Oxfordian limestone aquifer system exhibits significant variations in facies (rock type), with both vertical and lateral variations depending on sedimentary conditions and the presence of local rock fractures. Consequently, these rocks exhibit significant variations in permeability, which will determine flow patterns.

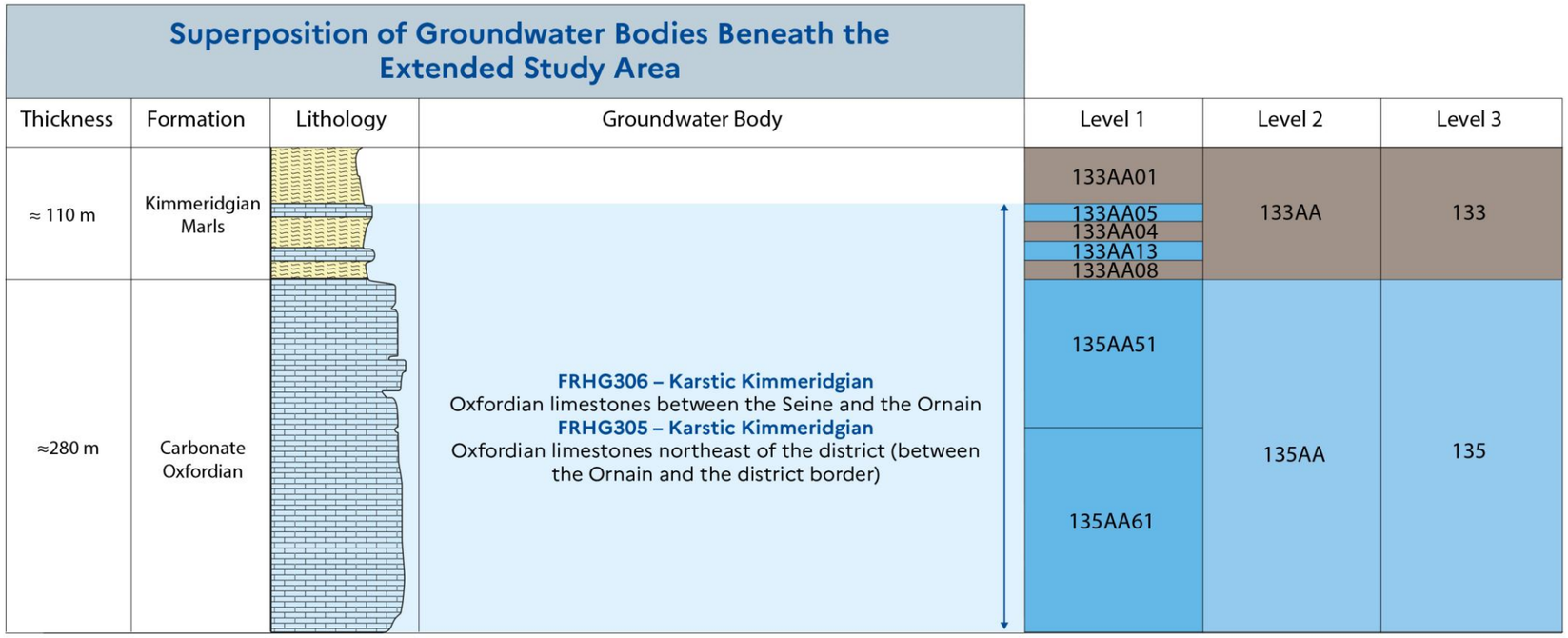


Figure 3-26 *Overlay of groundwater bodies directly beneath the extended study area (correspondence between the BRGM groundwater body reference system and the BDLISA) - focus on the Kimmeridgian and Oxfordian Limestone Aquifers and the C Aquifers*

The Oxfordian aquifer of the Paris Basin is classified by the BRGM as a resource to be protected, known as a "last resort" resource. This classification is based on the overall characteristics of the aquifer (macro scale), but it is generally considered that the productivity of the Oxfordian aquifer is highly dependent on the degree of fissuring and fracturing of the various facies within this geological unit. In the context of the Cigéo disposal facility project, the carbonate Oxfordian is an aquifer with limited productivity. The general flow of the Oxfordian limestone is directed towards the northwest, with recharge from rainfall in the outcrop area southeast of the study area, beyond the Gondrecourt-le-Château fault zone. The average hydraulic gradient (groundwater slope) is less than one percent, with average flow rates of approximately one kilometre per 100,000 years.

Table 3-4 Overall status of water bodies (2019 status report by the Seine-Normandy Water Agency to be entered

Water body	Code	Quantitative status 2019	Chemical status 2019	Overall status 2019
Kimmeridgian-Oxfordian karstic limestones between the Seine and Ornain	FRHG306	Good	Good	**Good**
Karstic Kimmeridgian-Oxfordian limestones in the northeast of the district (between the Ornain and the district boundary)	FRHG305	Good	Poor	**Poor**

Local results indicate poor water status for 2019. However, these local measurements do not appear to represent the overall status of the FRHG306 water body, as it has officially been classified as having "good" chemical status, according to the 2019 public status report data from the Seine-Normandy Basin Water Information System (105).

c) Water bodies FRHG311 and FRHG312: Dogger Aquifers

These water bodies result from the division of water body FRHG310, "Dogger limestones between Armançon and the district boundary," into two separate entities. This water body contains the Dogger aquifers, which are represented by the Bathonian and Bajocian limestone formations. The nature of the limestones gives them, in the remote study area, low porosity and poor aquifer characteristics.

The Bathonian aquifer contains a confined aquifer beneath the Callovian-Oxfordian layer. It is characterised by heterogeneous facies, resulting in significant local variability in permeability, which remains low (averaging around 10^{-8} m/s, ranging from 10^{-7} m/s to 10^{-10} m/s).

This aquifer is separated from the deeper Bajocian aquifer by the Longwy marls, which are about 30 metres thick. The Bajocian aquifer is even less productive than the Bathonian.

Table 3-5 Hydrogeological entities included in the FRHG312 water body within the study area remote from the Cigéo overall project

BDLISA Code	Description	Entity type
139AM01	Lower Callovian pearly slab and Upper Bathonian marly and oolitic limestones east of the Paris Basin	Aquifer
139AM05	Bathonian-Callovian marls and Rhynchonelles-bearing gravel to the east of the Paris Basin	Semi-permeable
139AM09	Gravel in Anabacia and marl in Terebratules from the Bathonian east of the Paris Basin	Semi-permeable
139AM19	Oolites with marly interbeds, Miliary Oolite, Jaumont Oolite, Doncourt Oolite, White Oolite, and Grande Oolite from the Lower Bathonian and Upper Bajocian	Aquifer
139AN99	Undifferentiated marls and marly limestones, Longwy marls in Lorraine, and Liostrea acuminata marls in Champagne from the Upper Bajocian–Lower Bathonian of the Paris Basin	Impermeable
139AP99	Bajocian limestones of the Paris Basin	Aquifer
139AP10	Ferruginous formation (oolitic iron ore) of the Aalenian in the eastern Paris Basin (Rhine-Meuse Basin)	Semi-permeable

The FRHG310 water body is divided into two new water bodies in the 2022–2027 SDAGE for the Seine Basin and Normandy Coastal Waterways (97) :

- the FRHG312 water body "Dogger Limestone between the Seine and the district boundary";
- the FRHG311 groundwater body "Dogger Limestone between Armançon and the Seine," which is not affected by the extended study area of the the physical environment or by the specific study area of the 400 kV transmission line.

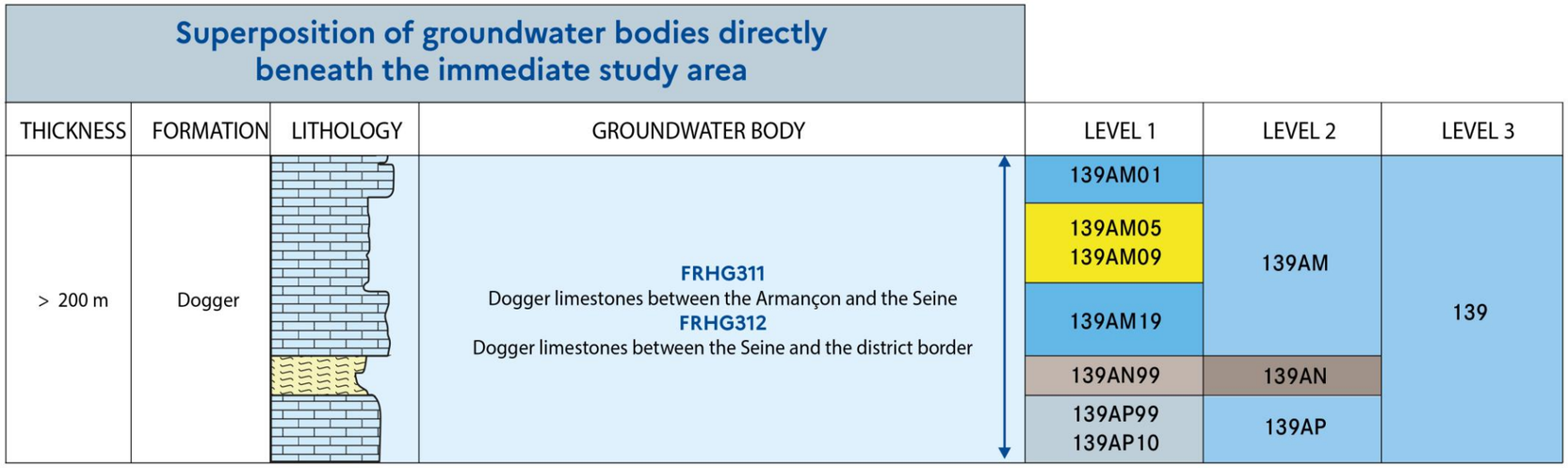


Figure 3-27 *Overlay of groundwater bodies directly beneath the extended study area (correspondence between the BRGM groundwater body reference system and the BDLISA) – focus on Dogger Aquifers (Blue: aquifer; gray: impermeable; yellow: semi-permeable)*

This body of water has been officially classified as being in "good" chemical status, according to public data from the Seine-Normandy Basin Water Information System.

Table 3-6 Overall status of water bodies (2019 status report by the Seine-Normandy Water Agency)

Water body	Code	Quantitative status 2019	Chemical status 2019	Overall status 2019
Dogger Limestone between the Seine and the district boundary	FRHG312	Good	Good	**Good**

d) Water bodies along the 400 kV transmission line

In addition to the water bodies in the study area located away from the Cigéo overall project, the following water bodies are encountered from east to west, within the specific study area of the 400 kV transmission line:

- the FRHG218 water body "Confined Albian-Neocadian," predominantly non-alluvial sedimentary;
- the FRHG208 water body "Southern and Central Champagne Chalk," consisting of Seno-Turonian chalk formations, which constitutes the most significant aquifer in the Champagne-Ardenne region;
- the predominantly sedimentary water bodies FRB1G111 "Dogger Limestones on the southern Meuse slope" and FRCG110 "Dogger Limestones of the Moselle slopes on the Rhine side," which belong to the Dogger Limestones of the Paris Basin;
- the water body FRB1G113 "Oxfordian and Kimmeridgian Meuse coastal limestones and Callovian-Oxfordian clays," which belongs to the Oxfordian limestones of the Paris Basin;
- the water body FRB1G115 "Alluvial deposits of the Meuse and its tributaries," which belong to the Quaternary alluvial deposits of the Meuse watershed;
- the FRHG005 water body "Alluvial deposits of the Perthois," corresponding to the Quaternary alluvial deposits in the Perthois Plain (Marne Valley and its tributaries);
- the FRCG105 water body "Lower Triassic sandstone north of the Vittel fault," which is predominantly sedimentary and belongs to the Rhine district;
- the FRCG108 water body "Lias and Keuper formations of the Lorraine Plateau on the Rhine side," which is impermeable but locally aquiferous, and is part of the Rhine district.

Table 3-7 Overall status of water bodies (2019 status report by the Seine-Normandy Water Agency)

Water body	Code	Quantitative status 2019	Chemical status 2019	Overall status 2019
Unconsolidated Albian-Neocian between the Seine and Ornain	FRHG215	Good	Poor	**Poor**
Confined Albian-Neoconian	FRHG218	Okay	Good	Good
Chalk of southern and central Champagne	FRHG208	Poor	Poor	**Poor**
Perthois alluvial deposits	FRHG005	Good	Good	Good
Dogger limestones, southern Meuse slope	FRB1G111	Good	Good	Good
Dogger limestones of the Moselle coast on the Rhine side	FRCG110	Good	Poor	**Poor**
Oxfordian and Kimmeridgian limestones of the Meuse coast and Callovian-Oxfordian clays	FRB1G113	Good	Poor	**Poor**
Quaternary alluvium of the Meuse watershed	FRB1G115	Good	Good	Good
Lower Triassic sandstone north of the Vittel Fault	FRCG105	Good	Good	Good
Lias and Keuper formations of the Lorraine Plateau on the Rhine side	FRCG108	Good	Poor	**Poor**

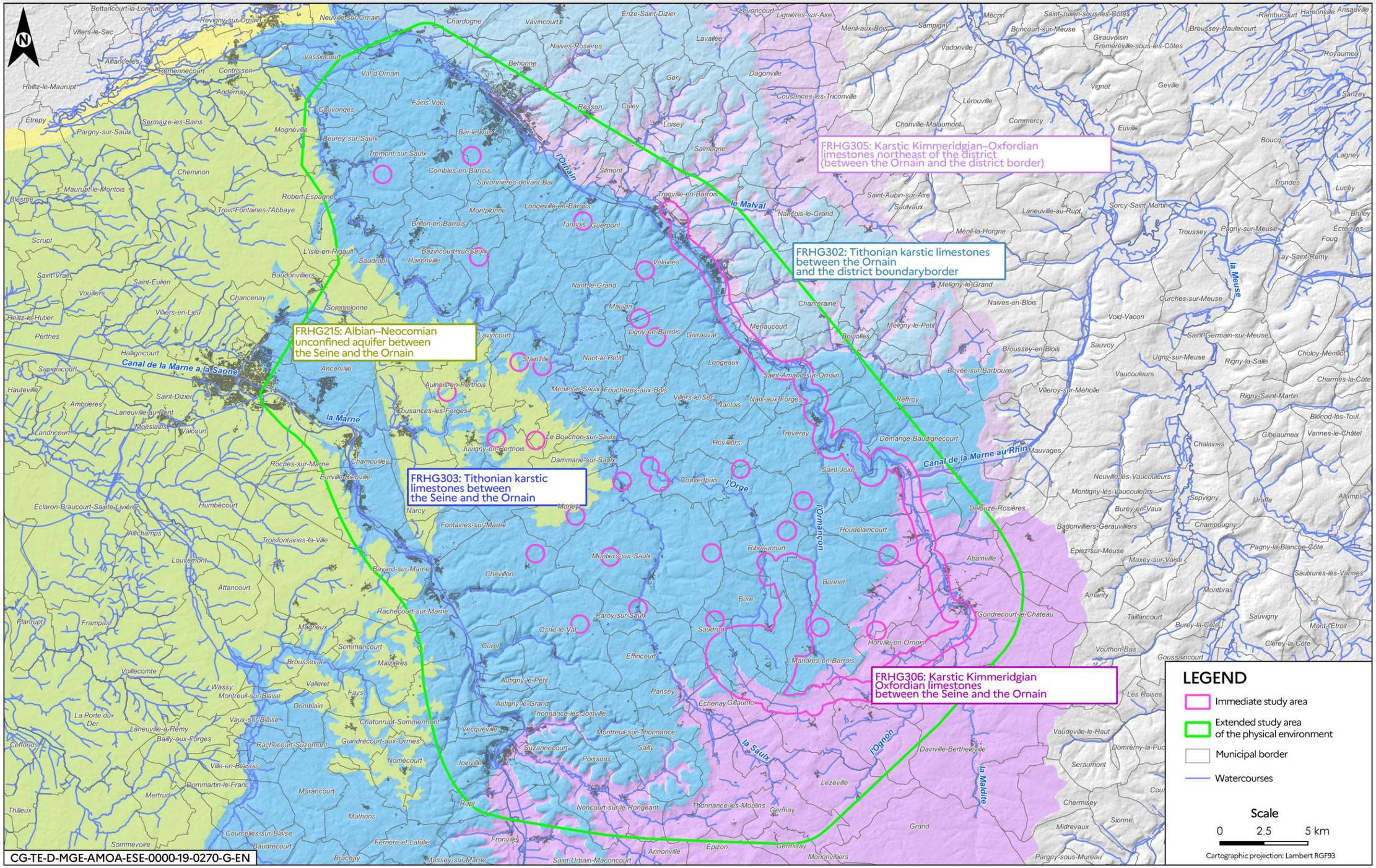


Figure 3-28 Groundwater bodies encountered at outcrops in the extended study area

3.5.1.3.2 Groundwater use

The Barrois Limestone aquifer and the Kimmeridgian-Oxfordian Limestone aquifer are used to supply drinking water to communities, for agricultural purposes, and for some private wells.

The facilities of the Cigéo disposal facility are located within the extended protection zone of the Rupt-aux-Nonains and Échenay drinking water collection locations and within the future protection zones of the Horville-en-Ornois drinking water supply collection locations (within the extended and immediate protection zones).

Other operations within the Cigéo overall project are adjacent to or cross other water intake protection zones and are subject to the associated requirements.

For agricultural water intakes, industrial uses, and other uses, several water collection locations have been identified in the extended study area based on bibliographic data. Verification of the current uses of structures located within the study area was conducted in the second half of 2020 as part of a survey of water intakes and their uses.

The drinking water supply collection locations and their associated protection zones identified in the extended study area are shown on the map figure 3-29.

Groundwater Issues

The Barrois Limestone aquifer is vulnerable due to its use for municipal drinking water supply, agricultural purposes, and some private uses. Preferential flow patterns within this aquifer strongly influence the functioning of certain watercourses.

The Kimmeridgian-Oxfordian karstic limestone aquifer is less vulnerable but faces challenges related to its use, particularly for drinking water.

The Dogger Limestone aquifer is isolated from the upper aquifers by the Callovian-Oxfordian and is not vulnerable.

The facilities of the Cigéo overall project are located within the protection zones of several drinking water supply catchments tapping into the aquifers of the Barrois, Kimmeridgian, and Oxfordian limestones.

The quantitative and qualitative stakes are generally high, due to the characteristics of certain water bodies (karstic, outcrop, etc.), their good status, or the SDAGE's good status objectives.

Preserving the condition of water bodies is a major challenge for the Cigéo overall project to ensure the sustainability of water uses. The challenge regarding water uses is generally significant due to the presence of water intakes for drinking water, agricultural, and industrial purposes.

Due to the presence of areas at risk of flooding from rising groundwater levels, primarily along watercourses, the risk associated with flooding from rising groundwater levels is moderate.

In summary, and at the scale of the Cigéo overall project, the issue is significant regarding the "groundwater" issue.

Significant issue regarding the quantity, quality, and preservation of groundwater uses.

Moderate level issue related to flood risk.

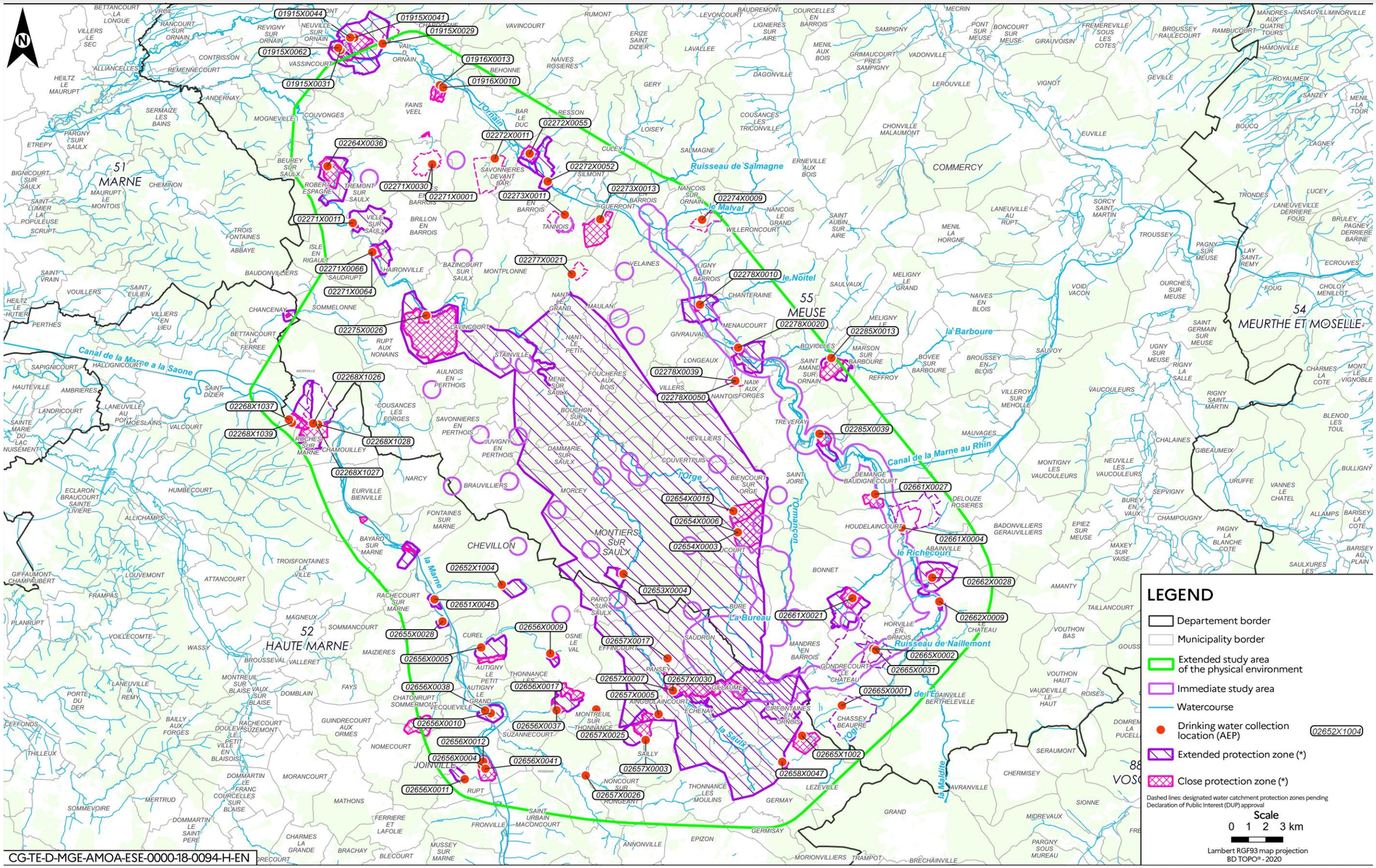


Figure 3-29 All municipal drinking water supply sources and associated protection zones identified in the remote study area (source: ARS, last updated April 2022)

3.5.2 Impacts and measures

There are three types of potential impacts on surface waters and groundwaters that may result either from changes in flow or from water withdrawals or discharges into natural environments:

- a quantitative impact;
- an impact on water quality;
- an impact on water uses.

SOURCES AND METHODOLOGY

Groundwaters

The impacts of the Cigéo disposal facility on groundwater, and more specifically on quantitative criteria (resource, flow), are assessed using two numerical models that incorporate the Barrois Limestone and/or Oxfordian Limestone aquifer systems. The simulations were conducted to assess the future behaviour of the hydrogeological systems under various climate scenarios or underground development scenarios for the Cigéo overall project and to compare them with baseline simulations (*i.e.*, initial conditions).

The assessment of drinking water and recycled water needs is based on a quantitative feasibility study. Knowledge of the production capacity of the three proposed water extractions sites for the water supply operation is based on hydrogeological studies and the opinion of a certified hydrogeologist.

Surface Waters

A specific study was conducted to assess the impact of the Cigéo disposal facility on the risk of flooding associated with the overflow of the Orge, Bureau, and Ormançon rivers.

The Cirfontaines-en-Ornois weather station has been selected as the reference station for the design of the stormwater management structures at the Cigéo disposal facility.

The determination of the qualitative impact of stormwater discharges and treated conventional discharges from the Cigéo disposal facility is based on the discharge standards applicable to the various types of discharges.

Area of influence

The potential hydraulic influence area of the surface facilities on the groundwater of the Barrois limestone lies downstream of the surface facilities of the Cigéo disposal facility. At the head of the drainage basin, flows are partially follow the morphology of the aquifer formation's substrate, consisting of Kimmeridgian marls. At the scale of the extended study area, artificial tracers conservatively indicate the flow directions and the northward extension of the potential area of influence. At the Rupt-aux-Nonains drinking water collection location, tracing conducted during low-water periods established a very high dilution factor of approximately 10^8.

3.5.2.1 Description of water potentially generated by the Cigéo overall project

The definition of impacts on surface water within the various facilities of the Cigéo overall project takes into account different types of water based on volume, quality, source, and timing (see Figure 3-29):

- **stormwater** consists of rainwater that runs off and is collected from impervious surfaces (roads, roofs, parking lots, etc.) and certain artificial surfaces within the potential project areas (green spaces, slopes, etc.). Stormwater from the Cigéo disposal facility is discharged into the Orge, Bureau, and Ormançon rivers. Stormwater runoff from the slopes is managed separately due to its different pollutant load and is then discharged into the Ormançon;
- **Wastewater** includes blackwater (toilets), graywater (showers, sinks, kitchen, etc.), and surface industrial water. Water recycling helps limit discharges. In the event of excess treated wastewater stored in the tanks, the overflow is discharged into the Bureau River in the ramp zone and into the Ormançon River in the shaft zone;
- **Industrial water** (surface or underground) consists of water generated by the construction and operations of the Cigéo overall project, for example at washing areas, concrete plants, and workshops. In the event of excess treated industrial water stored in the reservoirs, the overflow is discharged into the Bureau river in the ramp zone and into the Ormançon river in the shaft zone;
- **Groundwater** includes drainage waters, which consists of water infiltrating an underground structure during its construction and operation (deep excavation, surface-underground connections), and underground industrial water. Treated groundwater is discharged into the Bureau in the ramp zone and into the Ormançon in the shaft zone;
- **water pumped** during tests carried out in borehole.

These different types of water are grouped into three categories:

- **stormwater**;
- **conventional effluents,** comprising wastewater and mine water:
  - ✓ surface water, comprising wastewater (effluents from restrooms, sinks, showers, and cafeterias) and surface industrial water (water from conventional industrial activities, washing areas, etc.);
  - ✓ groundwater, comprising dewatering water, industrial water (washing water, water related to tunnel boring machine operations), and water from fire hydrant tests.
- **Unconventional effluents**—that is, those containing potential traces of radioactive contamination resulting from the facility's activities—may be generated in certain areas of the nuclear facility known as "areas where nuclear waste may be produced" and subject to specific management protocols. They are never mixed with conventional water, whether on the surface or underground.

OUTLET OR DISCHARGE POINT

The outlet or discharge point is defined as the connection between a discharge system and the natural environment. Outlets allow for the dispersion of effluents into the natural environment while minimising the risks of erosion and environmental degradation, ensuring the flow of effluents, and prioritising infiltration into the soil.

During the operational phase, with all discharge lines in place, the Cigéo disposal facility includes two discharge points in the ramp zone (Bureau and Orge), three discharge points in the shaft zone (Ormançon), two discharge points for the inter-site link (Bureau and Ormançon), and two discharge points for the connected terminal. These discharge points are shown on the map at figure 3-31.

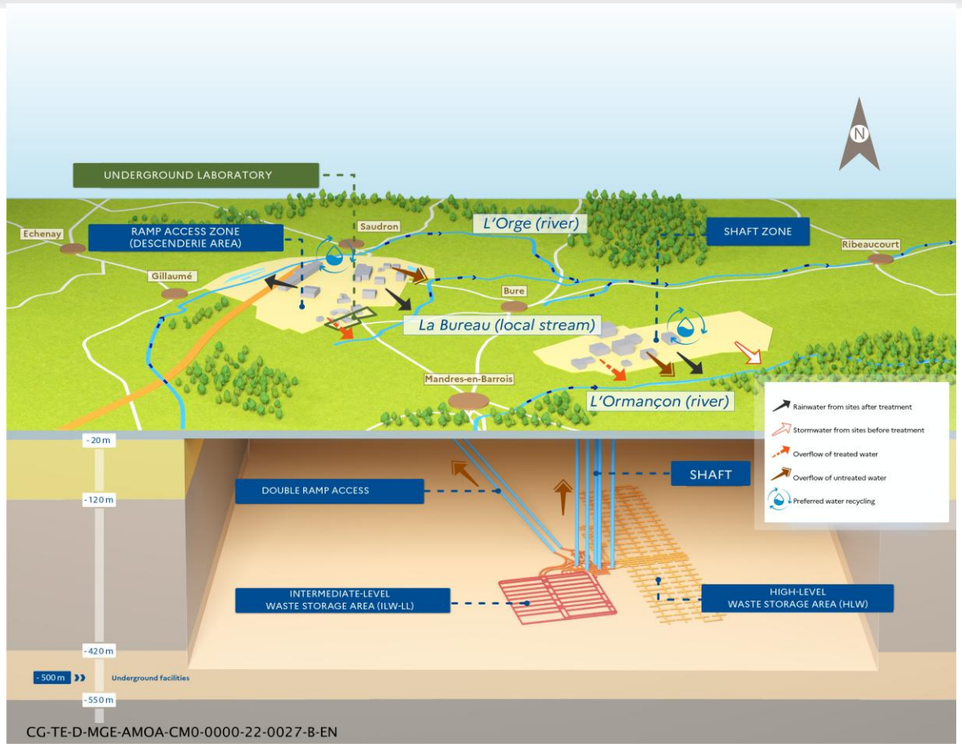


Figure 3-30 *Diagram showing the management of stormwaters and conventional wastewaters generated by the Cigéo overall project*

3.5.2.2 The ARC approach to limiting quantitative impacts

3.5.2.2.1 Potential impacts

Potential quantitative impacts on groundwater and surface water may be caused by:

- work related to the subsurface and the groundwater table: excavation of material draining the intersected groundwater table, creation of trenches of varying depths, construction of protective structures against groundwater seepage in the descent zone of the Cigéo disposal facility;
- the water requirements of the Cigéo overall project, which could potentially affect the resource;
- the construction of surface-underground connections and the drilling required for the environmental characterisation and monitoring of the Cigéo disposal facility (drainage of intersected groundwater aquifers and changes in flow—dam effects);
- surface imperviousness, which may reduce infiltration and the natural recharge of groundwater aquifers and increase the risk of flooding downstream of these impervious surfaces;
- the risk of flooding in the project area due to rising groundwater levels;
- works along watercourses (temporary or permanent crossings) and the creation of embankments that may cause a barrier effect on water flows;
- disruption of the hydraulic functioning of watercourses due to water discharges into the environment, as well as the presence of the protective structure against rising groundwater in the ramp zone;
- work in flood-prone areas leading to a reduction in water storage capacity and increasing the risk of harm to people and damage to property.

To limit these impacts on groundwater and surface water, and in line with the "avoid, reduce, compensate" approach, various avoidance and reduction measures are proposed and described in the following chapters.

3.5.2.2.2 Avoidance and reduction measures to preserve groundwater and surface water

Various avoidance measures have been defined to preserve the resource and avoid impacting groundwater flows, and first and foremost, the selection of locations for the ramps outside of fractured zones.

Work has been conducted on the design of surface-underground connections: spacing them apart, the definition of diameters that also help avoid impacts on the aquifers intersected by limiting changes in flow and the damming effect of surface-underground connections (i.e. ramps and shafts) within the Barrois Limestone aquifer and/or the Kimmeridgian and Oxfordian limestone aquifers.

Adjusting the timing of construction works according to hydrological conditions also helps preserve the water resource. Thus, minor works (such as trenching for pipelines, roads, and various utilities) are suspended during periods of high water, with safety measures implemented at the construction site to prevent significant drainage of the affected aquifer. Works along watercourses will be carried out during dry periods.

Several measures to mitigate various potential quantitative impacts on surface water have been defined, including conducting works along watercourses during dry periods, and prohibiting the withdrawal of surface water. Furthermore, the Cigéo disposal facility is not located in any of the identified flood zones near the facilities.

In addition to these avoidance measures, various reduction measures have been implemented, primarily concerning the protection of the nuclear building against the risk of groundwater rise and the design of the surface-underground connections.

The adapted design of the structure protecting against groundwater rise in the ramp zone addresses the impacts on groundwater flow in the Barrois Limestone formation and thus limits the impacts on surface water. It traverses the entire Barrois Limestone formation. However, this structure creates a dam-like effect in the aquifer, resulting in a piezometric impact upstream (increase) and downstream (decrease). This phenomenon is called "water table drawdown." The determination of the residual impact level of this structure is based on modelling results. The design of the structure to protect against groundwater upwelling is therefore subject to an iterative process to identify optimisation strategies that reduce its environmental impacts. Additional investigations included in the environmental characterisation process will allow for refining the modelling of groundwater aquifers and better understanding the modelled impacts.

The construction of surface-underground connections results in significant drainage and changes to groundwater flow. Appropriate construction measures for the surface-underground connections are implemented to reduce these quantitative impacts on groundwater (drainage effect) and the effects of potential groundwater table drawdown outside the footprint of the Cigéo disposal facility:

- installation of sealing plugs to prevent the interconnection of different aquifers;
- installation of various types of linings at the interface between the surface and the seabed;
- and a system for managing water collected in the surface-to-ground connections.

The implementation of these various measures ensures that the residual impact associated with the construction of surface-to-ground connections is negligible in terms of groundwater drainage and changes in groundwater flow.

Various reduction measures are also taken to protect surface water :

- optimisation of hydraulic systems and structures by prioritising the rehabilitation of existing structures (e.g., the terminal facility connected to an existing platform over a 10-km stretch);
- limiting potential work areas to what is strictly necessary to avoid surface sealing; implementing quantitative water management to prevent an increase in flood risk downstream of discharge points;
- The water management system is designed to handle collection and treatment for a 10-year return period rainfall during the preliminary construction phase, and is then replaced before the end of this phase by the permanent drainage system for the Cigéo disposal facility, which is designed for a 100-year return period rainfall (reference rainfall). The retention basins for the inter-site link and the connected terminal, meanwhile, are designed for a 10-year return period, in accordance with best practices for linear structures. However, right-of-way reserves have been set aside in case future studies, discussions with local authorities, or construction permits require the structures to be redesigned.

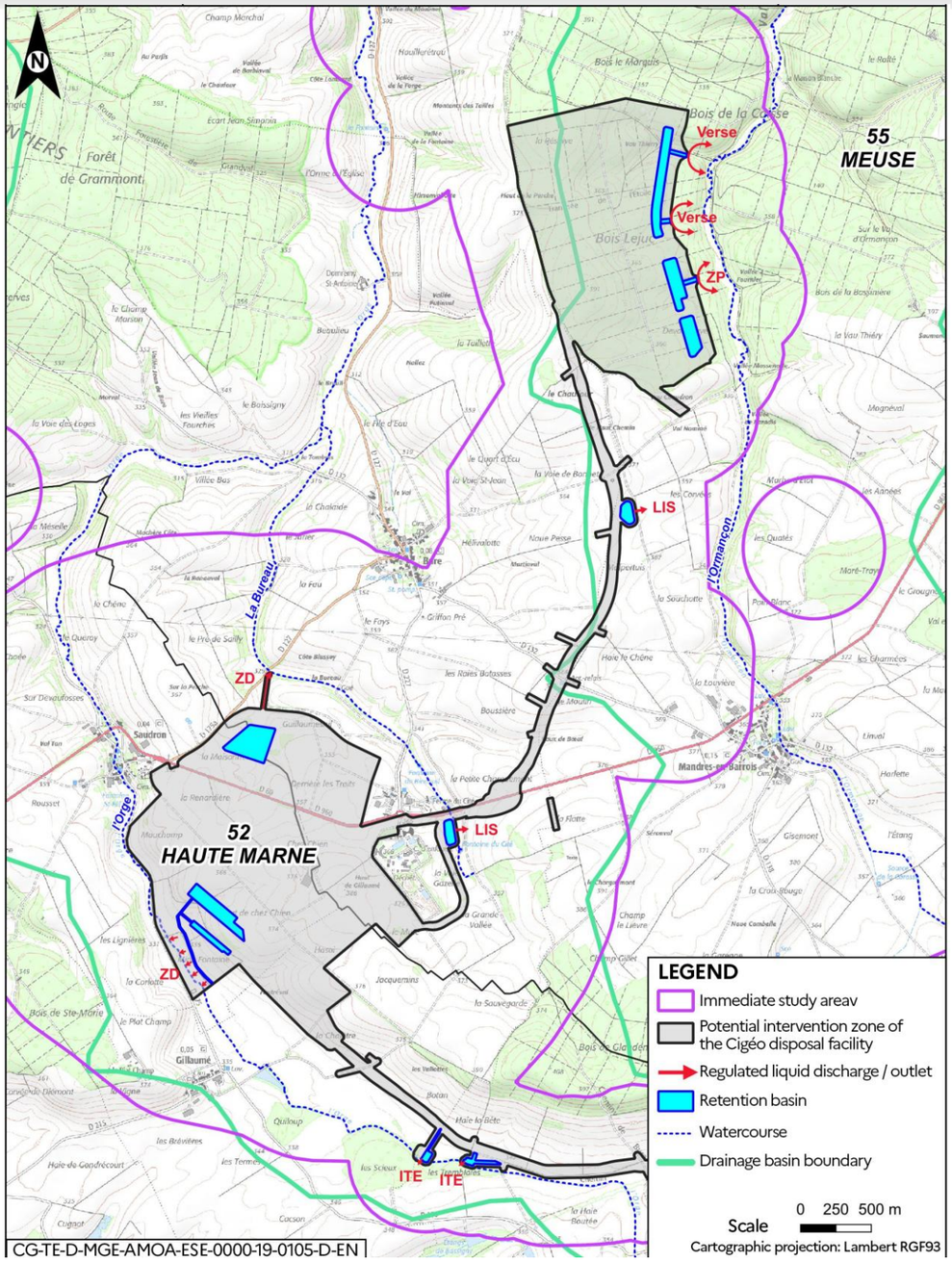


Figure 3-31 Map showing the locations of liquid discharge points at the Cigéo disposal facility

3.5.2.3 The ARC approach to limiting impacts on water quality

3.5.2.3.1 Potential impacts

Beyond the preservation of the resource, it is also necessary to ensure the preservation of surface and groundwater quality. Indeed, the Cigéo overall project could potentially impact water quality *through*:

- all work related to the subsurface;
- the discharge of stormwater and water generated by the various operations of the Cigéo overall project;
- the risk of accidental water pollution.

3.5.2.3.2 Prevention and mitigation measures to preserve water quality

Measures are in place to prevent impacts on the quality of surface and groundwater, such as: the use of existing roads and paths near watercourses (to avoid the creation of temporary watercourse crossings) and the prohibition of discharging untreated water.

The main measures to preserve the quality of receiving environments concern the management of water generated by the Cigéo overall project. To avoid altering surface water quality, various systems have been implemented to manage stormwater, conventional effluents, and non-conventional effluents. These systems are tailored to the nature of the water in question and the phase of the Cigéo overall project.

These reduction measures, described below, are supplemented by the implementation of measures to limit pollutant inputs into the environment, such as adherence to a zero-pesticide policy for the management of green spaces and road shoulders at the Cigéo disposal facility. To limit salt input into surface waters during the winter season, the use of salts in solution form (brine) is prioritised for snow removal on internal roads within the Cigéo disposal facility

a) **Rainwater and conventional water management**

For the shaft and ramp zones of the Cigéo disposal facility, stormwater is collected before being treated by settling, then stored to be gradually released into the natural environment. Additional treatment processes are implemented for runoff from the slopes.

Wastewater and industrial wastewater generated at surface and underground facilities are collected and treated by a wastewater treatment plant for the ramp zone and the shaft zone. The recycled water produced is used for the disposal facility's non-potable water needs (water for concrete production, irrigation, etc.). Excess recycled water is released into the environment in a controlled manner.

Groundwater undergoes pretreatment (hydrocarbon treatment, coagulation, and flocculation) before being pumped to the surface for further treatment (settling, neutralisation, filtration, and disinfection) and then stored with the recycled water, after which it is gradually discharged if not used.

All water treatment principles applied by the Cigéo disposal facility aim to ensure that the quality of discharged water is compatible with the good chemical and ecological status of surface waters.

At the current stage of the studies, the water collection and treatment system comprises two specific streams, including:

- a wastewater treatment plant at each surface facility of the Cigéo disposal facility to treat wastewater and surface industrial water;
- a system for treating groundwater from the underground disposal facilities.

The water treatment systems are designed to produce recycled water of a quality suitable for the disposal facility's non-potable water needs, thereby limiting water withdrawal from the resource.

The reuse of treated water requires the installation of storage tanks for so-called "recycled" water for a period of three days. After the three-day period, the water, following inspection, is discharged into the natural environment at the Bureau and Ormançon rivers. These discharges comply with the criteria for good ecological and chemical status of surface waters, as well as with the principle of not exacerbating flood risks downstream.

For other operations within the Cigéo overall project, the same reduction principles are applied to minimise qualitative impacts on water. During the operations of other project owners in the initial construction and operational phases of the Cigéo overall project, the surface water management system is operational. If necessary, on-site wastewater treatment is planned for technical buildings if connection to the local sewer system is not possible. Maintenance measures for the infrastructure created, particularly vegetation management, comply with regulations and environmental requirements in the areas traversed.

b) **Management of non-conventional effluents**

Unconventional effluents are collected, screened for radioactivity, and transferred to an external facility for treatment. They are therefore not discharged into the local environment.

During the operational phase of the Cigéo disposal facility, containment barriers—represented by the disposal structures—prevent any migration of radioactive elements into groundwater. These consist primarily of retention measures provided by the civil engineering of the underground facility (e.g., in the event of potentially radioactive fire effluents in a handling cell) and specific devices such as retention tanks (e.g., the tank containing HLW mine drainage water that may be contaminated). In addition, recovery and treatment systems are planned to collect these effluents. After the post-closure monitoring phase, in the long term, most radioactive elements remain trapped within the repository and the Callovian-Oxfordian formation in the near field of the repository, and only a few soluble, long-lived radioactive elements not retained by the clay will migrate into the Callovian-Oxfordian formation by diffusion, at a very slow and limited rate. This will take *at least* several hundred thousand years, and the associated impact will remain low.

3.5.2.4 The ARC approach to limiting impacts on land uses

3.5.2.4.1 Potential impacts

The quantitative and qualitative impacts on water, as detailed in the preceding paragraphs, may generate potential impacts on water uses

3.5.2.4.2 Avoidance and reduction measures to preserve water uses

All the measures described above contribute to maintaining water uses. However, the key element of the ARC approach to preserving local resources is linked to the design of the Cigéo disposal facility, which prioritises the recycling of water generated by the facility's operations, followed by its maximum use for its own activities that do not require potable water for human consumption. Thus, at each surface facility (shaft zone, ramp zone), a wastewater treatment plant is installed to treat surface wastewater and industrial wastewater, along with a system for treating groundwater. Recycling this water reduces the use of potable water for concrete production, the operation of tunnel boring machines, the washing of equipment, and the watering of green spaces.

For other operations within the Cigéo overall project, the same reduction principles are applied to minimise impacts on water use.

3.5.2.5 Residual impacts on surface and groundwater

Given the various design, avoidance, and reduction measures implemented for the Cigéo disposal facility, the residual impact is moderate in terms of quantity in the area where the water table of the Barrois Limestone aquifer has dropped, due to the construction of the protective structure against groundwater seepage in the ramp zone starting from the preliminary works phase. The residual impact on all uses of the resource is moderate in this area. A precautionary compensation measure for resource use is therefore adopted. This measure is tailored to the observed disruption (specific works, compensation, etc.) and is implemented in collaboration with the relevant manager/owner and government agencies.

Thus, no impact on surface water is expected in terms of quantity, quality, or use. No indirect impact of surface water quality on groundwater has been identified following the avoidance/reduction measures taken.

There is no residual impact on drinking water supply following:

- the completion of a quantitative feasibility study for the drinking water supply of the Cigéo disposal facility using existing water intakes, which enabled the design of the water supply system for the Cigéo overall project;
- the disposal facility's compliance with the requirements of the protection zones for the relevant drinking water supply intakes.

After implementing the "avoid-reduce" sequence and a precautionary compensation measure for water uses, the overall impact on water resources at the Cigéo disposal facility is low.

For the other operations of the Cigéo overall project, given the progress of the design studies of the other project owners, the selected principles for mitigation measures are as follows:

- the implementation of specific measures and construction works that comply with the requirements of the protection zones for drinking water collection locations to achieve a negligible residual impact on drinking water supply;
- the implementation of measures to avoid and reduce impacts on the subsoil and surface waters: a beneficial indirect effect on groundwater aquifers;
- the definition of work procedures to reduce impacts on groundwater.

For operations carried out by other project owners, in the absence of large-scale earthworks or excavation into the subsoil, and provided a design incorporating avoidance and reduction measures is implemented—particularly within the protection zones of drinking water collection locations—the residual impact on groundwater and surface water is low. Given the work to be undertaken for the other operations of the Cigéo overall project, the need for compensation measures does not appear necessary at this stage of the studies.

In accordance with the principles of avoidance and mitigation measures, the overall impact on water from the operations of the other project owners is low.

3.5.2.6 Compatibility of the Cigéo overall project with various planning tools

The SDAGE for the Seine Basin and Normandy Coastal Waterways 2022–2027 was adopted by the basin committee on March 23, 2022 (97). Five major challenges have been identified and translated into fundamental guidelines (OF) of the SDAGE for balanced water resource management at the basin level. An analysis of how the facilities of the Cigéo overall project align with the SDAGE guidelines leads to the conclusion that the activities and facilities of the Cigéo overall project are compatible with the Water Development and Management Master Plan (SDAGE) for the Seine Basin and Normandy Coastal Waterways 2022–2027. The same conclusion applies regarding the overall project's compatibility with the SDAGE guidelines for the Rhine-Meuse basin.

Adopted in November 2019 and approved in January 2020, the Grand Est Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) (103) covers the study area surrounding the Cigéo overall project as well as the operation to secure the 400 kV transmission line. These are consistent with the SRADDET Grand Est's rules regarding the preservation of water resources.

The portion of the study area located away from the Cigéo overall project and two-thirds of the study area along the 400-kV transmission line are included in the Flood Risk Management Plan (PGRI) for the Seine-Normandy basin, approved in March 2022 (112, 113). The eastern end of the study area along the 400 kV transmission line is included in the PGRI for the Rhine-Meuse basin, approved in March 2022.

The activities and facilities of the Cigéo overall project and the work to secure the 400 kV transmission line are compatible with the Flood Risk Management Plan for the Seine-Normandy basin. The work to secure the 400 kV transmission line (eastern section starting from Gondrecourt-le-Château) is compatible with the FRMP for the Rhine-Meuse basin.

The Cigéo overall project is compatible with all plans and programs related to the preservation of water resources.

3.6 Biodiversity and the natural environment

This chapter examines the various regulatory zoning areas (including Natura 2000 sites), wetlands, ecological corridors, biodiversity (species and present habitats), as well as risks related to chemical and radiological pollution.

3.6.1 Initial state

SOURCES AND METHODOLOGY

The baseline condition of the natural environment is determined through field inventories of fauna and flora conducted in the immediate biodiversity study area by consulting firms specialising in ecology. These data were preceded and supplemented by the collection of bibliographic data available for the period 2012 to 2022 from Andra's Long-Term Environmental Observatory, specialised literature, and relevant organisations. The biodiversity-related issues presented in this version of the environmental impact assessment have been updated compared to the previous version of the study due to additional inventories conducted in 2021–2022. Thus, the updated inventory data cover the period 2016–2022. Previous inventory years are included in the bibliographic data.

NAMES OF THE VARIOUS SPECIES

The various plant and animal species presented in this chapter are classified according to regulatory protection criteria or their rarity. Several designations are used and defined below:

- **protected species**
  A species that is prohibited from being hunted, fished, collected, destroyed, and sometimes transported, sold, or purchased at all stages of development (eggs, juveniles, adults, carcasses) and in the form of byproducts (skins, feathers, scales, etc.), in accordance with international, national, or local regulations;
- **species of Community interest**
  A species that is endangered, vulnerable, rare, or endemic (i.e., native to a well-defined territory or a specific habitat) whose conservation status is of concern and which is listed:
  - ✓ either in Annex II of the "Habitats, Fauna, Flora" Directive 92/43/EEC, for which special areas of conservation must be designated (6) ;
  - ✓ or in Annexes IV or V of the "Habitats, Fauna, and Flora" Directive 92/43/EEC (6) and for which protective measures must be implemented throughout the territory.
- **ZNIEFF (*French ecological, faunal and floristic interest natural zone*)-determining species**
  In the context of defining ZNIEFFs, the following are classified as key:
  - ✓ endangered, vulnerable, rare, or remarkable species meeting the criteria established by the IUCN or listed in nationally or regionally published Red Lists;
  - ✓ species protected at the national or regional level, or subject to European or international regulations, when they present a genuine heritage interest in the national or regional context;
  - ✓ species that do not have protected status or are not listed on Red Lists, but are found in specific ecological or biogeographic conditions, at the edge of their range, or whose population is particularly exceptional (remarkable numbers, range limits, endemism, etc.).
- **heritage species (or species of interest)**
  A concept that places a high value on species that are rarer than others. Species listed under the Birds Directive (7) or the Habitats Directive (6), and classified as NT, VU, EN[29] in the French and regional Red Lists, are considered heritage species. In the absence of a Red List, key ZNIEFF species of ranks 1 and 2 may be taken into account.
- **invasive alien species**
  An invasive alien species (IAS) is a species introduced by humans, either intentionally or unintentionally, into a territory outside its natural range, and which threatens ecosystems, natural habitats, or local species

[29] IUCN Status: **NT** = Near Threatened, **VU** = Vulnerable, **EN** = Endangered

3.6.1.1 Biodiversity protection policy

The requirement to protect biodiversity is present in numerous documents issued at the European, national, regional, and local levels, documents that are taken into account in the development of the Cigéo overall project and its implementation.

As early as 2004, France demonstrated its commitment to protecting biodiversity, notably by integrating it into all public policies. To this end, it has established: the national guidelines for the preservation and restoration of ecological corridors (114) starting in 2007, the National Biodiversity Strategy 2011–2020 (115)(115), and the Biodiversity Plan (116) in 2018. The main levers for action are knowledge, protection, restoration, enhancement, adaptation to climate change, and integration into the core of all national and international public policies.

The protection of wetlands (which constitute some of the richest ecosystems) in the area hosting the Cigéo overall project is governed by the Seine-Normandy Water Development and Management Master Plan (SDAGE) 2022–2027 (97). Part of the 400 kV transmission line is also covered by the Rhine-Meuse SDAGE 2022-2027 (98–102). It should be noted that there is no Water Development and Management Plan (SAGE) in the study area outside the Cigéo project area.

The Grand Est region is implementing plans that go beyond national action plans for insects, bats, and amphibians. It has also established Regional Guidelines for Wildlife Management and Habitat Quality Improvement (ORGFH).

The Grand Est Region's Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) was adopted on November 22, 2019, and approved on January 24, 2020 (103). The SRADDET is a planning document that outlines the strategy, objectives, and rules established by the Region in several areas of land use planning. It incorporates the atlases and action plans of each Regional Ecological Coherence Plan (SRCE) from the former regions.

The *Syndicat Mixte du Pays Barrois* approved its Territorial Coherence Plan (SCoT) on December 19, 2014 (117). One of the guiding principles of the Pays Barrois SCoT aims to protect and enhance biodiversity.

The preservation and consideration of biodiversity and natural environment issues are also incorporated into local urban planning schemes (PLU) at the municipal or intermunicipal level. One example is the Intermunicipal Local Urban Planning Scheme (PLUi) of the Haute Saulx Community of Municipalities, within which the Cigéo overall project is largely situated (118).

3.6.1.2 General characterisation of biodiversity in the natural environment extended study area

The Grand Est region is home to many different types of landscapes: mountains (the Vosges Massif), coastlines, the plains of Lorraine and Alsace, as well as a multitude of plateaus and waterways. This mosaic of landscapes supports the region's rich biodiversity. However, the overall trend for species within the region, as across the entire country, is one of decline.

Most areas of high ecological importance at the regional level remain relatively distant from the immediate biodiversity study area. The Cigéo disposal facility does not directly overlap with any regulated environmental zones (Natura 2000 sites, prefectural biotope protection decrees, etc.).

However, 15 Type I French ecological, faunal and floristic interest natural zone (ZNIEFF) and 7 Type II ZNIEFFs are present within the immediate biodiversity study area. In 2016, the Lejuc Wood was classified as a ZNIEFF I because it was incorporated into a new, larger ZNIEFF known as the "Forêt de la Fosse Lemaire" in Mandres-en-Barrois. In the case of the Lejuc Wood, it is the wealth of available observations, derived from inventories conducted by Andra, that justifies the classification rather than the exceptional presence of species on the site. Compared to the forests and woods in the area, it does not harbour any specific habitats or species and does not exhibit any particular ecological richness.

The natural environment extended study area is home to several biodiversity hotspots, where a significant number of heritage and/or protected species of flora and fauna sometimes live. This study area has been extended to a 30-km radius around the immediate footprint of the Cigéo disposal facility project, as well as the extent of the 400-kV transmission line (124 km in length) (see Figure 3-32). Within this area, notable sites include the Ramsar site of the Champagne Wetlands, particularly the Étangs de la Horre (National Nature Reserve, Natura 2000 site, ZNIEFF Type I), the Bassigny sector, the Meuse Valley (Natura 2000 site), and Lac du Der (Natura 2000 site). The three aforementioned Natura 2000 sites are notably crossed by the existing 400 kV transmission line.

A literature review was conducted for the period 2012–2022, covering the municipalities within the extended study area, to count the number of species recorded by taxon, with a focus on species protected at the national or regional level and/or of Community interest:

- flora: 1,858 species, including seven protected species;
- insects: 1,229 species, including four protected species and species of community interest;
- amphibians: 14 protected species, including five of community interest;
- reptiles: nine protected species, including five of community interest;
- birds: 161 protected species and 47 species of community interest;
- mammals: 30 species, including five protected species and three of community interest;
- bats: 18 protected species and species of community interest.

Global ecological issues

The natural environment extended study area, is home to several biodiversity hotspots, where a significant number of heritage and/or protected species of flora and fauna sometimes live.

The vast majority of the Cigéo project is planned for locations where biodiversity is common and where natural areas do not have high ecological functionality.

Moderate concern

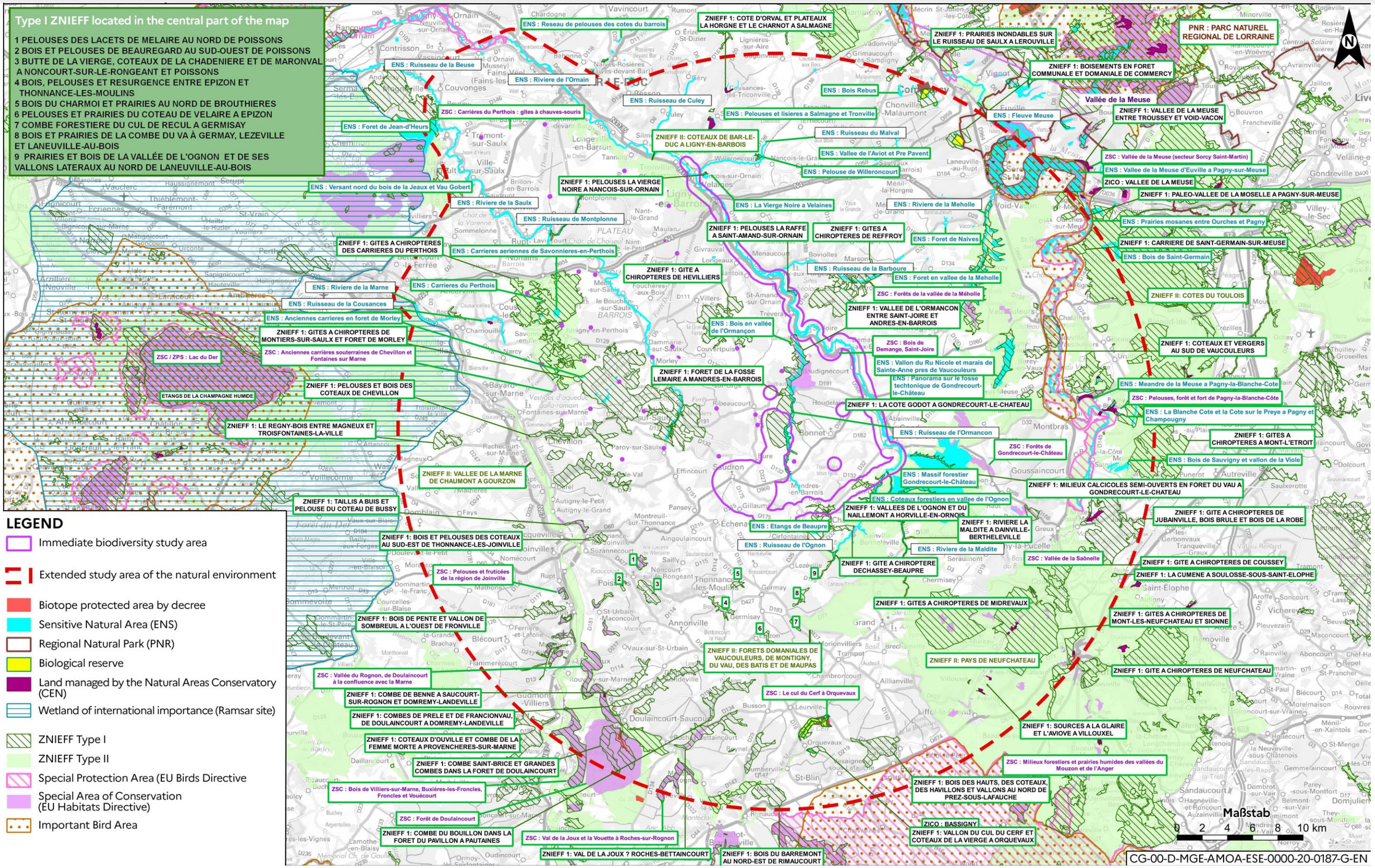


Figure 3-32 Environmental zoning in the natural environment extended study area

3.6.1.3 Wetlands

REGULATORY DEFINITION OF WETLANDS

Article L. 211-1 I 1° of the French Environment Code provides the following definition of a wetland: *"A wetland is defined as land, whether cultivated or not, that is usually flooded or saturated with fresh, salt, or brackish water on a permanent or temporary basis; or where the vegetation, when present, is dominated by hygrophilous plants for at least part of the year."*

The legal definition of wetlands is therefore based on two alternative criteria: first, lands that are usually flooded or saturated with water; and second, hygrophilous vegetation (species adapted to life in very wet or aquatic environments).

Wetlands (marshes, peatlands, mudflats, floodplain forests, etc.) are transitional zones between terrestrial and aquatic environments, characterised by the presence of water, either on the surface or in the soil.

This interface position makes these environments some of the most ecologically rich ecosystems. Wetlands provide essential functions such as regulation, habitat, production, and information.

3.6.1.3.1 Wetlands in the Grand Est region

The main types of inland wetlands in the Grand Est region are as follows:

- alluvial wetlands at the bottom of river valleys, including small watercourses (hydrographic network) at the headwaters of watersheds;
- wet meadows;
- wet thickets and forests found both on the slopes of the highest peaks and within the numerous alluvial valleys;
- peatlands;
- ponds, topographic depressions fed by precipitation, runoff, or groundwater resurgence;
- pond margins.

Certain wetlands in the Grand Est region are particularly remarkable for their uniqueness : the tufa marshes of Haute-Marne, the Ramsar site of the Wetland Ponds of Champagne, the inland salt marshes and meadows, and the Ried in Alsace.

3.6.1.3.2 Literature review on wetlands

An analysis of landscape evolution since the19th century reveals no major changes in land use, apart from the construction of the 027000 railway line. A large portion of the permanent wetlands are located at the bottom of valleys. Temporary wetlands can be observed along the tributaries of the three main watercourses.

Isolated wetlands may also be associated with ponds or other bodies of water. Given the hydrographic network, the potential for wetlands is significant around the Cigéo disposal facility.

Most of the immediate biodiversity study area is covered by plateau soils corresponding to the southern part of the Barrois Plateau. Hillside soils are more prevalent to the south and east of the study area. Finally, valley floor and valley soils cover small areas associated with watercourses such as the Ornain, Orge, and Ormançon.

Valley soils, located near watercourses and frequently flooded, are difficult to cultivate and are left as pastureland for livestock. Towns and villages are often situated in the valleys, near watercourses.

Within the immediate biodiversity study area, the mapping of predominantly wetland areas (ZDH) provided by the Grand Est DREAL (Regional Directorate for the Environment and Spatial Planning) allows for the identification of potential wetlands:

- the Ormançon watercourse is surrounded by ZDHs along its entire length: it is thus present in the study areas of the shaft zone, the inter-site link, and very partially at the connected terminal;
- The Orge and Bureau watercourses have ZDHs along their entire length up to the border between the departments of Meuse and Haute-Marne. A ZDH connects the Bureau and Ormançon watercourses north of the immediate biodiversity study area of the shaft zone and the centre of the immediate biodiversity study area of the inter-site link. The Orge ZDHs extends beyond its known course, at the immediate biodiversity study area of the connected terminal;
- The immediate biodiversity study area of the connected terminal also includes ZDHs associated with the Ognon River and its left-bank tributaries (notably the Ruisseau de l'Étang and the Ruisseau du Naillemont), as well as the Ornain River over a stretch of approximately 4 km;
- Finally, the Ornain and its tributaries contain ZDHs along their entire length within the immediate biodiversity study area of the 027000 railway line.

A wetland covering an area of 4 ha has been identified along the Orge River by the DDT 52 (Haute-Marne Departmental Directorate of Territories) and the AFB52 (French Agency for Biodiversity/Haute-Marne). This wetland is included in the immediate biodiversity study area associated with the descent zone.

3.6.1.3.3 Characterisation of wetlands in the Cigéo overall project

These wetlands are primarily located along watercourses (Orge, Ormançon, Bureau, Étang Stream, Tiermée Stream, Ornain and its main tributaries, Saulx) in connection with their associated aquifers.

The key areas of concern are concentrated along the edge of the access road zone, outside the areas altered by the project in the Orge Valley, where the Orge wetland extends from the source to Saudron. Concerns are particularly significant locally in the river valleys and on the periphery of the railway platform of the connected terminal.

Other confirmed wetlands have been identified within the immediate biodiversity study area. They are located along the Saulx and Orge watercourses.

Within the immediate study area of the 027000 railway line, the biodiversity concern is considered high.Several wetlands have been identified, linked to the presence of the Ornain River and its main tributaries.

A section of the 400 kV transmission line near the *Étang de la Horre* is located within the vast *Étangs de la Champagne Humide* complex, classified as a Ramsar site and a National Nature Reserve (RNN). Several of these areas are also designated as Notable Wetlands. These wetlands are home to exceptional biodiversity and are in a well-preserved ecological condition. They are specifically subject to special provisions in the Rhine-Meuse SDAGE.

For the D60/960 departmental road deviation project, surveys based on the two regulatory criteria (vegetation and soil) were conducted in the immediate biodiversity study area, which includes the corridors of the proposed deviation of the D60/960 departmental road located around the potential intervention zone of the drainage area.

The water supply project is defined at this stage solely by its functional requirements. Subsequent versions of this environmental impact assessment will specify the "wetland" issues for this project once the pipeline routes are known and finalised.

Issues related to wetland conservation

Wetlands are present within the immediate biodiversity study area, associated with watercourses. The issues are locally high.

Locally high level issue

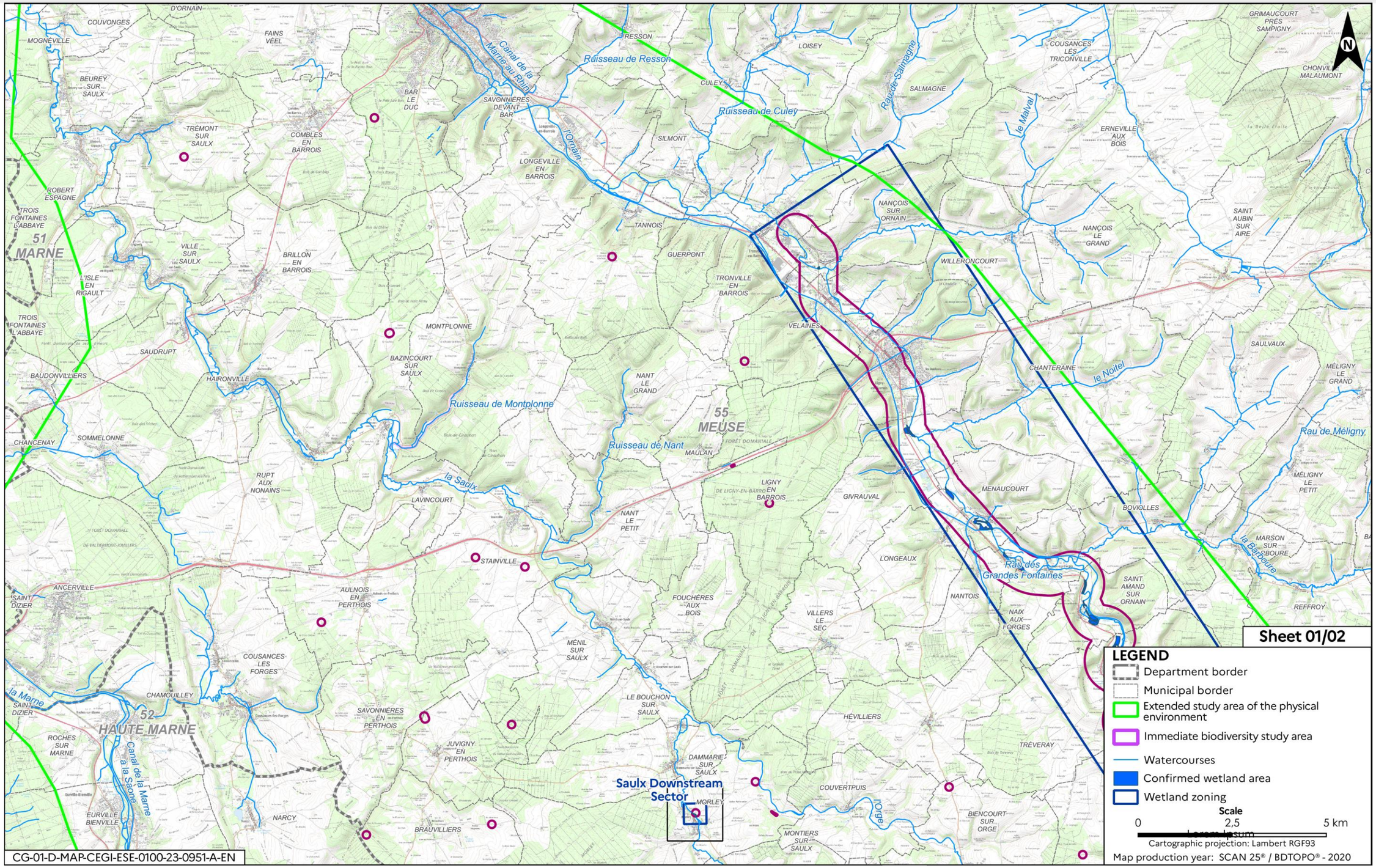


Figure 3-33 Location of confirmed wetlands according to the July 26, 2019 regulations within the immediate biodiversity study area of the Cigéo overall project (1/2)

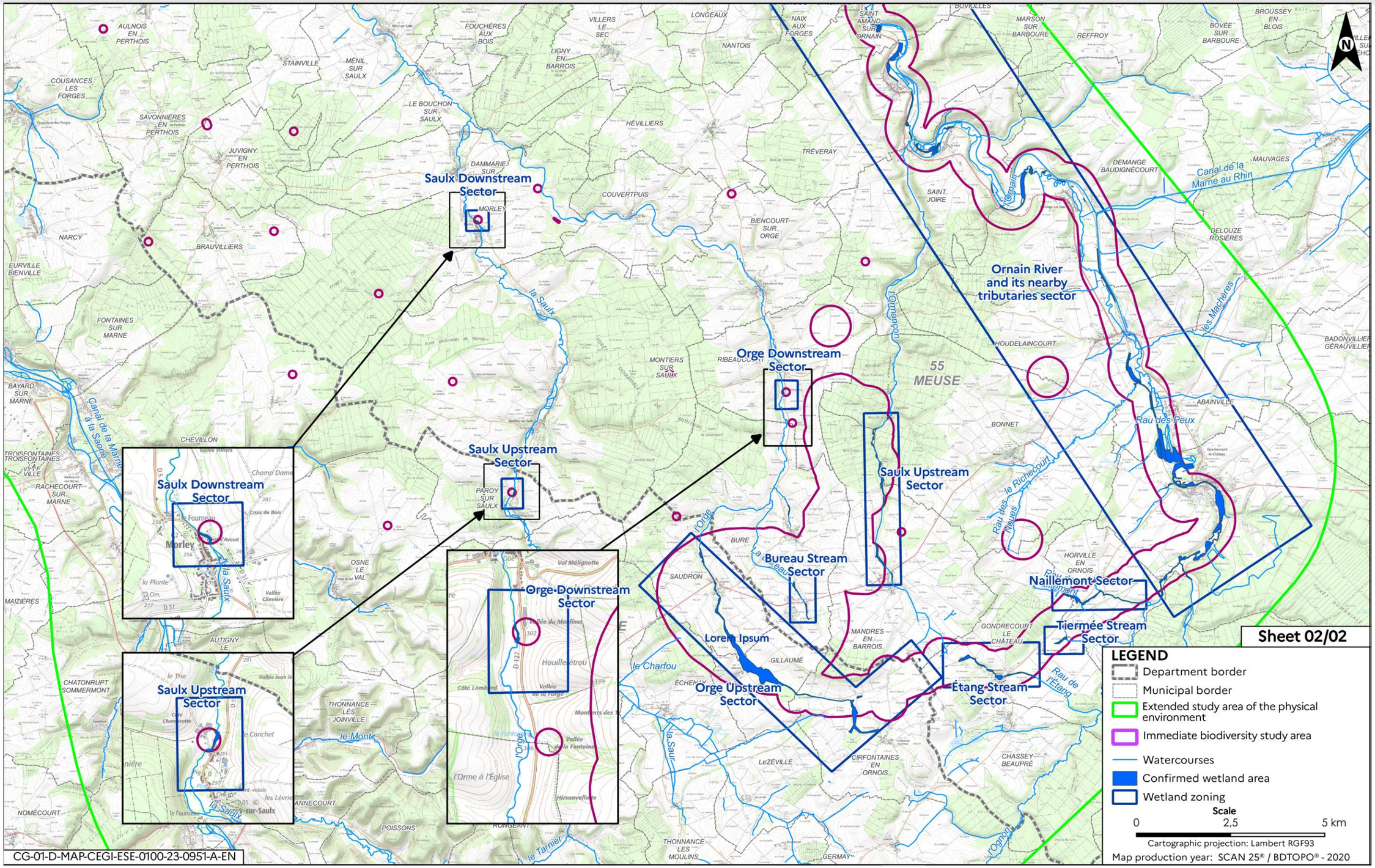


Figure 3-34 Location of confirmed wetlands according to the July 26, 2019 regulations within the immediate biodiversity study area of the Cigéo overall project (2/2)

3.6.1.4 Ecological continuity

ECOLOGICAL CONTINUITY

An ecological continuity is an element of the network of environments necessary for the functioning of habitats and the species they contain: breeding, feeding, wintering, and resting sites, movement corridors, etc. The concept of ecological continuity is linked to that of "landscape connectivity," which refers to the extent to which a landscape allows species to move.

Ecological continuities have two main components: biodiversity reservoirs and ecological corridors.

BIODIVERSITY RESERVOIRS

Biodiversity reservoirs are areas where biodiversity is most abundant, where species can complete all or part of their life cycle. They harbour core populations of wild species or are capable of supporting new ones. They include all or part of protected areas and natural areas important for the preservation of biodiversity.

ECOLOGICAL CORRIDORS

Ecological corridors are preferred migration routes used by wildlife that connect biodiversity reservoirs. Ecological corridors are not necessarily composed of "remarkable" habitats and are often ordinary natural areas.

3.6.1.4.1 National and regional levels of ecological connectivity

The Grand Est region is traversed by ecological continuities of national importance. The remote study area is located on the periphery of two ecological continuities in forested areas. However, at the regional level, the Cigéo disposal facility is outside the areas with the highest concentration of biodiversity reservoirs and corridors.

3.6.1.4.2 Biodiversity reservoirs and corridors identified in the SRADDET

Three regional ecological corridors cross the periphery of the immediate biodiversity study area (excluding the 400 kV transmission line), as shown on the figure 3-35:

- the terrestrial forest ecological corridor running north of the Lejuc woods and extending between the Montiers-sur-Saulx forest west of the Orge River and the Reffroy forest east of the Ornain River. It follows a section of the Ornain Valley and the 027000 railway line between the municipalities of Tréveray and Saint-Joire;
- the thermophilic herbaceous ecological corridor that runs along the Ornain Valley and the 027000 railway line;
- the terrestrial forest ecological corridor that runs southeast of the connected terminal.

Certain sections of watercourses are also identified as reservoir-corridors: the Ormançon, the Maldite, the Ognon, as well as the Ornain and its other tributaries.

Within the immediate biodiversity study area (excluding the 400 kV transmission line), most forested areas are identified as permeable zones, i.e., areas where species can move freely. Within the 400 kV transmission line study area, the main elements constituting the green and blue infrastructure are:

- wetland biodiversity reservoirs: the Horre Pond, the Osne-le-Val ZNIEFF, and the Meuse Valley;
- wetland corridors: La Saulx, the Marne, the Blaise, the Héronne, the Ornain, and the Lentilles Stream, the Meuse;
- biodiversity reservoirs: the Val d'Osne ZNIEFF, the large forested areas, the surroundings of the Étang de la Horre, the ZNIEFF (forestry), the Gondrecourt Forest, and the surrounding forested areas;
- terrestrial corridors: the banks and woodlands of the Étang de la Horre, the Val de Marne, the Saulx Valley, and the wooded areas east of Gondrecourt and in Taillancourt.

3.6.1.4.3 Sub-networks representative of the study area distant from the Cigéo overall project

SUB-NETWORKS

A sub-network corresponds to the set of areas comprising the same type of habitat (forest, wetland, or calcareous grassland, etc.) and the network formed by these more or less connected areas. They consist of biodiversity reservoirs, ecological corridors, and other areas that contribute to forming the sub-network.

The connectivity of the three ecological sub-networks representative of the Cigéo project's host territory has been modelled:

- sub-network of forested habitats

  Wooded areas are well represented and are of even greater importance when associated with other types of non-wooded habitats that are particularly rich (shrubby edges, meadows, and grasslands, etc.). The main continuities of the forested sub-network are located near the Lejuc woods, in the shaft zone, at the connected terminal, and along the 027000 railway line.

  The main breaks in connectivity related to the Cigéo overall project are located at the connected terminal and the 027000 railway line. The immediate biodiversity study area therefore presents a significant local challenge for the movement of species within the forested sub-network;

- open habitat sub-network

  Open habitats are represented by a mosaic of grassland and agricultural habitats. The main continuity of the open habitat sub-network are located along the Ormançon Valley, then along the ITE and the 027000 railway line. The ramp zone and adjacent operations are only partially affected by this sub-network.

  The main breaks in connectivity related to the Cigéo overall project are located at the connected terminal and the 027000 railway line;

- Sub-network of aquatic and wetland habitats

  This sub-frame is characterised by the wetland and aquatic corridor associated with the Ornain River, which crosses the immediate biodiversity study area by running parallel to railway line 027000 from north to south. Along this route, several discontinuities exist, particularly in its central section. This corridor is all the more important because the impacts of railway line 027000 are compounded by those of the D966 departmental road, which also runs alongside the course of the Ornain.

  At the heart of the Cigéo disposal facility, the most sensitive corridor is the one associated with the Ormançon, east of the shaft zone. It constitutes an important local corridor, as it feeds the biodiversity reservoir associated with the Bois de la Caisse.

  Finally, at the connected terminal, the immediate biodiversity study area is crossed by corridors linked, on the western side, to the Étang stream and, on the eastern side, to the Naillemont stream.

  The stakes associated with this sub-network range from high in the shaft zone to moderate for the ramp zone and the sonnected terminal (ITE).

Issues for the preservation of ecological connectivity

Three sub-networks cross the immediate biodiversity study area: the forested areas sub-network, the open areas sub-network, and the aquatic and wetland areas sub-network.

Moderate level issue that may be high locally

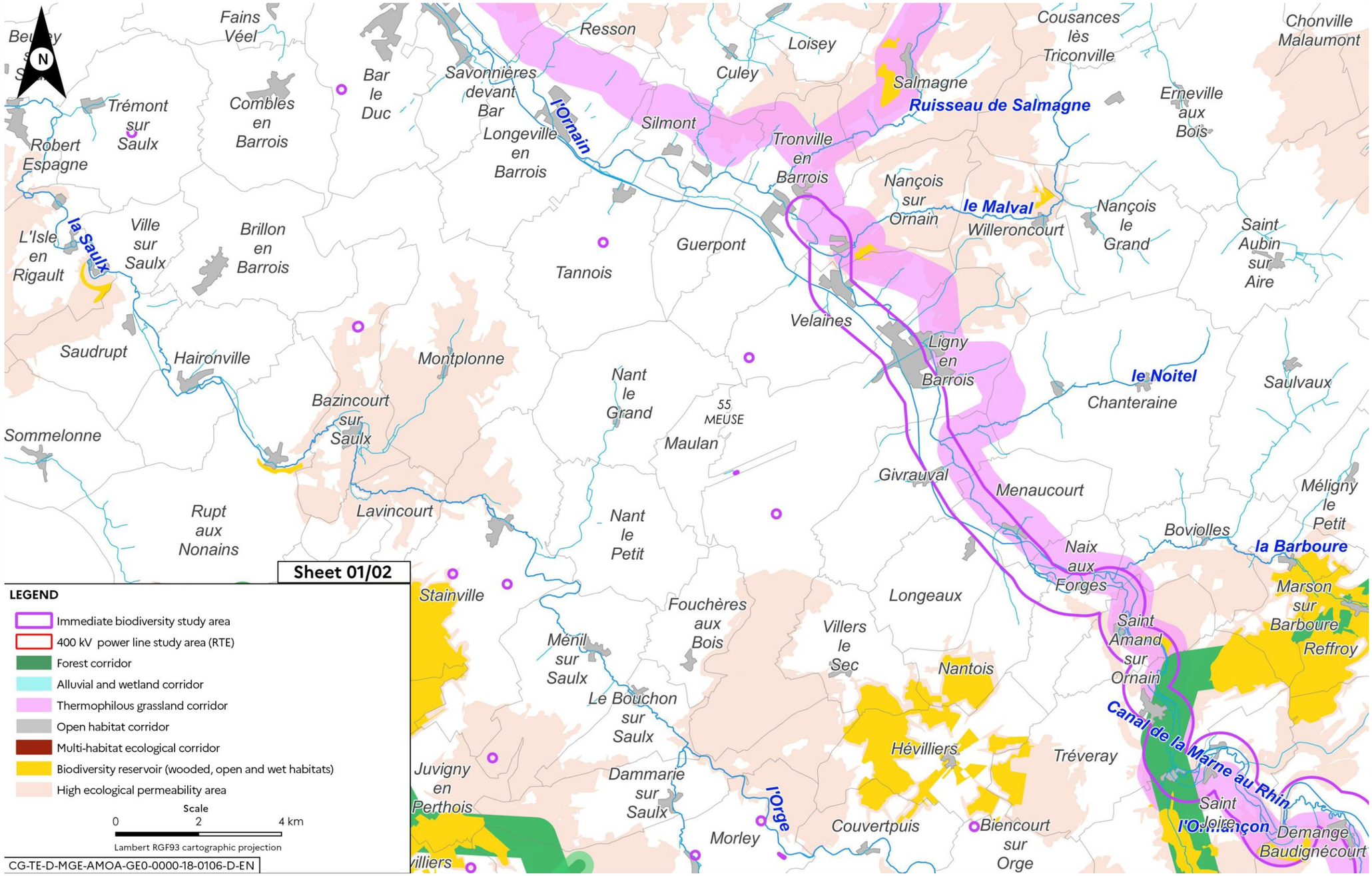


Figure 3-35 *Map of ecological corridors within the immediate biodiversity study area (1/2)*

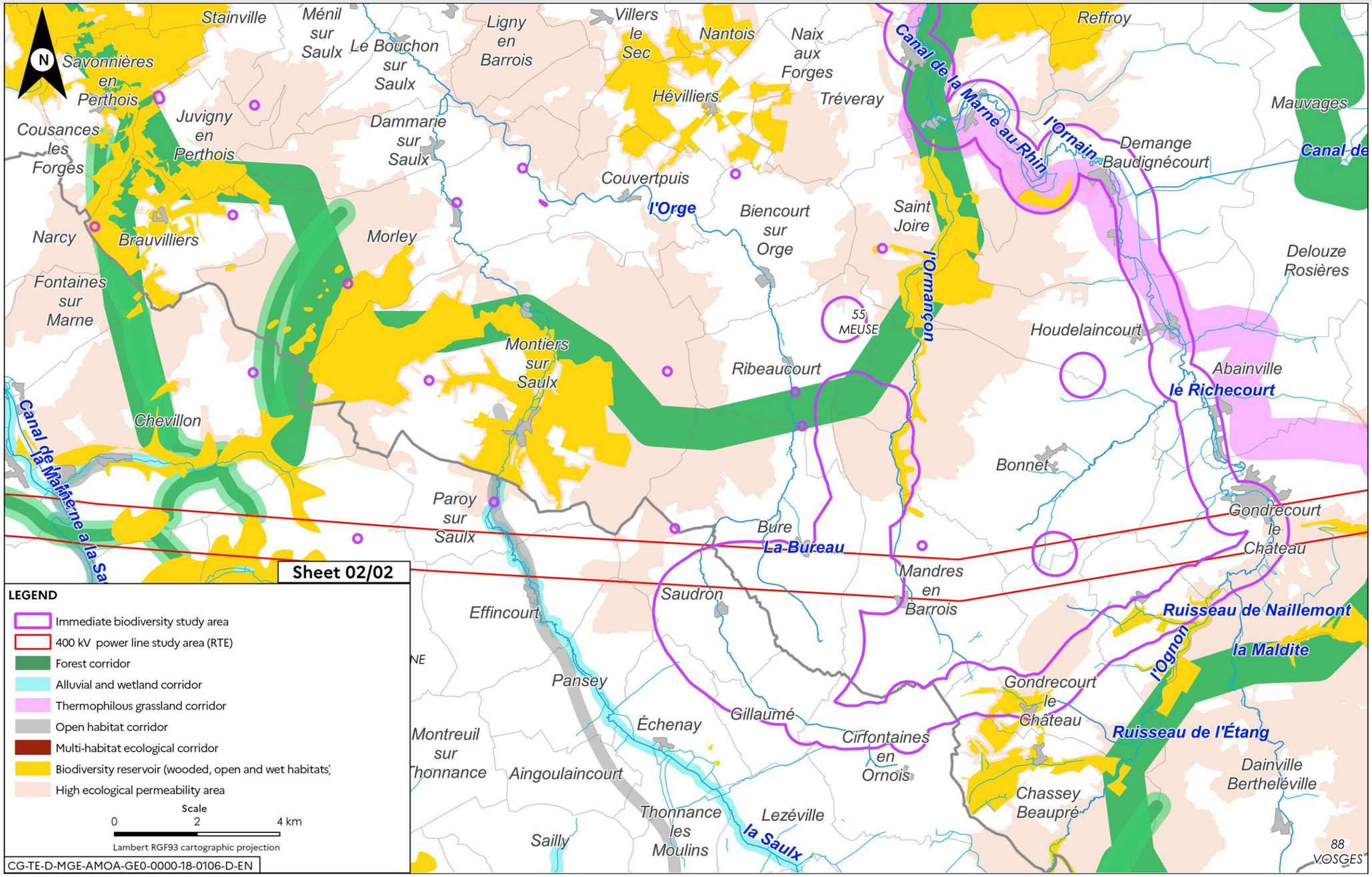


Figure 3-36 Map of ecological corridors within the immediate biodiversity study area (2/2)

3.6.1.5 Biodiversity issues at the scale of the Cigéo overall project

HABITAT NAMES

Natural habitats

A natural habitat is a terrestrial or aquatic area distinguished by its geographic, abiotic, and biotic characteristics, whether entirely natural or semi-natural. While taking all environmental factors into account, the identification of natural habitats relies primarily on vegetation, which best reflects the ecological conditions of a given environment.

Habitat of Community Interest

Habitats of Community interest are listed in Annex I of the Habitats Directive 92/43/EEC (6). They were selected based on the following criteria:

- at risk of extinction within their natural range;
- having a reduced range as a result of their decline or because of their inherently limited range;
- constituting outstanding examples, specific to a European biogeographic region, and representative of the ecological diversity of the European Union.

Priority habitat

A habitat at risk of extinction within the European territory of the Member States and for whose conservation the European Union bears a special responsibility. Priority habitats are marked with an asterisk in appendixes I and II of the "Habitats" Directive 92/43/EEC.

ECOLOGICAL ISSUE

The conservation value represents the value attributed to a species, a biological group or a community of species, a natural habitat, vegetation, or a combination of these various elements. This is an assessment made without prejudging the project's effects.

LEVEL OF IMPORTANCE OF A SPECIES HABITAT

The level of interest of a species' habitat corresponds to the potential of an environment to meet all or part of the needs of wildlife species (reproduction, movement, feeding, overwintering, migration, etc.).

GROUPING OF WILDLIFE SPECIES INTO ASSORTMENTS

Based on the characterisation of issues affecting protected and heritage species, it was decided to group them into assemblages with similar ecological affinities. These assemblages were defined by taking into account target heritage and/or protected species.

3.6.1.5.1 Ecological issues (fauna and flora) within the immediate study area regarding biodiversity associated with the 400kV transmission line corridor and adjacent operations (electricity connection, deviation of the D60/960 departmental road, and inter-site link)

a) Natural habitats

The immediate study area associated with the access road zone and adjacent operations is characterised by open agricultural landscapes covering 80% of its total area. These habitats are considered to be of low ecological concern.

For the remainder of the area, five habitats of community interest have been identified, two of which are priority habitats under the "Habitats" Directive and are of very high conservation importance: "Intermittent watercourses x White willow gallery forests" and "Intermittent watercourses x Ash and alder forests of slow-flowing rivers x *Phalaris arundinacea* vegetation x Calamagrostis margins of flowing waters" (*91E0). Two habitats, although not prioritised, are classified as high-issue given their good conservation status (Calcareous beech forests with Melic grass, Central European lowland forage grasslands). The other community habitats identified are non-priority within the meaning of the Directive and have been classified as moderate priority: they are located on the periphery of the immediate study area, along the banks of the Orge or the Bureau. These include the habitats "Freshwater x Lemnaceae cover," "White Willow gallery forests x Small woods, copses," "Swampy alder forests," "Swampy willow forests with gray willows," "Calcareous beech forests with melic grass x Small woods, copses," "Central European lowland forage grasslands x Improved dry grasslands," "Central European lowland forage grasslands x Continuous pastures," "Fallow land x Central European lowland forage grasslands," and "Riparian vegetation."

b) Flora

Field inventories conducted through 2022 have revealed the presence of one protected species in Lorraine: the highly threatened dropwort (*Filipendula vulgaris*), as well as seven heritage species, five of which are highly threatened: large Venus's-looking-glass (*legousia speculum-veneris*), orange New Zealand sedge (*carex testacea)*, annual nettle (*urtica urens*), bulbous bluegrass (*poa bulbosa*), and field buttercup (*ranunculus arvensis*), and two species of moderate concern: Venus's comb (*scandix pecten-veneris*) and unspotted lungwort (*pulmonaria obscura*). Note that seven other heritage species are listed in the bibliography and may be present: littlepod false flax (*camelina microcarpa*), marsh-marigold (*caltha palustris*), brookgrass (*catabrosa aquatica*), smooth hawksbeard (crepis capillaris), cleavers (*galium aparine*), French oat-grass (*gaudinia fragilis*), and dyer's plumeless saw-wort (*serratula tinctoria*).

In addition, the downstream area is affected by five invasive alien species: the butterfly bush (*buddleja davidii*), Himalayan balsam (*impatiens glandulifera*), Japanese knotweed (*reynoutria japonica*), black locust (*robinia pseudoacacia*), and thicket creeper (*parthenocissus inserta*).

c) Fauna

Insects

Field surveys have revealed the presence of three protected species: the southern damselfly (*coenagrion mercuriale*), the marsh fritillary (*euphydryas aurinia*), and the large copper (*lycaena dispar*)at the Orge and Bureau sites. The conservation concerns are generally low for insects, except for heritage species, particularly one species of high concern: the southern damselfly (coenagrion mercuriale), and one species of moderate concern: *Procraerus tibialis*. Two other heritage species are listed in the bibliography and are taken into account: the variable damselfly (*coenagrion pulchellum*) and the coronilla burnet (*zygaena ephialtes*).

Insects of grassland habitats, insects of fresh, open woodlands, and insects of wet meadows present a moderate risk.

Finally, insects of riparian forests and stream/riverbanks are of high concern.

The heritage insect species recorded in the immediate study area associated with the ramp zone and adjacent operations—which are linked to open habitats such as grasslands, fallow land, lawns, pastures, and wetlands, as well as watercourses and woodlands, the habitats present within the immediate study area—and particularly within the potential intervention zone—are generally of very low interest to insects. It should be noted that in this study area, the woodlands are young and offer fewer habitats favourable to beetles.

The Orge Valley, which features numerous dry patches particularly favourable to the southern damselfly (*coenagrion mercuriale*), is considered to be of very high interest in certain areas.

Wooded areas, including hedgerows and copses, are classified as being of high to moderate interest.



Figure 3-37 Large copper (Source: Biotope)

Amphibians

Surveys have identified nine protected species present, three of which are heritage species: common toad (*bufo bufo*), alpine newt (*mesotriton alpestris*), smooth newt (*lissotriton vulgaris*), marsh frog (*pelophylax ridibundus*), palmate newt (*lissotriton helveticus*), and common parsley frog (*pelodytes punctatus*), along with the common midwife toad (*alytes obstetricans*), edible frog (*pelophylax kl. esculentus*), and common frog (*rana temporaria*) as heritage species. Conservation concerns are generally considered low, except for the common midwife toad, the common parsley frog, and the smooth newt, which are considered to pose a moderate threat.

The amphibian communities of anthropogenic village habitats (ponds, wash houses, gardens) as well as those of wet meadows present a moderate conservation concern.

The Ormançon stream and the Orge valley appear to be of low to moderate interest, while all artificial reservoirs and the areas surrounding the Bureau—a watercourse with numerous dry stretches—are considered to be of low interest.

Apart from a few wooded areas, thickets, and hedgerows of moderate importance—which may serve as wintering habitats near potential breeding sites—the immediate study area, dominated by agricultural landscapes, is generally of low importance in terms of amphibian habitats.

Regarding the potential project area, only its western edge presents a moderate local interest near the Orge River; the rest of the potential project area is of very low interest.

Reptiles

Five protected species were observed: the common slow worm (*anguis fragilis*), the common wall lizard (*podarcis muralis*), the sand lizard (*lacerta agilis*), the barred grass snake (*natrix helvetica*), and the green whip snake (*hierophis viridiflavus*). The conservation concerns are generally low, except for the green whip snake, the common wall lizard, and the sand lizard, which are of moderate concern.



Figure 3-38 Green whip snake (Source: Biotope)

Reptiles in hedgerow habitats are of moderate concern.

The immediate study area for biodiversity in the ramp zone is dominated by agricultural land and is generally of low interest to reptiles. However, some areas may prove favourable for reptiles, such as certain open, bushy habitats or the banks of watercourses. Only the Bureau and Orge sectors and a linear stretch of hedgerows present a moderate to high level of interest for reptiles.

Within the potential project area, the western fringe—characterised by diverse habitats associated with the Orge River—indicates moderate to high significance in this sector. Additionally, several shrubby habitats of moderate to high significance have been identified along the D60 departmental road.

Birds

38 heritage bird species have been identified in the study area, most of which are associated with thickets and hedgerows in open habitats. All are protected, except for the European turtle dove (*streptopelia turtur*). Five species are of high conservation concern: the Eurasian stone-curlew (*burhinus oedicnemus*), the Eurasian hoopoe (*upupa epops*), the Whinchat (*saxicola rubetra*), the Montagu's harrier (*circus pygargus*), and the tree sparrow (*passer montanus*).

Birds of thickets and open-country hedgerows (meadows/grasslands/hedgerows/agricultural landscapes) and birds of forest edges, young or open forests, and thickets are classified as having medium conservation concern. Ground-nesting birds in agricultural plots are of high conservation concern.

The habitats are predominantly represented by croplands. Aside from croplands and ruderal areas, which are of low interest, the other habitats serve either as breeding grounds for a significant number of heritage species of concern, or as feeding areas essential for successful reproduction or any other part of their life cycle. They are generally of medium interest and, in some cases, high to very high.

Within the potential project area, the level of habitat interest is generally low for birds associated with aquatic environments and moderate in the western fringe near the Orge River.

Regarding the group of birds associated with old-growth forests, the potential project area presents only a low level of interest.

Terrestrial and semi-aquatic mammals

Surveys conducted through 2022 revealed the presence of five protected terrestrial mammal species—the European wildcat (*felis silvestris silvestris*), hazel dormouse (*muscardinus avellanarius*), red squirrel (*sciurus vulgaris*), and European hedgehog (*erinaceus europaeus*)—as well as the Eurasian water shrew (*neomys fodiens*) and three non-protected heritage species—the bicolored shrew (*crocidura leucodon*), European polecat (*mustela putorius*), and European edible dormouse (*glis glis)*—within the study area. Among these species, five are classified as having a medium conservation concern: the European wildcat, hazel dormouse, European edible dormouse, bicolored shrew, and European polecat. Additionally, one protected and heritage semi-aquatic mammal species was observed—the Eurasian water shrew—which is also classified as having a medium conservation concern.

The mammal communities of forest habitats, those of hedgerow and forest edge habitats, and those of wetland/aquatic habitats are classified as having moderate conservation concern.

Wooded areas (including hedgerows and copses) are classified as being of moderate to high interest. They not only serve as habitats and foraging sites for mammals but, above all, act as movement corridors for these species. The same applies to watercourses (Orge, Bureau, and Ormançon) and associated habitats.

Open habitats such as meadows, pastures, and cultivated areas, which cover most of the study area, are generally of low to very low interest, even though they may be used as hunting grounds by the European wildcat.

Villages have been assigned a low level of interest. This type of habitat is home to several native wild mammal species, such as the hedgehog (*erinaceinae*), a protected species often found in villages and gardens. The main areas of interest within the potential project area are located on the eastern and western edges due to their proximity to the Orge and Bureau rivers.

Small streams and other aquatic environments are favourable to the Eurasien watershrew. They are therefore considered to be of medium importance.

Chiroptera/bats

Field surveys have identified 18 protected species: western barbastelle (*barbastella barbastellus*), greater mouse-eared bat (*myotis myotis*), whiskered bat (*myotis mystacinus*), Geoffroy's bat (*myotis emarginatus*), Alcathoe bat (*myotis alcathoe*), Brandt's bat (*myotis brandtii*), Bechstein's bat (*myotis bechsteinii*), Daubenton's bat (*myotis daubentonii*), Natterer's bat (*myotis nattereri*), common noctule (*nyctalus noctula*), Leisler's bat (*nyctalus leisleri*), gray long-eared bat (*plecotus austriacus*), brown long-eared bat (*plecotus auritus*), lesser horseshoe bat (*rhinolophus hipposideros*), common pipistrelle (*pipistrellus pipistrellus*), Nathusius's pipistrelle (*pipistrellus nathusii*), soprano pipistrelle (*pipistrellus pygmaeus*), and serotine bat (*cnephaeus serotinus*).

Two species are considered present: Kuhl's pipistrelle (*pipistrellus kuhlii*) and the greater horseshoe bat (*rhinolophus ferrumequinum*).

Of the 18 species recorded, ten are heritage species. One species is considered high-priority: the greater mouse-eared bat, and 15 are medium-priority.

Bats of forest edges and hedgerows while hunting and in transit, bats of forest habitats (wet or dry) while hunting, bats of valleys/watercourses while hunting and in transit, and ubiquitous and anthropophilic bats are classified as medium-risk.

Apart from the woodlands and copses in the descent zone, the potential for bat habitat is zero due to the absence of trees or shrubs. This zone is dominated by open areas (crops and some pastures). The habitats of greatest interest are concentrated along the watercourses (Orge, Bureau, and Ormançon) within the forested and shrubby areas. Thus, within the potential project area, the eastern and western edges near the watercourses are the sectors where the highest levels of interest are concentrated.

The potential intervention area is also of interest for bat hunting, particularly the central part consisting of open areas.

Few landscape features facilitate species movement.

Aquatic Fauna

The immediate study area associated with the ramp zone and adjacent operations is bordered by the following watercourses: the Orge on the western edge, the Bureau to the north (dry for much of the year), and the Ormançon on the eastern edge of the immediate area associated with the inter-site link. However, these watercourses are not particularly favourable to aquatic fauna.

No protected fish species have been recorded in the immediate study area. Four fish species of low conservation concern have been identified in the Orge, downstream of the study area, including one species of community interest: the European bullhead (*cottus gobio).* The *bythinella* (a protected aquatic mollusc) has also been observed.

Ecological issues in the ramp zone and adjacent operations

Analysis of the various species groups shows that conservation concerns within the immediate study area regarding biodiversity associated with the ramp zone area and adjacent operations primarily involve bats, birds, insects, and terrestrial mammals.

Habitats of interest for all groups within the immediate biodiversity study area—whether for reproduction, feeding, or transit—are primarily located in the small valleys of the Orge and Bureau rivers. Other structural elements, such as hedgerows located in the middle of croplands and wooded areas, are also of interest to most of the species surveyed.

Moderate level issue

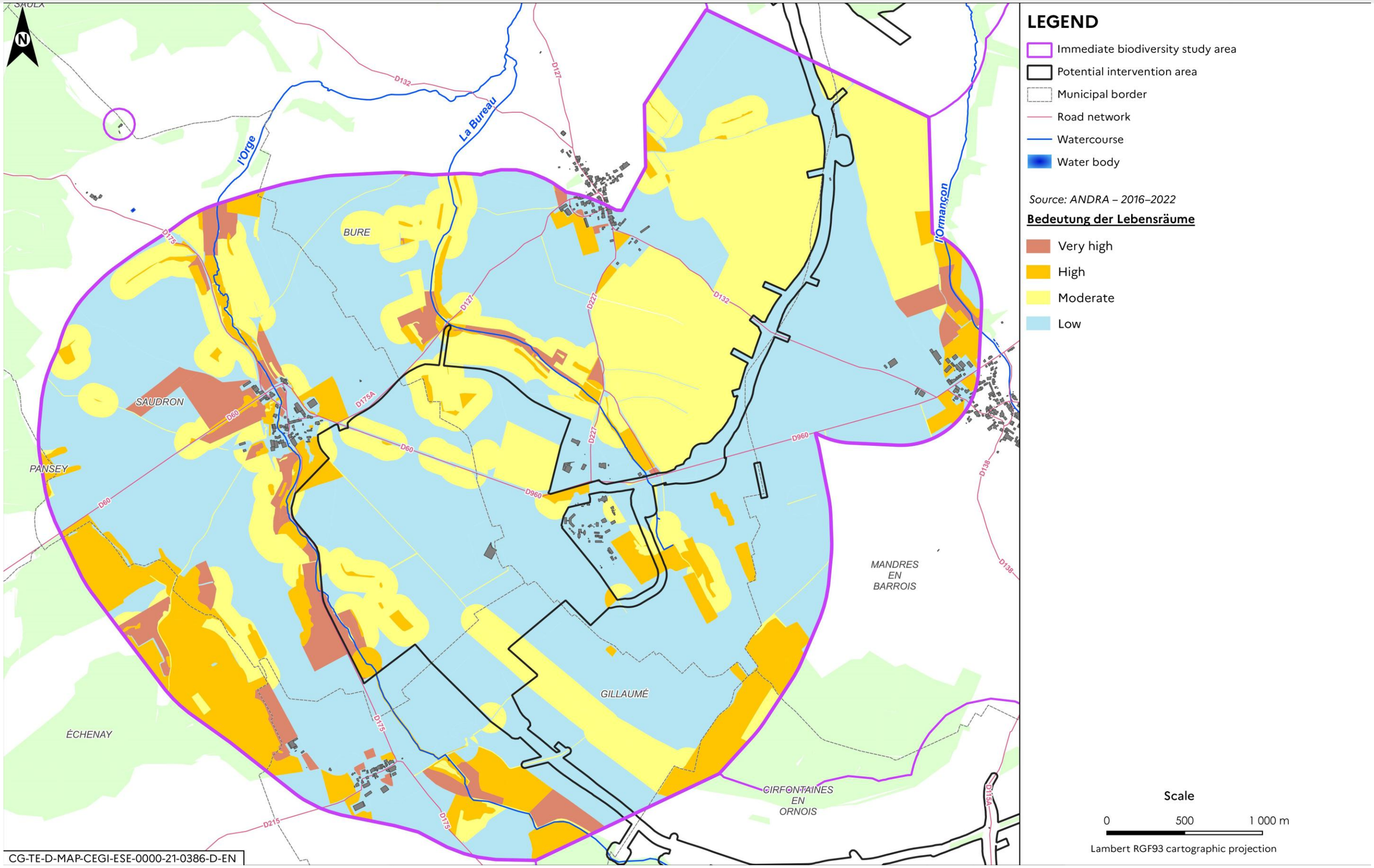


Figure 3-39 *Summary of habitat interest levels for all species groups within the immediate study area for biodiversity associated with the ramp zone and adjacent operations*

3.6.1.5.2 Ecological issues (fauna and flora) within the immediate study area for biodiversity associated with the shaft zone

a) Natural habitats

The immediate biodiversity study area is characterised by the presence of five heritage natural habitats, including the "Beech forest with Melic grass," considered a high-priority habitat due to its community interest. The following habitats are worth noting: "Deciduous forest scrub x Calcareous beech forests with Melic grass," "Central European lowland forage grasslands," "Central European lowland forage grasslands x Continuous pastures," "Mesophilic forest edges x Roadways and edges (roads, vehicle-accessible paths)" which present a medium conservation priority.

b) Flora

Surveys conducted up to 2020 revealed no protected species. One heritage species, the maiden pink (*dianthus deltoides*), was observed and is of high conservation concern. Five other heritage species are listed in the bibliography and are considered present with medium conservation concern: littlepod false flax (*camelina microcarpa*), smooth hawksbeard (*crepis capillaris*), cleavers (g*alium aparine*), *gaudinia fragilis*, and Venus's comb (*scandix pecten-veneris*)). Additionally, the shaft zone is affected by an invasive alien species: Japanese knotweed (*reynoutria japonica*).

c) Fauna

Insects

Field surveys have revealed the presence of two protected species: the large copper (*lycaena dispar*) and the southern damselfly (*coenagrion mercuriale*), as well as six heritage species: the small pearl-bordered fritillary (*boloria selene*), the white-letter hairstreak (*satyrium w-album*), the scarce swallowtail (*iphiclides podalirius*), *Eurosoma minor*, the weaver beetle (*lamia textor*), and *Hylis simonae*. One species is of high concern: the white-letter hairstreak, and six are of moderate concern. One heritage species is considered present (*Hylis simonae*) based on the literature.

All insect communities (insects of fresh, open woodlands; insects of grassland habitats; insects of wet meadows; insects of riparian forests; and insects of stream/river banks) are classified as being of moderate concern.

Most of the study area in the shaft zone, and particularly in the potential intervention zone, consists of beech-melic grasslands interspersed with coppice. These areas are considered to be of high to moderate interest.

South of the woodlands, croplands are also present and are considered to be of low interest.

Amphibians

Six protected species were observed during field surveys: smooth newt (*lissotriton vulgaris*), common midwife toad (*alytes obstetricans*), alpine newt (mesotriton alpestris), palmate newt (*lissotriton helveticus*), common toad (*bufo bufo*), and common frog (*rana temporaria*). Among them are two heritage species of medium concern: the smooth newt and the common midwife toad. Another protected species, the fire salamander (*salamandra salamandra*), is listed in the bibliography and was taken into account even though it was not observed during the field surveys.

The common midwife toad, found in anthropogenic village habitats (ponds, wash houses, gardens), and the smooth newt, found in hedgerow habitats, are classified as species of moderate concern.

Part of the study area features a mosaic of habitats, including several wetlands and a small nearby stream, making the area favourable for amphibians during both their aquatic phase (reproduction) and their terrestrial phase (migration, summering, and overwintering).

In terms of wintering and migration, woodlands play an important role for amphibians that spend most of their time in the terrestrial phase and use wetlands only for reproduction. As such, interactions are likely between watercourses and woodlands. The Lejuc Wood and other copses are thus considered to be of moderate importance for wintering.

The levels of importance of species habitats for amphibians in the potential project area are primarily linked to wintering habitats, some of which are characterised by high levels of importance.



Figure 3-40 Common midwife toad and smooth newt (source: Biotope)

Reptiles

Investigations have revealed the presence of five protected species: smooth snake (*coronella austriaca*), viviparous lizard (*zootoca vivipara*), sand lizard (*lacerta agilis*), common slow worm (*anguis fragilis*), and barred grass snake (*natrix helvetica*). Among these species, two are heritage species of medium concern: smooth snake and sand lizard.

The reptile community of bocage areas has been assigned a medium conservation priority.

The forested area provides favourable conditions for the presence of the common slow worm and the barred grass snake. In the Lejuc forest, the southern and western forest edges are considered to be of moderate to high importance for the sand lizard and the smooth snake, and some forest plots are considered to be of moderate to high importance for the viviparous lizard. The rest of the forest massif, as well as the Ormançon Valley running through it, are nevertheless considered functional, at least for the movement of the various reptile species present, particularly due to the presence of "internal edges" defined by forest roads.



Figure 3-41 Sand lizard and smooth snake (Source: Biotope)

Birds

During inventories, *at least* 26 heritage species of medium regional concern were recorded, 25 of which are protected. Nineteen species are of medium concern and seven of low concern. Additionally, two protected heritage species are considered present based on the literature.

A medium level of concern is associated with the bird communities of thickets and hedgerows in open environments (meadows/grasslands/hedgerows/agricultural areas); edge-dwelling birds, young or open forests birds, thickets birds, and birds of old-growth forest environments, which may be locally abundant.

The habitats identified in the shaft zone are favourable to the community of birds of old-growth forest habitats, within deciduous high forests, and, to a lesser extent, to the community of birds of forest edges, young or open forest habitats, and thickets within coppice forests.

Within the potential project area, the level of habitat suitability is generally low to very low for birds of aquatic habitats. Only the northeastern edge of the afforestation area is characterised in part by moderate suitability, given its proximity to the Ormançon.

Regarding the group of birds inhabiting old-growth forest habitats, the potential project area presents a moderate level of interest in the younger, more open woodlands and coppice stands, and a high level of interest in the plots of large and very large hardwood trees, particularly in the eastern section.

Regarding the bird community of agricultural habitats, the forested potential intervention area presents only very low interest for these birds.

In contrast to the bird communities of old-growth forest habitats, the level of interest for the bird communities of young or open forest habitats and thickets is low in the eastern part of the potential project area, where mature forest has developed, and generally moderate in the younger forests and coppice stands to the west and north.

The level of interest in habitats associated with pioneer environments is very low to low across nearly the entire potential project area.

Finally, the level of interest for habitats associated with birds of thickets and hedgerows in open areas is low to very low across the entire potential project area. Only clearings in the northern part or open areas with hedgerows at the southern end present moderate interest.

Terrestrial and semi-aquatic mammals

Three protected species have been identified: the European wildcat (*felis silvestris silvestris*) (also heritage species), the hazel dormouse (*muscardinus avellanarius*), and the red squirrel (*sciurus vulgaris*); and according to the literature, the European hedgehog (*erinaceus europaeus*) may be considered present. Three heritage species have also been observed: the bicolored shrew (*crocidura leucodon*), the european edible dormouse (glis glis), and the European polecat (*mustela putorius*).

The immediate study area, consisting mainly of wooded areas, is particularly favourable to forest species such as the European wildcat and the red squirrel. Wet wooded areas are also very favourable to the European polecat. The hazel dormouse, meanwhile, frequents semi-open areas with shrubby vegetation, using small shrubs and brambles as feeding and resting areas.

Forest plots, characterised by mature forest habitats, were classified as high priority, while younger woodlands were classified as moderate priority. These habitats serve as habitats and feeding grounds for the mammal community and, most importantly, together with the Ormançon Valley, form a movement corridor for the observed animals.

The remainder of the study area, namely open habitats such as meadows and cultivated fields, presents a moderate challenge. Croplands are, in fact, quite frequently used as hunting grounds by the European wildcat.



Figure 3-42 European wildcat (Andra) and hazel dormouse (© G. Delenclos, 2012)

Bats

Surveys have identified 16 protected species: western barbastelle (*barbastella barbastellus*), greater mouse-eared bat (*myotis myotis*), whiskered bat (*myotis mystacinus*), Geoffroy's bat (*myotis emarginatus*), Alcathoe bat (*myotis alcathoe*), Bechstein's bat (myotis bechsteinii), Brandt's bat (*myotis brandtii*), Daubenton's bat (*myotis daubentonii*), Natterer's bat (*myotis nattereri*), common noctule (*nyctalus noctula*), Leisler's bat (*nyctalus leisleri*), Lesser Horseshoe bat (*rhinolophus hipposideros*), Common Pipistrelle (*pipistrellus pipistrellus*), Nathusius's Pipistrelle (*pipistrellus nathusii*), soprano pipistrelle (pipistrellus pygmaeus), and serotine bat (*cnephaeus serotinus*). Among these protected species, 12 are heritage species, three of which are of high conservation concern: Greater mouse-eared bat, Geoffroy's bat, and lesser horseshoe bat. Two protected species are considered present based on the literature: Kuhl's pipistrelle (*pipistrellus kuhlii*) and greater horseshoe bat (*rhinolophus ferrumequinum*).

The following have been identified: edge/hedgerow bats hunting and in transit; forest bats (both humid and dry habitats) hunting, with medium to locally high conservation importance; valley/stream bats hunting and in transit; and ubiquitous and anthropophilic bats with medium conservation importance.

Considering the bat species frequenting the afforestation area, as well as other groups (woodpeckers, saproxylic beetles), it appears that many trees with cavities and/or those dying or with peeling bark could be favourable to bats. The functionality of this afforestation area is good, as evidenced by the results of inventories of other faunal groups.

Within the Lejuc forest, the potential for roosting trees is generally quite high, with nearly all plots east of the central forest road having high potential. Conversely, forest plots west of this road tend to have low or even very low potential (young plantations). In this sector, however, a few plots do exhibit high potential.

Numerous landscape features facilitate bat migration: hedgerows, woodlands, valleys, and watercourses all provide favourable conditions for species to move and interact between neighbouring populations. The Ormançon Valley and the western edge of the Lejuc Woods are considered the main flight routes.

Aquatic Fauna

One protected species has been identified in the Ormançon: the brown trout (*salmo trutta*), whose eggs and spawning grounds are protected, though the conservation concern for this species is considered low; and one heritage species of moderate conservation concern: the European bullhead (*cottus gobio*). No protected mollusc species have been recorded.

The Ormançon is home to a variety of fish species typical of salmon-bearing streams. Low flow rates and summer dry spells pose minimal conservation challenges for these species in the section of the stream east of the shaft zone.

Ecological issues within the shaft zone

Within the immediate study area for biodiversity associated with the shaft zone, species-related concerns primarily involve bats, terrestrial mammals, and birds in forested areas. The forest edges and the Ormançon valley present specific challenges for insects, reptiles, and amphibians.

The majority of habitats in the shaft zone are considered to be of high importance. Only the croplands west of the potential project area are of low importance.

High level issue

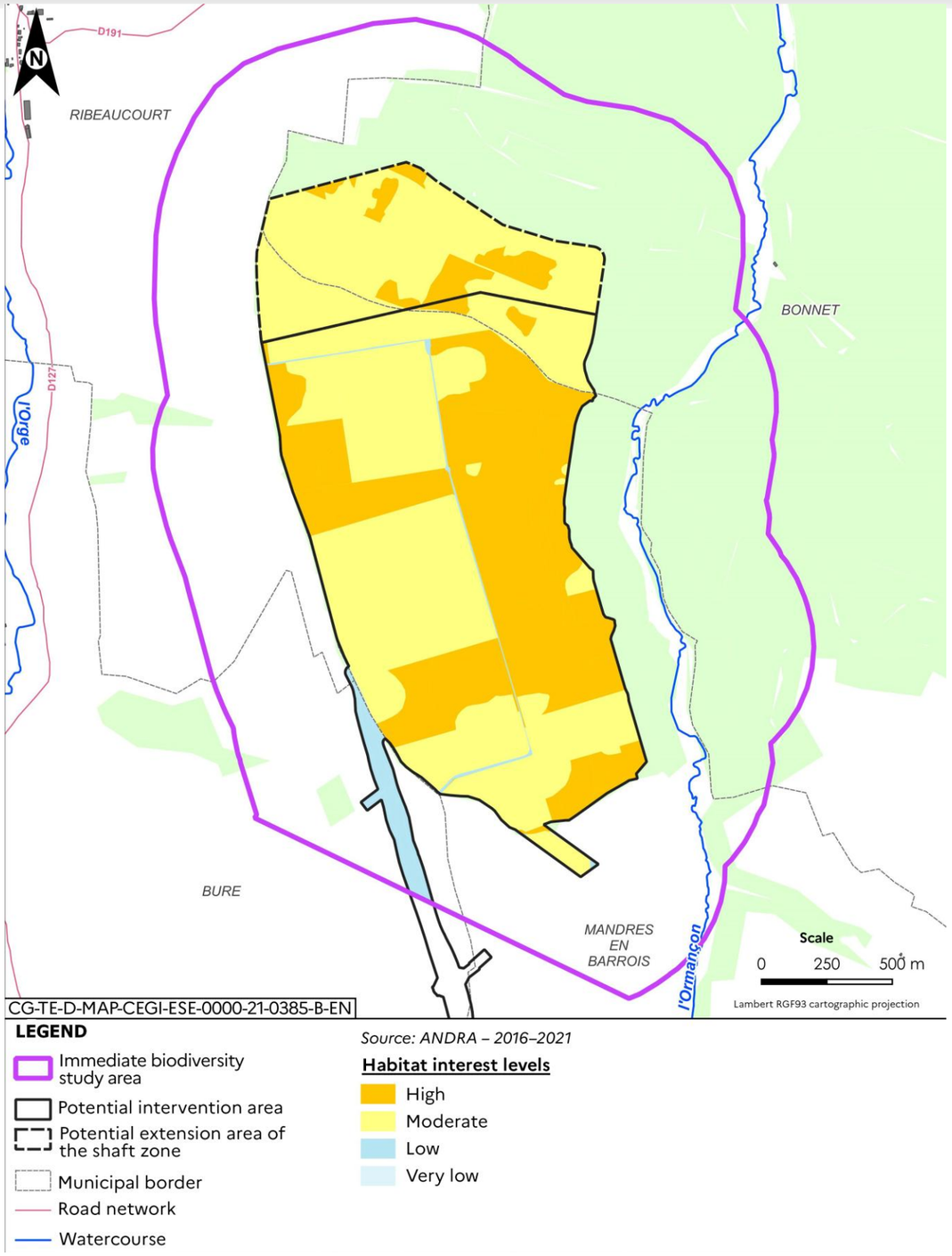


Figure 3-43 *Summary map of habitat interest levels for all species groups within the potential intervention zone of the shaft zone.*

3.6.1.5.3 Ecological issues (fauna and flora) within the immediate study area regarding biodiversity associated with the connected terminal

a) Natural habitats

The immediate study area for biodiversity associated with the connected terminal is characterised by the presence of 68 natural habitats, including six community habitats. The six identified community habitats are as follows and correspond to Natura 2000 habitats: “Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*,” “Rivers from lowland to montane levels with vegetation of the *Ranunculion fluitantis* and *Callitricho-Batrachion*,” “Natural eutrophic lakes with Magnopotamion or Hydrocharition vegetation,” “Beech forests of the Asperulo-Fagetum,” “Semi-natural dry grasslands and scrubby facies on limestone (*Festuco-Brometalia*),” “Low-altitude hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*).” Eight habitats are of very high concern (seven of which are priority habitats as defined at the beginning of the “3.6.1.5” chapter of this non-technical summary) and seven habitats are of high concern.

b) Flora

Five regionally protected species have been identified: dropwort (*filipendula vulgaris*), green houndstongue (*cynoglossum germanicum*), water germander (*teucrium scordium*), hairy melic (*melica ciliata*), and narrow-leaved helleborine (*cephalanthera longifolia*). Sixteen of the observed species are heritage species, including one of very high conservation concern: dropwort, and eight of high conservation concern: Round-headed leek (*allium sphaerocephalon*), green houndstongue, water germander, and large Venus's-looking-glass (legousia speculum-veneris). Finally, a medium level of concern is assigned to the following species: round-headed rampion (*phyteuma orbiculare*), narrow-leaved helleborine, *cannabis ruderalis*, unspotted lungwort (*pulmonaria obscura*), buttercup (*ranunculus penicillatus*), wall whitlowgrass (*drabella*), and spreading hedge parsley (*torilis arvensis*). Eight heritage species are considered present based on the literature: Cleavers (*galium aparine*), marsh marigold (*caltha palustris*), dyer's plumeless saw-wort (*Serratula tinctoria*), brookgrass (catabrosa aquatica), European Michaelmas daisy (aster amellus), large white buttercup (*ranunculus platanifolius*), smooth hawkweed (*crepis capillaris*), and Tuberous pea (*lathyrus tuberosus*).



Figure 3-44 *Hairy melic (melica ciliata)on the connected terminal branch study area (source: Floragis)*

Three invasive alien species were also recorded: the tree of heaven (*ailanthus altissima*), thicket creeper (*parthenocissus inserta*), and Japanese Knotweed (*reynoutria japonica*).

c) Fauna

Insects

Investigations revealed the presence of two protected species: the orange-spotted emerald (*Oxygastra curtisii*) and the southern damselfly (*coenagrion mercurial*), as well as nine other heritage species. Three species are of high conservation concern: the Nickerl's fritillary (*mellicta aurelia*), the white-letter hairstreak (s*atyrium w-album*), and the southern damselfly. Two heritage species are considered present based on the literature: the large copper—also a protected species—and *mycetophagus fulvicollis*.

Insects of riparian forests and stream/river banks are of high concern, while insect communities in meadow habitats and in open, somewhat moist woodlands are of moderate concern.

The Naillemont Stream downstream of the connected terminal (ITE) and the Étang Stream, where a population of the southern damselfly has been observed, are considered to be of very high interest.

The Ornain Valley and the Glandenoie Woods are considered to be of high interest because several heritage species have been observed there.

Within the potential intervention zone (ZIP) of the connected terminal, the new section, located in Cirfontaines-en-Ornois, presents a low level of habitat interest for insect communities. Conversely, the section located between Horville-en-Ornois and Gondrecourt-le-Château is characterised by moderate to high levels of interest along the entire route.



Figure 3-45 *Southern damselfly (source: Biotope)*

Amphibians

During the inventories, eight protected species were identified: common parsley frog (*pelodytes punctatus*), common midwife toad (*alytes obstetricans*), palmate newt (*lissotriton helveticus*), alpine newt (*mesotriton alpestris*), common frog (*rana temporaria*), common toad (*bufo bufo*), edible frog (*pelophylax kl. esculentus*), and marsh frog (*pelophylax ridibundus*), two of which are of medium concern: the common parsley frog and the common midwife toad.

The communities of anthropogenic village habitats (ponds, wash houses, gardens) and amphibians of wet meadows are classified as having medium conservation concern.

The study area of the connected terminal comprises a mosaic of habitats including wetlands and small streams, making the area favourable for amphibians, whether for their aquatic phase (reproduction) or their terrestrial phase (migration, summering, overwintering). Only the western part of the project, where the route leaves the old track, appears less favourable to amphibians. Indeed, these are areas of cropland and pasture that are clustered together and lack wooded areas or wetlands, with the exception of the Gillaumé ponds.

The Ornain River and its adjacent wet meadows are of high ecological interest. This area is home to two heritage amphibian species: the common midwife toad, classified as a species of moderate concern, and the common parsley frog, classified as a species of high concern.

The Naillemont stream and the adjacent wet meadows south of Horville-en-Ornois are also of high ecological interest, as they are home to a heritage species, the common midwife toad.

Reptiles

The following eight protected species have been observed: smooth snake (*coronella austriaca*), green whip snake (*hierophis viridiflavus*), common wall lizard (*podarcis muralis*), sand lizard (*lacerta agilis*), viviparous lizard (*zootoca vivipara*), asp viper (*vipera aspis*), common slow worm (*anguis fragilis*), and barred grass snake (*natrix Helvetica*), four of which are of medium conservation concern: the green whip snake, the common slow worm, the asp viper, and the smooth snake.

The reptile fauna of the hedgerow habitats is of medium concern.

Nearly the entire route of the connected terminal is classified as being of high interest (presence of all species, with a fairly high number of observations for some). Thermophilic areas and abandoned railway tracks constitute a corridor favourable to the east-west movement of these species.

However, some sections of the connected terminal are of more moderate interest, particularly between the Ferme de Saint-Éloi and the former Luméville station, where few reptile sightings have been recorded. This section, however, constitutes a primary movement corridor and may serve as a link between two areas occupied by the green and yellow snake.

In addition, some sectors with no or few observations were classified as being of low interest due to their functional quality and the low probability of the presence of either species (heritage species or species of low conservation concern). These sectors are mostly connected to areas of medium or high interest via equally functional habitats. These are primarily villages and valleys (Ornain, Naillemont, Ormançon, and Orge).

Areas classified as being of very low interest correspond mainly to vast open areas (arable land, pastures) without hedgerows, copses, or other habitats unlikely to support reptiles.

Birds

The inventories identified 42 heritage species recorded during the breeding season in the immediate study area, 41 of which are protected. Among them, six species are of high conservation concern: black stork (*ciconia nigra*), whinchat (*saxicola rubetra*), European Eagle-Owl (*bubo bubo*), tree sparrow (*passer montanus*), European hoopoe (*upupa epops*), and Montagu's Harrier (*circus pygargus*), and 24 are of medium conservation concern.

Birds of thickets and hedgerows in open habitats (meadows/grasslands/hedgerows/agricultural areas) are identified as high-priority, as are ground-nesting birds in agricultural plots.

Birds of forest edges, young or open forests, thickets, birds of mature forest habitats, birds of aquatic/wetland/riparian woodlands, and birds of pioneer habitats have a medium conservation concern.

Areas of high conservation interest are limited to watercourses within the study area, which may serve as feeding grounds for the black stork (a species of high conservation concern) during the nesting season and as a migratory stopover, as well as orchards that could potentially support the tree sparrow during the breeding season. Apart from croplands, ruderal areas, and industrial sites—which are considered to be of low interest—the other habitats serve either as breeding grounds for a significant number of heritage species of concern or as feeding areas essential for successful reproduction or other parts of their life cycle. They are therefore considered to be of medium interest.

Within the potential project area, the level of habitat importance is generally low for birds associated with aquatic environments and moderate near the Ru de Naillemont and the Ornain.

With regard to bird species found in mature forest habitats, the potential project area is of only low to moderate interest along the entire route.

Regarding bird species found in agricultural habitats, few plots are of moderate interest, with nearly the entire route characterised by low to very low interest.

The bird communities of young or open forest habitats and thickets, meanwhile, are characterised by low interest in the eastern part of the potential project area up to the D115A departmental road, and then generally moderate interest along the remainder of the route to the west.

Habitats in the pioneer habitat group are of very low interest along nearly the entire route.

Finally, the level of interest for the habitats of the thicket and hedge birds in open areas is high to, in some places, very high along nearly the entire route, except for the less shrubby section west of the D115A departmental road, which is considered to be of moderate interest.

Terrestrial and semi-aquatic mammals

Surveys have identified the presence of four protected terrestrial mammal species: European wildcat (*Felis silvestris silverstris*), hazel dormouse (*muscardinus avellanarius*), red squirrel (*sciurus vulgaris*), and European hedgehog (*erinaceus europaeus*), as well as four heritage species: European wildcat, European polecat (*mustela putorius*), hazel dormouse, and European edible dormouse (*glis glis*). Five species are of moderate concern: the European wildcat, the hazel dormouse, the European polecat, the European edible dormouse, and the bicolored shrew (*crocidura leucodon*). One protected semi-aquatic species was also observed: the Eurasian water shrew (*neomys fodiens*).

Wooded areas (including hedgerows and copses) are classified as being of high importance because, not only do they provide habitats and foraging sites for mammals, but, above all, they serve as movement corridors for this fauna. The immediate biodiversity study area of the connected terminal is also classified as being of high interest, as the former railway line serves as a functional corridor for numerous species, including heritage species such as the European wildcat and the European polecat.

Open habitats, such as meadows, pastures, and cultivated areas, which cover most of the study area and serve as hunting grounds for the European wildcat, are of low interest.

Villages are of low interest. This type of habitat is home to several species of native wild mammals, such as the European hedgehog, a protected species often found in villages and gardens.

The potential project area is characterised by an overall average level of interest across the entire connected terminal, due to the forested and shrubby habitats bordering the track, which form an ecological corridor used by mammals.

Only the section of the connected terminal located between Gillaumé and Cirfontaines-en-Ornois is characterised by very low ecological interest.

Bats

During surveys conducted up to 2020, 17 protected species were recorded: western barbastelle (*barbastella barbastellus*), greater mouse-eared bat (*myotis myotis*), whiskered bat (*myotis mystacinus*), Geoffroy's bat (*myotis emarginatus*), Alcathoe bat (*myotis alcathoe*), Bechstein's bat (*myotis bechsteinii*), Brandt's bat (*myotis brandtii*), Daubenton's bat (*myotis daubentoniid*), Natterer's bat (*myotis nattereri*), common noctule (*nyctalus noctule*), Leisler's bat (*nyctalus leisleri*), Grey long-eared bat (*plecotus austriacus*), lesser horseshoe bat (*rhinolophus hipposideros*), common pipistrelle (*pipistrellus pipistrellus*), Nathusius's pipistrelle (*pipistrellus nathusii*), soprano pipistrelle (*pipistrellus pygmaeus*), and serotine bat (cnephaeus serotinus). Of these species, 12 are heritage species, and three are of high conservation concern: Greater mouse-eared bat, Geoffroy's bat, and lesser horseshoe bat.

The community of edge- and hedgerow-dwelling bats hunting and in transit is of high concern. The other communities (forest-dwelling bats (both moist and dry) hunting, valley/stream-dwelling bats hunting and in transit, and ubiquitous and anthropophilic bats) are identified as being of medium concern.

For arboreal roosts, the immediate biodiversity study area is largely dominated by open habitats (primarily croplands, with some grasslands). Devoid of trees, these areas have zero potential.

The entire immediate study area is frequented by bats in flight, though overall activity is higher in wooded or shrubby areas, particularly along the old railroad track.

The entire immediate study area can be used by bats for hunting, but semi-enclosed or enclosed sectors appear to be more heavily utilised (greater species diversity and hunting activity) than cultivated areas, even though the latter may host heritage species such as the greater mouse-eared bat or the common noctule.

The potential intervention area within the shrubby and wooded sectors constitutes a more attractive hunting ground compared to the more open sector, with a generally high level of interest.

The route of the old railway line intersects several other networks and structural elements, forming a network that is important for the movement of several species, some of which are highly specialised and sensitive to landscape structures (lesser horseshoe bat, grey long-eared bat, and Brandt's, Alcathoe's, and Geoffroy's bats).

The old railway line is thus considered a flight route along its entire length. The other flight routes directly concern the immediate biodiversity study area or its surroundings and demonstrate the possible connections between the study area and the habitats of nearby species (roosts or hunting grounds).

Aquatic fauna

Two protected species—the brown trout (*salmo trutta*) and the brook lamprey (*Lampetra planeri*)(for the protection of eggs and spawning areas)—and two species of Community interest—the European bullhead (*cottus gobio*)and the brook lamprey —have been recorded in the Ornain. All are considered to be of low conservation concern. In addition, a protected aquatic mollusc has been observed: *Bythinella*, classified as high priority.

The "poor" water quality, the presence of stagnant water, low water levels, and the absence of spawning areas create low conservation concerns for fish.

Ecological issues within the connected terminal area

Following the analysis by species group, the conservation concerns within the study area of the connected terminal must be assessed differently due to the linear nature and, consequently, the habitat heterogeneity of the project. Significant challenges have been identified for the vast majority of groups and the habitats they inhabit, particularly insects, amphibians, reptiles, and bats. The connected terminal is a fairly specific, thermophilic sector (one that thrives primarily in warm conditions), allowing a large number of protected and heritage species to thrive along its length. The Ornain River and Naillemont Creek present a very significant challenge for certain species groups.

The majority of the potential project area contains habitats for species of high conservation interest, except for the new section to the west.

High level issue

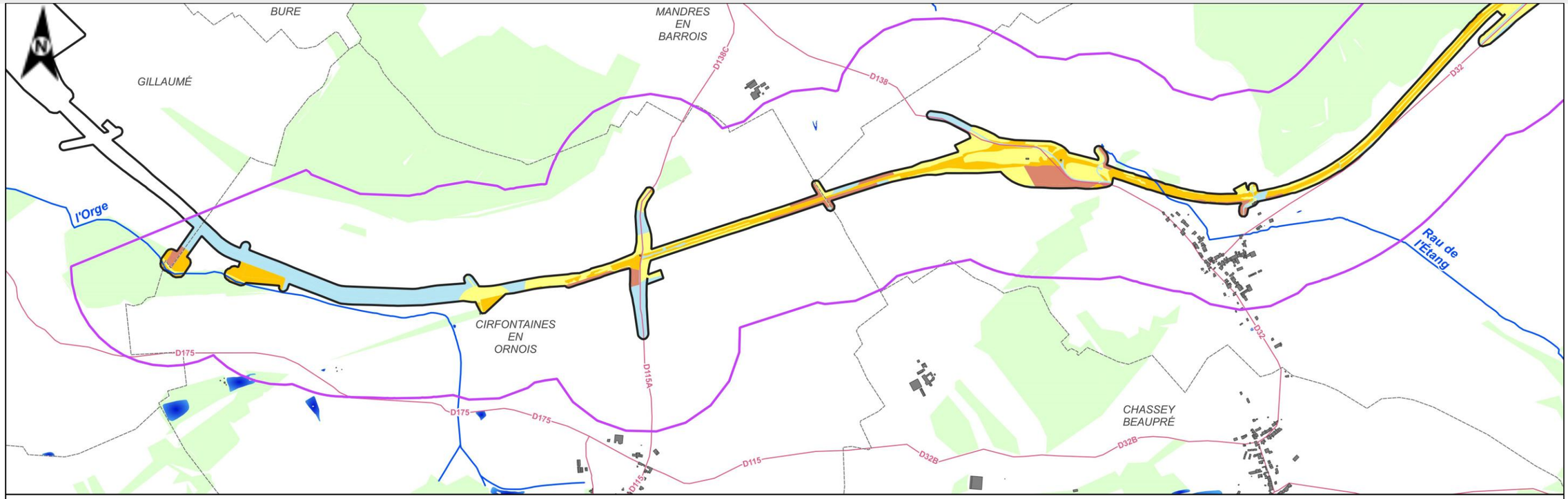
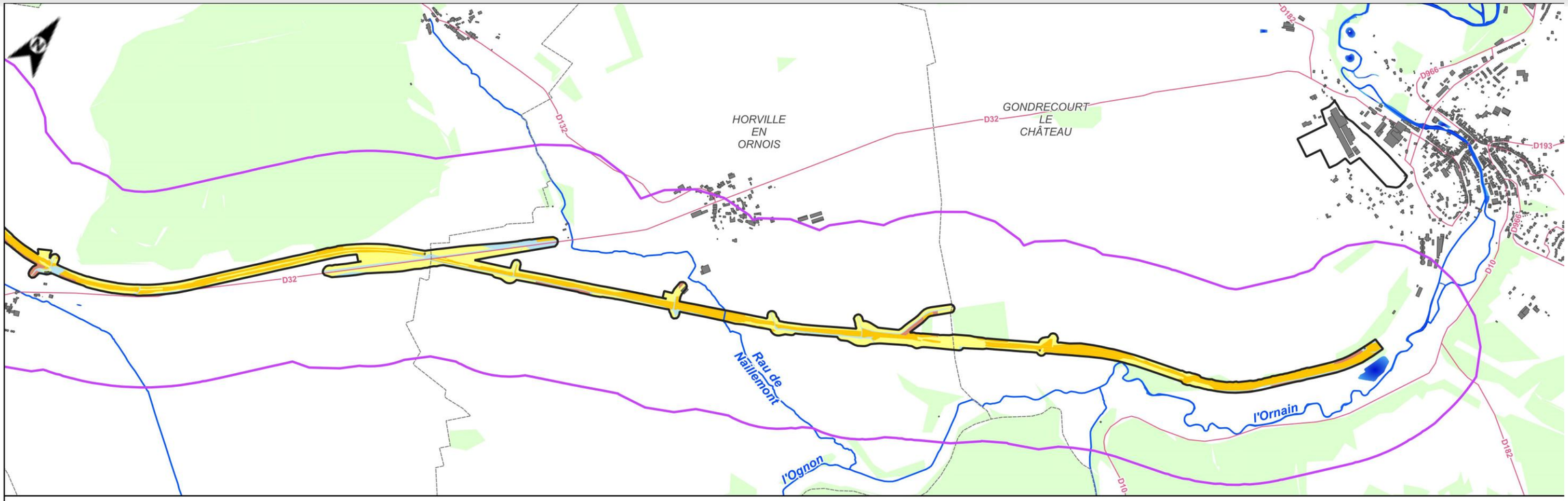


Figure 3-46 *Summary map of habitat interest levels for all species groups within the potential intervention area of the connected terminal (ITE) – 1/2*



LEGEND

- Municipal border
- Immediate biodiversity study area
- Potential intervention area
- Road network
- Watercourse
- Water body

Source: ANDRA – 2016–2021

Habitat interest levels

- Very high
- High
- Moderate
- Low

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Scale
0 500 1 000 m
Lambert RGF93 cartographic projection
Base map: BD TOPO – 2020

Sheet 02/02

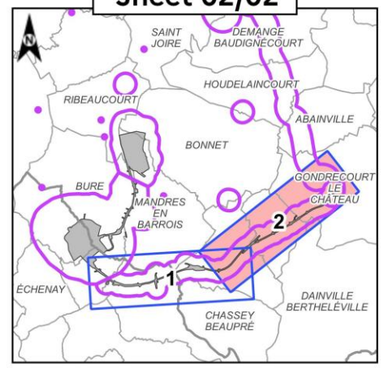


Figure 3-47 Summary map of habitat interest levels for all species groups within the connected terminal (ITE) potential project area – 2/2

3.6.1.5.4 Ecological issues (fauna and flora) related to the power transmission project (RTE)

Regarding the 400/90 kV electrical substation and the underground connections, the six substation location options and the potential intervention area for the installation of the connections are located within the immediate biodiversity study area associated with the ramp zone and adjacent operations. The issues were previously presented in the "3.6.1.5.1" chapter of this non-technical summary.

Given the nature of the work to secure the 400 kV transmission line and the scale of the project, ecological surveys were focused on the three sensitive areas classified as Natura 2000 sites that are crossed by the power line or located in its immediate vicinity, namely:

- the sites of Étang de la Horre (RAMSAR area, National Nature Reserve, Natura 2000 sites, Type II ZNIEFF), where towers 103 to 108 are located. Transitional habitats may be periodically disturbed by operations necessary to secure the power line from vegetation. Three towers are used by pairs of European kestrels during the breeding season, but no species that justified the designation of sites as Natura 2000 sites has been observed nesting on these towers or in their immediate vicinity. Other heritage species have been observed flying overhead (Black Kite, Marsh Harrier, Honey Buzzard, and Common Buzzard), but they show no obvious dependence on the pylon rights-of-way or their margins;
- the Gondrecourt-le-Château Forest (Natura 2000 site, ENS, and ZNIEFF I and II), where no pylons are located directly within the Natura 2000 site, but where pylons 232, 233, 239, 240, 241, 242, and 243 are located nearby. No species of community interest were identified in May 2019 or in 2021, and no nesting was observed on the pylon structures. However, it should be noted that there are corvid nests on the anchor plates of the suspension cables;
- the Meuse Valley (Natura 2000 site): this Natura 2000 site includes a wide variety of aquatic habitats, wetlands, and even dry calcareous grasslands on certain hillsides, forming a significant complex. The birdlife present at this site is diverse, comprising in particular some thirty species listed in Annex I of the "Birds Directive"(7).

No species of community interest were identified in May 2019 or in 2021 on or near these towers. The bird species observed in 2021 were only encountered while flying over the site, with no apparent dependency observed. In 2019, the Black Kite, a species listed in Annex I of the Birds Directive, was observed on several occasions flying over the meadows and near the riparian woodlands of the site. No evidence of nesting was observed. However, breeding of the species is likely along the banks of the Meuse, between pylons 258 and 259.

Ecological issues related to the power transmission project

The impacts within the study area of the 400 kV transmission line are generally low but locally high in the identified sensitive sectors (regulatory and inventory zones).

Overall moderate issue

3.6.1.5.5 Ecological issues (fauna and flora) of the water supply project

At this stage, the water supply project is defined solely by its functional requirements; therefore, only the available literature data on the study area, which is distant from the natural environment, has been reviewed to characterise the environment.

In the western section, there are no protected or sensitive natural areas between the Thonnance-lès-Joinville or Échenay water intakes and the zones to be connected. The nearest site is the Type I ZNIEFF "Woodlands and grasslands on the hillsides southeast of Thonnance-lès-Joinville." The rolling landscape and varied habitats are conducive to biodiversity.

On the eastern side, the plain is characterised by intensive agriculture, which leaves little room for biodiversity. Several sensitive natural areas are present between the Gondrecourt water intake and the zones to be connected. They are associated with the Ornain (ENS) and, above all, with the Ormançon (ENS and ZNIEFF of the Ormançon Valley).

3.6.1.5.6 Ecological Issues (fauna and flora) related to the 027000 railway line revamping project

a) Natural habitats

The immediate biodiversity study area is characterised by agricultural land and urbanised environments: it comprises 89 natural and semi-natural habitats (including seven habitats of community interest) of high or medium ecological importance.

b) Flora

Inventories conducted in 2018 revealed the presence of 333 plant species, including 20 heritage species and no species protected at the national level or in the Lorraine administrative region.

The areas with the highest conservation priority are located in the north (between Les Combes and Velaines, as well as the area between Menaucourt and Saint-Amand-sur-Ornain). Two species have regional protection status in the Grand Est region (Purple Helleborine, Marsh Bluegrass).

c) Fauna

Insects

Field surveys conducted from 2018 to 2021 revealed the presence of 134 insect species (75 Lepidoptera—Rhopalocera and Heterocera, 25 Orthoptera, 28 odonates, two hymenoptera, three coleoptera, and one mantoptera), two of which are protected (southern damselfly (*coenagrion mercurial*) and large copper (*lycaena dispar*)). Seven other species that are not protected but of ecological concern: short-winged conehead (*conocephalus dorsalis*), water-meadow grasshopper (*pseudochorthippus montanus*), lesser marbled fritillary (*brenthis ino*), European mantis (*mantis religiosa*), Nickerl's fritillary (*mellicta aurelia*), *Zygaena ephialtes*, and scarce swallowtail (*iphiclides podalirius*)), and one potential species: marsh fritillary (*euphydryas aurinia*).

Habitats conducive to these insects include dry hillsides, wet meadows, and ditches. Ecological connectivity occurs *via* wet valleys for hygrophilous species (large copper, southern damselfly, short-winged conehead) and *via* forest and hedgerow edges for all other species.

Amphibians

Surveys conducted between 2018 and 2021 identified nine amphibian species, including three heritage species (common midwife toad (*alytes obstetricans*), common parsley frog (*pelodytes punctatus*), smooth newt (*lissotriton vulgaris*)) and six others that are more common and of low conservation concern.

The main areas of interest include habitats frequented by the common parsley frog, ditches colonised by the smooth newt along the railroad tracks in Velaines, the Ornain Valley—home to the common midwife toad downstream from Demange-aux-Eaux—and the wet meadows, hedgerows, and ponds in the Ornain Valley that support the reproduction of all present amphibians.

Ecological connectivity is limited due to the small number of suitable natural habitats. A few migration routes connect the various wooded areas and are used to reach breeding sites at the end of the hibernation period.

Reptiles

Surveys conducted between 2018 and 2021 identified seven species, five of which are heritage species: the green and yellow snake, the common lizard, the smooth snake, the asp viper, and the wall lizard, as well as two more common species: the slow worm and the Swiss grass snake.

The main areas of concern include habitats frequented by the green whip snake (*hierophis viridiflavus*) in Ligny-en-Barrois, the abandoned railway line, and dry hillsides suitable for the smooth snake (*coronella austriaca*), the sand lizard (*lacerta agilis*), and the asp viper (*vipera aspis*), the active railway line suitable for the sand lizard (*lacerta agilis*), sunny forest edges (except for the four species mentioned above), and wet meadows and ponds suitable for the barred grass snake (*natrix Helvetica*).

Reptiles are not very mobile but use local corridors to move between two favourable habitats, such as forest edges, hedgerows, and the old railroad track. All these areas also serve as refuges.

Birds

Surveys conducted between 2018 and 2021 during the breeding, migration, and wintering seasons revealed the presence of 100 species, including 47 heritage species, 38 of which are protected. Seven species of Community interest listed in Annex I of the Birds Directive (7) : red kite (*milvus milvus*), woodlark (*lullula arborea*), common kingfisher (*alcedo atthis*), black kite (*milvus migrans*), middle spotted woodpecker (*dendrocoptes medius*), black woodpecker (*dryocopus martius*), red-backed shrike (*lanius collurio*); two migratory heritage species: black stork (*ciconia nigra*), garganey (*spatula querquedula*); and fairly large populations of wintering species. Given the diversity of habitats present, a wide variety of bird species frequent the area (including those associated with agricultural/open, aquatic/wetland, forest, built-up/ubiquitous, and generalist environments). The key issues are primarily related to afforestation and the alternation of open and semi-open habitats. These areas are conducive to the reproduction of species as well as their foraging.

Terrestrial Mammals

Surveys conducted from June 2018 to March 2021 identified 28 species, including three protected species: the European wildcat (*Felis silvestris silverstris*), the red squirrel (*sciurus vulgaris*), and the European hedgehog (*erinaceus europaeus*); two heritage species: the European wildcat and the European polecat (*mustela putorius*); and one species that is both a potential protected and heritage species: the hazel dormouse (*muscardinus avellanarius*).

The main areas of interest are those where the two heritage species are present, namely forested areas, certain groves or linear habitats (hedgerows, riverbanks), and open habitats (meadows and cultivated areas). The remainder of the immediate biodiversity study area is considered to be of little or no interest (primarily urbanised areas or roads).

Five major corridors have been identified, only one of which is functional (between Abainville and Houdelaincourt) and appears to be used primarily by the European wildcat and the European polecat. Of high importance, it is generally favourable to all medium- to large-sized species and serves as a link between the Côte Coubo forest massif to the east and a wooded strip to the west. The functionality of the other four has not been confirmed.

The railway line also represents a highly significant functional corridor from the far south to the southern entrance of Ligny-en-Barrois, as it connects favourable habitats (woodlands, meadows, etc.), bypasses urban areas and roads, and even crosses the canal and the Ornain River.

Bats

Surveys conducted between 2018 and 2021 revealed the presence of 17 bat species (all protected).

Many natural habitats are favourable to bats: roosts in buildings and trees, hunting and transit areas (Ornain Valley, forest edges and woodlands, hedgerow landscapes, rows of trees).

Aquatic fauna

A protected species of aquatic mollusc (thick-shelled river mussel (*unio crassus*)) was recorded in the Ornain, which presents a moderate conservation concern for molluscs.

Surveys conducted for Andra from 2009 to 2017 identified 12 fish species in the Ornain, including three protected at the national level (Brown trout (*salmo trutta*), brook lamprey (*Lampetra planeri*), common dace (*leuciscus leuciscus*)) and two listed in Annex II of the "Habitats" Directive (6) (European bullhead (*cottus gobio*), brook lamprey). The Ornain River presents a moderate threat to fish fauna.

A protected and heritage aquatic mammal species (Eurasian water shrew (*neomys fodiens*)) has been observed in the Ornain, representing a moderate local concern for this group.

Ecological issue within the 027000 railway line area

The revamping of the 027000 railway line will alter the path of an existing railway track. In the immediate study area, the Ornain Valley near the railway track presents potential high-level impacts for many species.

High-level issue

3.6.1.5.7 Ecological issues (fauna and flora) within the D60/960 deviation area

The route alternatives for the D60/960 departmental road deviation are located within the immediate study area, around the ramp zone. These impacts were previously presented in the "3.6.1.5.1" chapter of this non-technical summary.

Ecological issues within the deviation area

Moderate issues on the study panel for the deviation alternatives

3.6.1.5.8 Ecological issues related to other environmental characterisation and monitoring operations (camp sites, Borehole Study Zone, and Barrois limestone)

The immediate study area for biodiversity associated with environmental characterisation and monitoring operations partially overlaps with that of the operations presented previously, for which the ecological issues (fauna and flora) are described in the preceding chapters.

The ecological issues in the sectors of the immediate study area for biodiversity associated with environmental characterisation and monitoring operations that were not described previously are presented below, by type of activity.

a) Material storage areas – Base camps

The vast majority of material storage areas and base camps are located on natural habitats that have already been altered by human activity. These environments are of little interest for hosting diverse flora and fauna, as evidenced by the low to very low levels of interest for the majority of taxa.

According to observations, natural habitats are used primarily as transit routes for species.

The species observed for which the level of concern is moderate or higher belong to various groups of insects, birds, mammals, and bats.

b) Deep borehole drilling at the edge of ZIOS (ZBS_FOND_UP1 Programme)

These platforms are located on arable land plots that are of very limited interest to flora and most faunal communities.

The natural habitats at the platforms are used for transit and, to a lesser extent, for foraging. The surrounding habitats are used, depending on the habitat type, for foraging, transit, resting, and reproduction.

The species for which the level of concern is moderate or higher within the 500-metre buffer zone around the platforms belong to various groups of insects, reptiles, birds, mammals, and bats.

c) Reconnaissance drilling campaign for the Barrois Limestone Formation (CFB)

This drilling campaign is unique in that it is dispersed across the study area far from the natural environment, with drill sites potentially more than 30 km apart. The buffer zones (immediate biodiversity study areas) around these platforms, which are necessary for conducting the drilling, are thus located within a variety of natural habitats, such as croplands, semi-open areas, and forested areas. This diversity of vegetation types results in varying levels of ecological interest for each buffer zone around the platforms, depending on the dominant habitats present. It appears that buffer zones in forested environments are characterised by higher levels of interest than more anthropized environments such as croplands.

Species' use of buffer zones is also guided by the habitats that comprise them. Thus, in more natural environments, species feed, rest, pass through, or reproduce. In less natural environments, species are primarily observed passing through or feeding, and more rarely reproducing.

Species for which the level of concern is moderate or higher belong to various groups of insects, amphibians, reptiles, birds, mammals, and bats.

Ecological issues related to the environmental characterisation and monitoring operations

Overall moderate issue, but potentially high locally in certain areas for natural habitats, flora, and certain insects, birds, and bats.

3.6.1.5.9 Radiological conditions

The radioactivity measured in the extended study area is representative of an area far from current nuclear activities. A few artificially produced radioactive elements from known sources, such as fallout from atmospheric nuclear weapons tests or nuclear accidents like Chernobyl, have been recorded in line with nationally measured levels (89).

3.6.1.5.10 Summary of key biodiversity issues

The table 3-8 presents a summary of the main issues identified across the various zones and operations of the Cigéo overall project. For each habitat or group/assembly, the issues associated with the species present are presented, along with the levels of interest of the species' habitats for each group or assembly.

The figure 3-48 to figure 3-50 allow users to visualise the main biodiversity issues across the entire immediate biodiversity study area (excluding the 400 kV transmission line): movement corridors, species habitat importance, environmental zoning, and the location of heritage flora. The most significant issues are primarily located in forested areas and along waterways.

Table 3-8 Summary of the main issues identified across the various zones and operations of the Cigéo overall project

Groups	Biotic communities	Ramp zone and adjacent operations	Shaft zone	Connected terminal (ITE) area	400 kV transmission line	027000 rail line	Environmental characterisation and monitoring operations (base camps, Borehole Study Area and Barrois limestone)	Cigéo Overall Project Summary
Natural habitats	-	Low Strong for the plains grasslands and beech forests Very common in ash, alder, and willow forests	Medium	Medium Very strong locally (priority habitats)	-	Medium Locally abundant in riparian habitats, forest edges, and limestone grasslands	High	**MODERATE** (locally strong to very strong)
Flora	-	Strong Very strong locally (*Filipendula vulgaris*)	Strong locally Moderate	Moderate Strong locally	-	Moderate Strong for Starry Bellflower	Moderate Strong locally	**MODERATE** (locally strong to very strong)
Insects	**Meadow insects**	Moderate A few localised sightings along the edge of the Bureau	Moderate	Moderate	-	Average	Medium	**HIGH** (high for the large Ccopper, Mercury southerne damseflyBlue, and Nickerl's fritillaryFoxtail Skipper)
	Insects of cool, open woodlands	Low	Medium	Medium			High	
	Saproxylic insects	Medium One sighting in a partially isolated wooded area west of the Orge	Medium	Medium			Low	
	Insects of wet meadows	Moderate Very localised observations along the Orge River	Medium	Low		High for the large copper, southerne damsefly, and Nickerl's fritillary	Moderate	
	Insects of riparian forests, riverbanks/streams	High southerne damselfly identified along the Ormançon and Orge rivers	Moderate Localised issue near the Ormançon	High			Moderate	

Groups	Biotic communities	Ramp zone and adjacent operations	Shaft zone	Connected terminal (ITE) area	400 kV transmission line	027000 rail line	Environmental characterisation and monitoring operations (base camps, Borehole Study Area and Barrois limestone)	Cigéo Overall Project Summary
Amphibians	**Anthropogenic environments in villages (ponds, wash houses, gardens)**	Moderate Very localised observations along the Ormançon River northeast of the descent	Medium Localised observations along the Ormançon	Moderate	Low	Moderate	Moderate	**MEDIUM** (high for the common midwife toad and the Yellow-bellied Toad)
	Forest habitats (wintering) with ponds/pools (breeding)	Low Numerous sightings along the Orge River	Medium	Low	High for the Yellow-bellied Toad	Strong for the common midwife Toad	Moderate	
	Amphibians of wooded meadows (grasslands and woody structures)	Low Very localised sightings in Ormançon and south of Bure	Low	Low			Low	
	Amphibians of wet meadows	Moderate Numerous sightings of common frog along the Orge. A single sighting of a common parsley frog near the Ormançon	Low	Moderate			Low	
Reptiles	**Reptiles of wooded areas**	Medium Few sightings. Areas of interest located near the Orge and Bureau rivers	Medium	Moderate	-	Medium	Medium	**MEDIUM** (high for the asp viper and the smooth snake)
	Forest Reptiles	Low Limited number of observations. Areas of interest in the woodlands southeast and southwest of the descent	Low Sightings localised at the edges of the forest fringes of the Lejuc woods	Low		High for the common viper and the smooth snake	Low	
	Aquatic reptiles	Low Limited number of sightings along the Orge and Ormançon rivers	Low Few sightings	Low			Low	

Groups	Biotic communities	Ramp zone and adjacent operations	Shaft zone	Connected terminal (ITE) area	400 kV transmission line	027000 rail line	Environmental characterisation and monitoring operations (base camps, Borehole Study Area and Barrois limestone)	Cigéo Overall Project Summary
Birds	Birds of open-country thickets and hedgerows (meadows/grasslands/hedgerows/agricultural landscapes)	Medium	Medium	High	Moderate for the Peregrine Falcon (tower 140) and the Eurasian Kestrel (towers 98, 129, 138, 139, 140, 230)	Moderate	Moderate	**HIGH** (strong for the Lesser Kestrel, the Tree Sparrow, the Meadow Pipit, the Eurasian Eagle-Owl, and the Black Stork)
	Edge birds, young or open forests, thickets	Medium	Medium	Medium			Strong	
	Birds of mature forest habitats	Low to locally moderate in the woodlands southeast and southwest of the logging area	Moderate to locally high in mature forest stands	Moderate		Strong for the Tree Sparrow, the Eurasian hoopoe, and the Meadow Pipit	Moderate	
	Ground-nesting birds in agricultural plots	Strong for the Eurasian stone-curlew, Montagu's Harrier	Low	High			High	
	Birds of aquatic/wetland/riparian forest habitats	Weak Species observed only once along the Orge River	Low	Moderate			High	
	Pioneer habitat birds	Low	Low	Medium			Medium	
Terrestrial and semi-aquatic mammals	Forest mammals	Medium	Medium	Medium	-	Medium	Average	**MEDIUM** (locally high for the European wildcat and the European polecat)
	Mammals of hedgerow/forest edge habitats	Medium	Medium	Moderate		High for the European wildcat and the European Polecat	Moderate	
	Wetland/aquatic mammals	Medium	Medium	Moderate			Low	
Bats	Edge/woodland bats during hunting and transit	Medium	Moderate to locally high	High	-	Moderate	Strong	**STRONG**
	Forest bats (in both wet and dry habitats) while hunting	Moderate	Moderate to locally strong	Moderate		Strong for the Greater Mouse-eared Bat, Geoffroy's bat, and Bechstein's Bat	Strong	
	Valley/river bats hunting and in transit	Moderate	Medium	Medium			Medium	
	Ubiquitous and anthropophilic bats	Medium	Medium	Medium			Medium	
Fish fauna	-	Low	Low	Low	-	Medium	Very low	**LOW**
Aquatic molluscs and crustaceans	-	High for the *Bythinella*	Very low	High for the *Bythinella*	-	Moderate	Very weak	**WEAK**

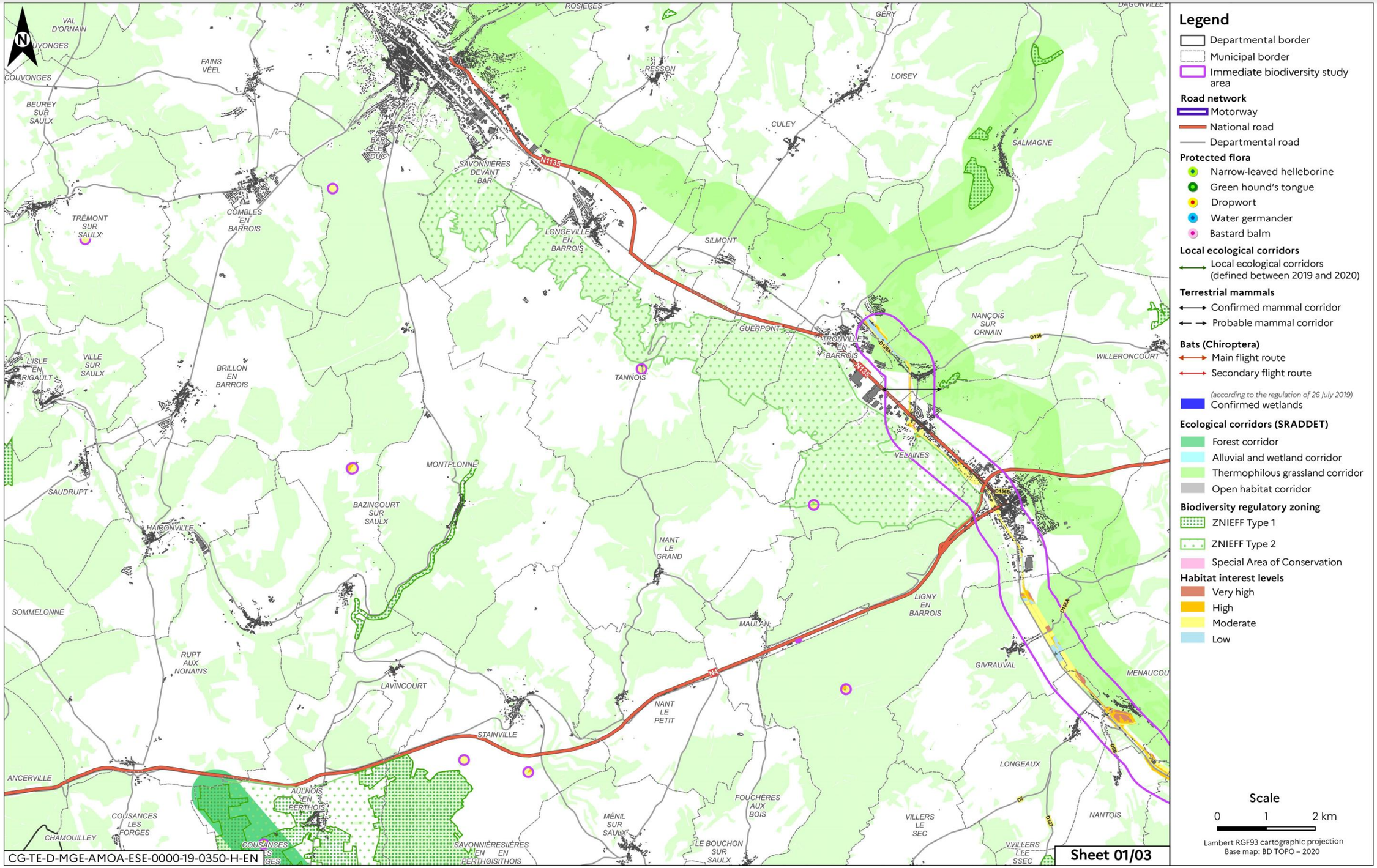


Figure 3-48 *Summary map of biodiversity issues - Cigéo overall project – 1/3*

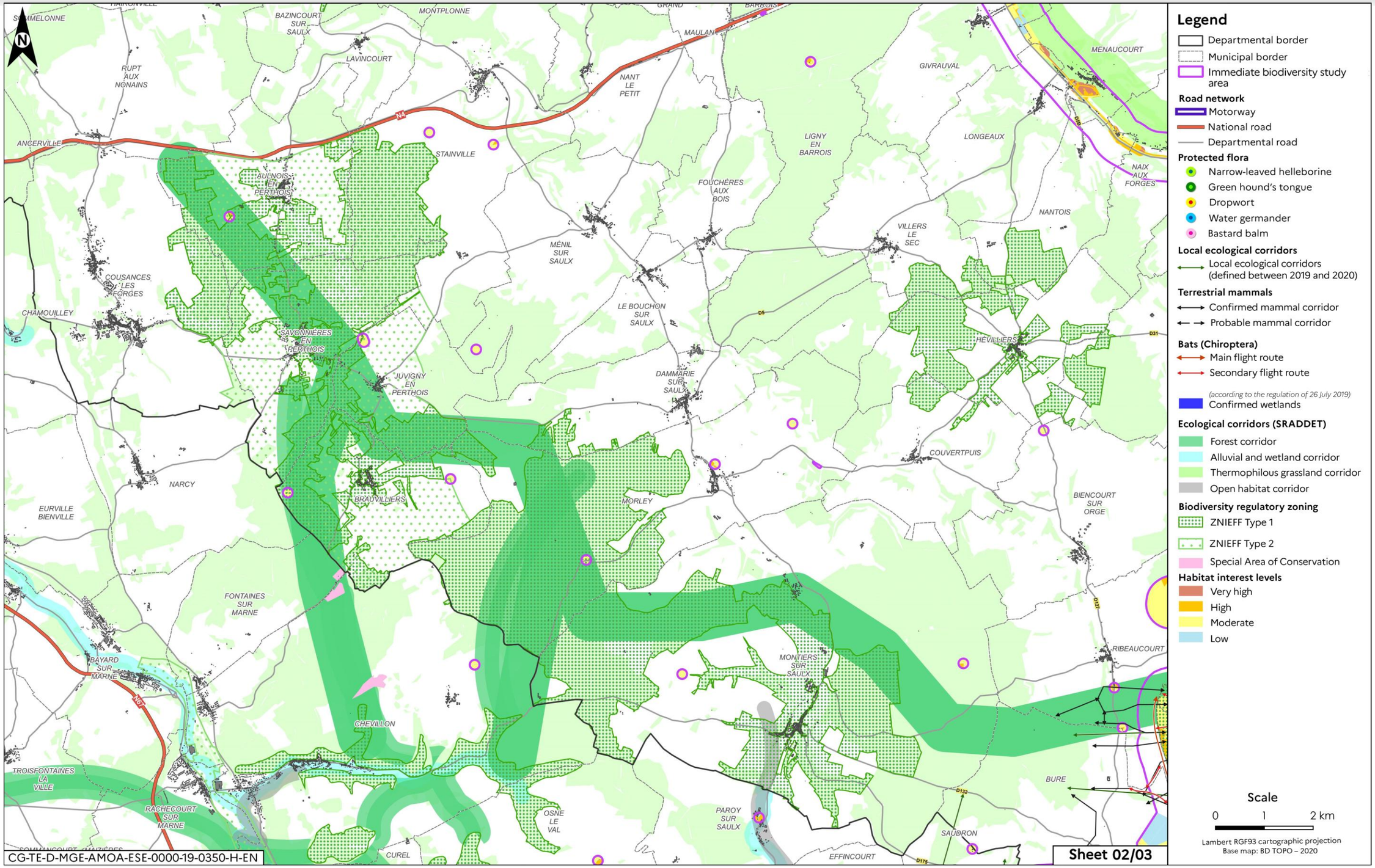


Figure 3-49 *Summary map of biodiversity issues - Cigéo overall project – 2/3*

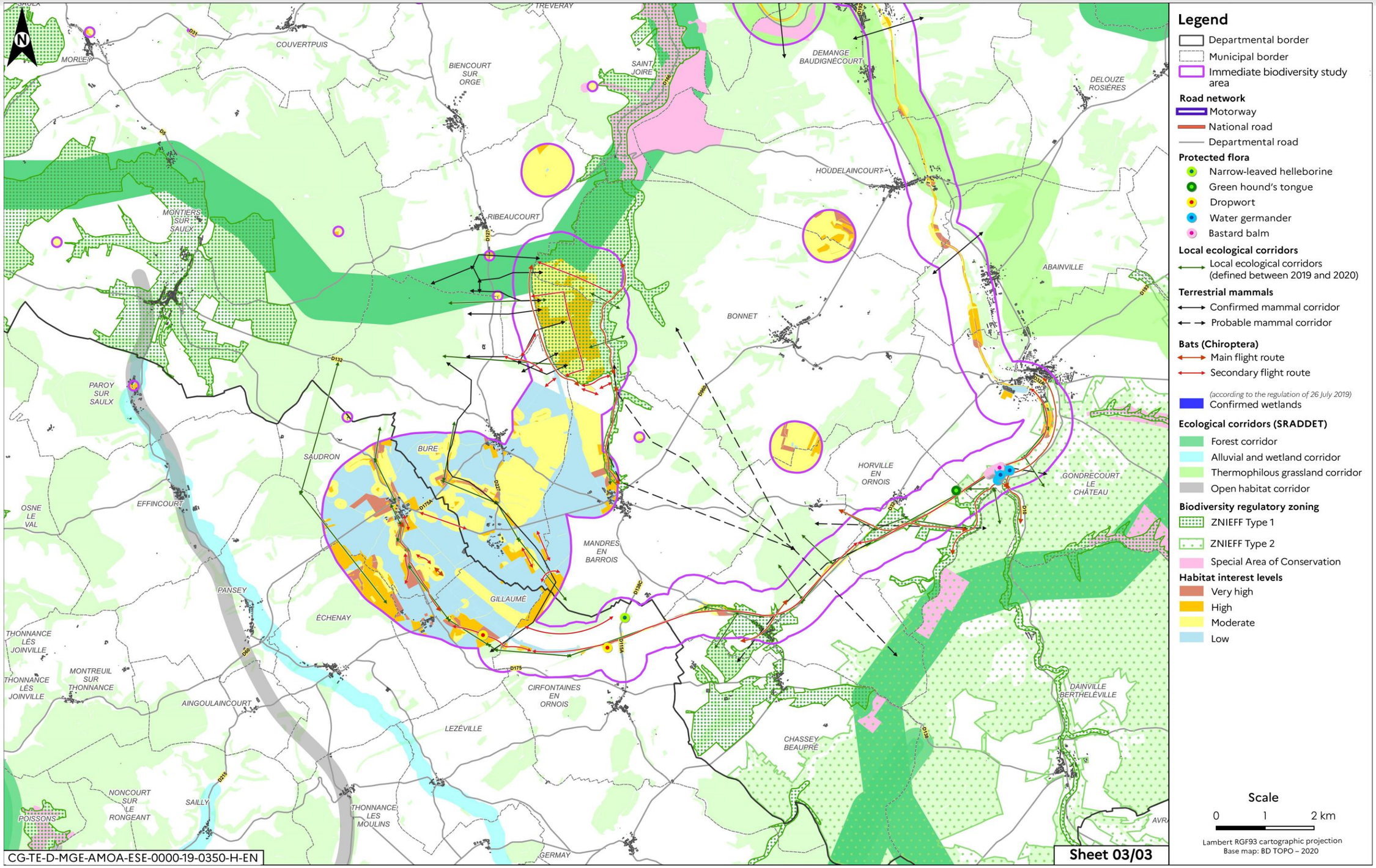


Figure 3-50 Summary map of biodiversity issues - Cigéo overall project – 3/3

3.6.2 Impacts and measures

3.6.2.1 Potential impacts on the natural environment and mitigation measures

The construction and subsequent operation of the Cigéo overall project will have significant potential impacts on the various components of the natural environment present within and near the project footprints (natural habitats, flora, fauna, wetlands, ecological corridors).

To eliminate harmful impacts on the natural environment, avoidance measures were defined as soon as the design phase, such as avoiding sensitive natural areas (river valleys, Natura 2000 sites, confirmed wetlands, etc.). Impacts that could not be avoided have led to the implementation of reduction measures, such as adjusting work schedules to align with species' biological rhythms, limiting night work, and installing wildlife barriers. Details of the measures are presented in chapter 6 of Volume IV of this environmental impact assessment. The following lists table 3-9 these measures.

Table 3-9 Avoidance and reduction measures implemented as part of the Cigéo overall project to protect the natural environment

Measure Code	Theme Code	Measure Title	Periods concerned	Operations concerned
Reduction measures				
ME0	E2.2f	Project design measures that avoid areas with environmental concerns (site selection, route or footprintselection, footprint optimisation, etc.). This measure is broken down into 12 "sub-measures" depending on the operations concerned.	APR, CI, F	Cigéo Disposal Facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of Departmental Road D60/960 Water supply
ME0_A	E2.2e	Optimisation of the shaft zone (ZP) footprint	APR, CI, F	Cigéo disposal facility (ZP)
ME0_B	E3.2b	Reuse of excavated materials to limit the volume stored	APR, CI, F	Cigéo Disposal Facility (ZP)
ME0_C	E4.1a	Phasing of land clearing in the shaft zone	APR, CI, F	Cigéo Disposal Facility (ZP)
ME0_D	E2.2e	Leaving peripheral woodlands in the shaft zone as is	APR, CI, F	Cigéo Disposal Facility (ZP)
ME0_E	E2.2e	Preservation of wooded land strips and open areas in the ramp zone	APR	Cigéo Disposal facility (ZD)
ME0_F	E2.1a	Preservation of shrub and tree cover	APR	Cigéo Disposal Facility (LIS) Power supply
ME0_G	E3.1z	Selection of a conveyor for the inter-site link	APR	Cigéo Disposal Facility (LIS)
ME0_H	E3.1z	Lack of fencing along linear infrastructure	APR, CI, F	Cigéo Disposal Facility (LIS, ITE) Revamping of the 027000 railway line
ME0_I	E2.2e	Reuse of existing infrastructure	APR	Cigéo disposal facility (ITE) Revamping of the 027000 railway line Power supply
ME0_J	E3.2b	Limited installation of overhead lines	APR	Power supply
ME0_K	E2.2b	Siting outside of sensitive natural areas	APR	Cigéo disposal facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
ME0_L	E1.1.a	Avoidance of sensitive areas in the context of the implementation of environmental characterisation and monitoring operations	APR	Cigéo disposal facility
ME1	E3.1z	Installation of barriers to prevent wildlife intrusion (amphibians, reptiles, and small mammals) prior to works in construction zones	APR, CI	Cigéo Disposal Facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply

Measure Code	Theme Code	Measure Title	Periods concerned	Operations concerned
Mitigation measures				
MR1	R2.1o	Capture/relocation of individuals prior to the construction phase	APR, CI	Cigéo Disposal Facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR2	R2.1d	General provisions limiting the risk of chronic or accidental pollution during construction and operation periods	APR, CI, F	Cigéo disposal facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR3	R2.1h	Adaptation of structures (hydraulic structures, engineering structures, and others) and fences to allow wildlife passage	APR, CI, F	Cigéo disposal facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR4	R2.1f	Prioritise avoiding the importation of topsoil by preferentially reusing local soil (to prevent the spread of invasive alien plant species)	APR, CI	Cigéo disposal facility (ZP, ZD, LIS, ITE) Power supply
MR5_A	R2.2k	Vegetation of slopes after backfilling	CI, F	Cigéo Disposal Facility (ZP)
MR5_B	R2.1.e	Vegetation of topsoil stored in mounds for projects lasting more than one year	APR, CI, F	Cigéo Disposal Facility
MR6	R2.1f	Management Plan for Invasive Alien Plant Species (EVEE)	APR, CI	Cigéo Disposal Facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR7	R3.1b	Adaptation of lighting during construction and operation periods	APR, CI, F	Cigéo disposal facility (ZP, ZD, LIS, ITE)
MR8	R2.1i	Relocate natural habitats for reptiles and amphibians prior to the start of construction	APR, CI	Cigéo Disposal Facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR9	R2.2f	Installation of wildlife crossings	APR, CI	Cigéo disposal facility (ZP, LIS, ITE) Revamping of the 027000 railway line
MR10	R2.1k	Inspection by a chiropterologist prior to any destruction of potential roosts and recommendations in the event of the presence of individuals	APR, CI	Cigéo Disposal Facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR11	R3.1b	Limit construction and operational activities at night (10 p.m. – 7 a.m.)	APR, CI, F	Cigéo Disposal Facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply

Measure Code	Theme Code	Measure Title	Periods concerned	Operations concerned
MR12	R1.1a	Generic reduction measures during construction, incorporated into the Technical Specifications (CCTP) for contractors	APR, CI	Cigéo disposal facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR13	R2.1r	Restoration or revegetation after construction	APR, CI, F	Cigéo disposal facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Rerouting of Departmental Road D60/960
MR14	R2.1n	Collection and preservation of heritage plant species in areas affected by construction for later replanting	CI, F	Cigéo disposal facility (ZP, ZD, LIS, ITE)
MR15	R2.2k	Creation and maintenance of a network of hedgerows in arable farmland, between the Gramont massif and the Lejuc woods	APR, CI, F	Cigéo Disposal facility (ZP)
MR16	R2.1z	Creation of agricultural cover favourable to the stone curlew	APR, CI	Cigéo Disposal facility (ZD)
MR17	R2.2k	Restoration of the wooded corridor at the connected terminal (ITE)	APR, CI	Cigéo Disposal Facility (ITE)
MR18	R2.2o	Incorporation of differentiated management of green spaces at the Cigéo disposal facility into the operator's specifications	CI, F	Cigéo Disposal Facility (ZP, ZD, LIS, ITE)
MR19	R1.1a	Adaptation of construction works to wetlands in the event of encroachment upon them	APR	Power supply
MR20	R2.1z	Establishment of a structure for environmental consulting and monitoring of the construction works	APR, CI	Cigéo disposal facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR21	R3.1.a	Beginning of works resulting in the destruction of species habitats (removal of vegetation, low walls, rock piles, etc.) to be carried out outside of sensitive periods for wildlife	APR	Cigéo disposal facility (ZP, ZD, LIS, ITE) Revamping of the 027000 railway line Power supply Deviation of the D60/960 departmental road Water supply
MR22	R1.1.c	Restriction of access to sensitive areas or elements within or near the footprints during construction	APR	Cigéo disposal facility
MR23	R2.1.i	Limitation of the environment's carrying capacity for wildlife during the construction period	APR, CI	Cigéo Disposal Facility (ZD) Power supply
MR24	R2.1.z	Creation of habitats favourable to the presence of hedge and open-habitat birds	APR	Cigéo Disposal Facility

APR = preliminary work, CI = initial construction, F = operation

3.6.2.2 Residual impacts on protected or outstanding natural areas

Given the distance, the nature of the work, and the avoidance and mitigation measures implemented, the impacts of the Cigéo overall project are not significant on the Natura 2000 sites located in the extended study area, whether during construction or the operational phase (see Chapter 3.6.4 of this non-technical summary). For other types of protected or notable natural areas, a few French ecological, faunal and floristic interest natural zones (ZNIEFF) are located within the immediate biodiversity study area of the Cigéo overall project.

Part of the Type I ZNIEFF "Forêt de la Fosse Lemaire" is located within the potential intervention zone of the shaft zone. Upon completion, the project will impact nearly half of the ZNIEFF's surface area. In the case of the Lejuc Wood, inventories conducted by Andra have helped to better understand the site's biodiversity and justify its classification as a ZNIEFF. Compared to other forests in the area, this woodland does not possess any particular ecological richness. After implementing avoidance and reduction measures to preserve part of the habitats, the residual impacts of the shaft zone on the ZNIEFF "Forêt de la Fosse Lemaire" remain significant, and measures will be implemented to offset the habitat loss for the species that justified the site's designation.

Through the implementation of avoidance and mitigation measures, none of the operations planned as part of the securing operations of the 400 kV transmission line are likely to impact the habitats or species of interest within the Natura 2000 areas crossed. As a reminder, the risk of bird collisions with the cables of the 400 kV transmission line will not increase during the operational period, as this is not the construction of a new line but rather its reinforcement without the addition of extra cables. At this stage of the studies, residual impacts are low, and no offsetting measures are required.

Offsetting measures for the habitats of species in the affected communities will offset the impacts on key ZNIEFF species and achieve the objective of zero net loss of biodiversity.

3.6.2.3 Residual impacts on wetlands

Given the distance from wetlands and the avoidance and reduction measures implemented—such as the reuse of former railway platforms—the Cigéo disposal facility has no significant residual impact on wetlands, either during construction or during operation.

In accordance with regulations, if these additional steps were to reveal impacts—even minor ones—despite the avoidance and reduction measures, Andra commits to implementing offsetting measures.

The objective of the offsetting measures is to achieve functional equivalence by applying a ratio of two and relying on the "Guide to the National Method for Assessing Wetland Functions" (119) published by the former ONEMA (May 2016).

Thus, with a functional equivalence ratio of 2 to 1, the functional gain achieved through the offsetting program will be at least twice as great as the functional loss caused by the project.

The Cigéo disposal facility has a low residual impact on wetlands. The residual impacts of operations by other project owners will be specified at a later date.

3.6.2.4 Residual impacts on ecological connectivity

The Cigéo overall project is located outside the main regional corridors. However, a regional forest corridor passing north of the wellfield area is identified in the Grand Est region's SRADDET (103). The gradual deployment of the shaft zone from south to north, along with the avoidance measure (measure ME0), which ensures the preservation of a forested strip 100 metres wide to the west and 200 metres wide to the east and north of the shaft zone, helps maintain ecological connectivity between the two forest areas. To mitigate the impact, a network of hedges and grassy strips will be created during the initial clearing phases between the Grammont Forest and the northern part of the Lejuc Wood (measure MR15) in order to reduce the residual impact to a level that is not significant on ecological connectivity. At the local level, mitigation measures such as the creation of wildlife crossings ensure that there is no significant residual impact on the ecological connectivity observed during field ecological studies.

The service corridor beneath the 400 kV transmission line, whose maintenance may involve tree cutting, remains as is without generating additional impacts. During the operation period, the line has no impact on the components of the green and blue infrastructure. The restoration of the land in the wetland area ensures that there is no difference between the pre- and post-construction conditions at the project site and potentially in the wetlands located in the immediate vicinity of the structure.

The Cigéo overall project has a low residual impact on ecological connectivity.

3.6.2.5 Residual impacts by species group and assemblage and by facility or operation

3.6.2.5.1 Residual impacts by species group and community

Within the Cigéo overall project, the operations generating the greatest residual impacts are the construction of the shaft zone in the forested zone and that of the connected terminal. Operations in the ramp zone and the inter-site link cause very few residual impacts (only on birds of thickets and hedgerows in open areas).

For wildlife, the most significant residual impacts concern communities of bats, birds, and insects associated with forest environments, as well as forest edges and wooded landscapes, due to the destruction of large areas of habitats favourable to their reproduction or foraging, particularly woodlands, hedgerows, and copses. To a lesser extent, communities of terrestrial mammals, reptiles, and amphibians associated with these same forest and wooded areas are also affected. The residual impact is also moderate regarding the destruction/degradation of habitats for communities of species associated with wetland/aquatic environments.

Table 3-10 Moderate to high residual impacts of the Cigéo disposal facility related to the destruction/degradation of habitats for species communities (yellow: moderate; orange: high)

Groups	Species	Cigéo disposal facility (operation causing the highest level of residual impact)
Insects	Fresh, open woodlands	Shaft zone
	Grassland habitats	Connected terminal
	Riparian forests, riverbanks/streams	Connected terminal
Amphibians	Forest habitats (wintering) with pools/ponds (breeding)	Shaft zone
	Bocage (meadows and woody structures)	Connected terminal

Groups	Species	Cigéo disposal facility (operation causing the highest level of residual impact)
Reptiles	Bocage habitats	Shaft zoneand connected terminal
	Forest habitats	Shaft zoneand connected terminal
	Aquatic habitats	Connected terminal
Birds	Thickets and hedges in open areas	Connected terminal
	Edge zones, young or open forests, thickets	Shaft zone and connected terminal
	Mature forest areas	Shaft zone and connected terminal
	Aquatic/wetland/riparian woodlands	Connected terminal
Mammals	Bocage/Forest edge habitats	Shaft zone and connected terminal
	Forest environments	Shaft zone
	Wetland/aquatic habitats	Connected terminal
Bats	Bocage/Forest edge habitats for hunting and transit	Shaft zone
	Forest habitats (humid or dry) during hunting	Shaft zone
	From valleys/waterways during hunting and transit	Shaft zone and connected terminal
	Ubiquitous and anthropophilic	Shaft zone and connected terminal

The risk of individual mortality is low, given the avoidance and reduction measures implemented: avoiding bird and bat breeding seasons for land clearing or phasing the preliminary works of the excavated materials storage area. However, mortality remains possible for less mobile species such as reptiles or certain small mammals.

For flora, residual impacts are significant in specific cases for the hairy melic (*melica ciliata*)(a protected species), whose populations within the footprint of the connected terminal cannot be avoided during construction.

The impacted habitats and species are common to the region (no habitats or species of high conservation concern).

3.6.2.5.2 Residual impacts by facility or operation

Impacts on the natural environment are greatest during the preliminary works phase, due to clearing operations and site preparation works carried out across all areas.

In the ramp zone, residual impacts mainly affect birds, due to the presence of small but functionally important woodlands and hedgerows for reproduction.

On the inter-site link, residual impacts are low in the central section not associated with the shaft zone or the ramp zone.

Regarding the risk of destruction of protected species, the most significant residual impacts concern the shaft zone and the connected terminal. They affect bats, birds, mammals, and reptiles. The residual impact on flora is considered significant locally at the connected terminal because the ciliate milkwort (a protected species) cannot be avoided given its location.

Disturbance to species—meaning disruption of a stage in their life cycle—is deemed not significant given the alternative habitats present in the immediate vicinity and the reduction measures implemented, such as adjusting nighttime lighting or limiting nighttime work.

Given the level of detail in the design of the electrical substation construction and the underground connections linking the Cigéo disposal facility to the substation, residual impacts cannot be assessed in great detail at this stage. Residual impacts will be specified once the project is selected, following the completion of design studies and public participation in the project's development.

Regarding the project to secure the 400 kV transmission line, the implementation of avoidance and reduction measures, such as adjusting the timing of construction works and the footprint, helps limit residual impacts on the natural environment. During the operation phase, the risk of bird collisions with the 400 kV transmission line cables will not increase, as this project involves securing the existing line rather than creating a new one, without adding any additional cables. At this stage of the studies, the residual impacts are low, and no offsetting measures are required.

Design studies for the revamping of the 027000 railway line are currently underway at the time of writing of this environmental impact assessment. Residual impacts on the natural environment cannot be accurately assessed at this stage. The footprint required for the works will be located primarily on the line's existing platform through the use of specialised trains for this type of operations. Note that the areas altered for the revamping of this railway line may be expanded at the road crossings to be constructed, for which design studies are currently underway.

As for the connection operations to the water supply network, they consist of the rehabilitation and installation of underground pipes. Given the highly temporary nature of the construction phase, the residual impacts on the natural environment for this operation can be considered low or even very low during the operational phase. Geographical and technical avoidance measures will be implemented during the design phase to minimise the project's impacts as much as possible. Impacts will be reduced in particular by selecting pipeline routes that follow existing road edges to avoid sensitive natural areas.

Overall, surveys of natural habitats along the design variants for the deviation of the D60/960 departmental road revealed a predominance of arable farmland with no major ecological significance. The main areas of concern are located in the valleys of two intermittent watercourses. The final route will be selected based on a multi-criteria analysis and following public enquiries. After implementing avoidance and reduction measures, any significant residual impacts will be addressed through offsetting measures aimed at achieving a net-zero impact or even an increase in biodiversity.

The drilling of characterisation and monitoring wells will have no significant residual impact on the natural environment due to the very limited duration of the construction phase and the absence of impactful activity during the operational phase.

After implementing avoidance and reduction measures, the main significant residual impacts on the natural environment relate to the destruction of habitats for wildlife species of interest, covering a total area of approximately 420 ha. This alteration of the environment is necessary primarily for the construction of the Cigéo disposal facility.

To meet the goal of no net loss of biodiversity, reduction measures are implemented based on the ecological debt generated by the project.

3.6.2.6 The impacts of radiological and chemical emissions on wildlife

3.6.2.6.1 Radiological emissions

METHOD FOR ASSESSING RADIOLOGICAL RISK TO FLORA AND FAUNA

The method adopted by Andra for **assessing the radiological risk to flora and fauna** resulting from the normal operation of the Cigéo overall project is based on the use of the ERICA approach and tool developed and used at the European level (120, 121). This method involves calculating the absorbed dose rates for the 14 reference organisms representative of the terrestrial ecosystem, then comparing them with the reference value of 10 µGy/h recognised as having no effect: amphibian, arthropod, flying insect, small mammal, large mammal, gastropod mollusc, bird, reptile, annelid, herbaceous plant, shrub, tree, lichen-bryophyte, chiropteran.

The approach is similar to that used in assessing radiological risk to human health. Based on the context and available environmental data, the assessment of radioactive emissions from the overall project and their dispersion, the goal is to analyse the exposure of organisms in terms of absorbed dose rate and to characterise the risk by comparing the exposure of organisms, *via* the absorbed dose rate indicator, to the absorbed dose rate at which no effect is expected for 95% of species (10 µGy/h), as defined at the European level.

The absorbed dose is the amount of energy deposited in a unit of mass by ionizing radiation. It is expressed in Gray, denoted Gy (1 Gy is equivalent to one joule per kilogram). Dose rate is the absorbed dose per unit of time. It is expressed in Gray per hour, denoted Gy/h. The micro (symbol µ) is the prefix of the International System of Units (SI) representing 10^{-6}, or one millionth of a unit. This is the order of magnitude generally used for flora and fauna.

The local environmental context of the Cigéo overall project is characterised by a forested environment (woodlands and shrublands), small watercourses, and open areas (farmland and herbaceous vegetation), which serve as feeding, hunting, and breeding grounds for a large number of species. Regarding wildlife, the species that may be affected by radioactive atmospheric emissions from the Cigéo overall project are terrestrial organisms (primarily birds, mammals, and insects) and semi-aquatic organisms (amphibians).

As a reminder, the radioactive elements released into the atmosphere by the Cigéo disposal facility's installations are gases (tritium (^{3}H), carbon-14 (^{14}C), and krypton-85 (^{85}Kr)) and radioactive aerosols (alpha and beta emitters). The Cigéo disposal facility does not release liquid effluents from areas where nuclear waste may be produced into the local environment. As with the assessment of impacts on air quality or human health, their quantification and dispersion modelling allow for the evaluation of concentrations of radioactive elements in the air (in Bq/m^3) and in the soil (in Bq/kg) per deposition (depositions concern only aerosols and, to a lesser extent, tritium in the form of tritiated water, HTO).

The average exposure across the study area is assessed, as well as exposure in the sensitive zones of the Natura 2000 site "Bois de Demange Saint-Joire" located north of the shaft zone and the ZNIEFF of "the Ormançon Valley between Saint-Joire and Mandres-en-Barrois" bordering the shaft zone.

Regardless of location, the absorbed dose rates for the 14 organisms studied are less than 0.001 µGy/h. These absorbed dose rates are therefore well below the no-effect threshold of 10 µGy/h. The radiological risk from releases resulting from the normal operation of the Cigéo overall project can therefore be considered to have no impact on wildlife.

The Cigéo project has a very low residual impact on wild flora and fauna related to radioactive emissions.

3.6.2.6.2 Chemical Emissions

The methodology adopted to characterise the impact of conventional emissions on wildlife for the Cigéo disposal facility is based on a three-tiered approach:

- Level 1 (screening): a conservative approach based on simplified assumptions aimed at calculating a total risk index for the ecosystem. The use of maximum exposure values leads to an overestimated impact assessment;
- Level 2 (generic assessment): a more realistic approach using more representative reference organisms and more realistic transfer models. Less conservative assumptions are introduced (e.g., average values for exposure data when available, incorporation of mitigation measures into the source term);
- Level 3 (detailed assessment): an approach requiring local information and specialised expertise. Effect reference values such as the *"Predicted No Effect* Concentration" (PNEC) or "Environmental Guideline Values" (EGV) used in Levels 1 and 2 may be replaced by effect information that must be scientifically justified and referenced.

Level 2 is directly applied to assess risks to flora and fauna associated with chemical discharges from the Cigéo overall project.

Level 2 proceeds in four steps equivalent to those of the health risk assessment: hazard identification, exposure assessment, definition of effect assessment criteria, and risk characterisation. If, following the Level 2 assessment, the risk to wild flora and fauna cannot be ruled out, Level 3 of the approach is then applied. The four steps are repeated only for the first two levels of the Andra approach. At Level 3, the selection of threshold values, quality levels, and interpretation of results are the responsibility of the evaluator.

The assessment of the chemical risk associated with liquid and atmospheric chemical discharges from the Cigéo repository during the initial construction and operation phases shows that the risk to flora and fauna, based on discharge values, can be considered negligible.

The Cigéo overall project has a very low residual impact on wildlife due to chemical emissions.

3.6.2.7 The ecological debt of the Cigéo disposal facility project

Residual impacts rated as moderate to very high are subject to ecological compensation. The species assemblages considered in the calculation of this debt are presented in the chapter "3.6.2.5" of this non-technical summary.

Ecological compensation requirements are calculated based on the areas of habitats of impacted species, to which a multiplier coefficient is applied according to their overall ecological value, by species group. This results in an ecological debt, expressed in compensation units (CU).

For the Cigéo overall project, the total compensation requirement is primarily linked to:

- for the ramp zone and the inter-site link, to open habitats and hedgerows favourable to birds;
- for the shaft zone, to deciduous woodlands favourable to birds, bats, insects, and some other mammals, and to a lesser extent to amphibians and reptiles (a pond and forest edges);
- for the connected terminal, to open habitats (such as fallow land and meadows) and hedgerow/shrubby habitats favourable to birds, reptiles, amphibians, insects, bats, and a few other mammals.

3.6.2.8 Ecological compensation

HABITAT DIFFERENCE COMPENSATION METHOD

The habitat gap compensation method, weighted by a multiplier coefficient based on the importance a habitat holds for a species (or a community), was developed by CDC Biodiversité. This method is consistent with the "standardised approach to ecological compensation sizing" promoted by the Ministry of Ecological Transition, the French Office for Biodiversity (OFB), and CEREMA, released in May 2021 (122). It consists of quantifying and qualifying, using the same method, the ecological loss or debt associated with the project's impacts. The principle is then to achieve, through offsetting measures, an ecological gain that is *at least* equivalent to the ecological debt caused by the project's residual impacts on biodiversity, so that the Cigéo overall project causes no net loss of biodiversity.

The schematic diagram of the compensation principle is presented at figure 3-24.

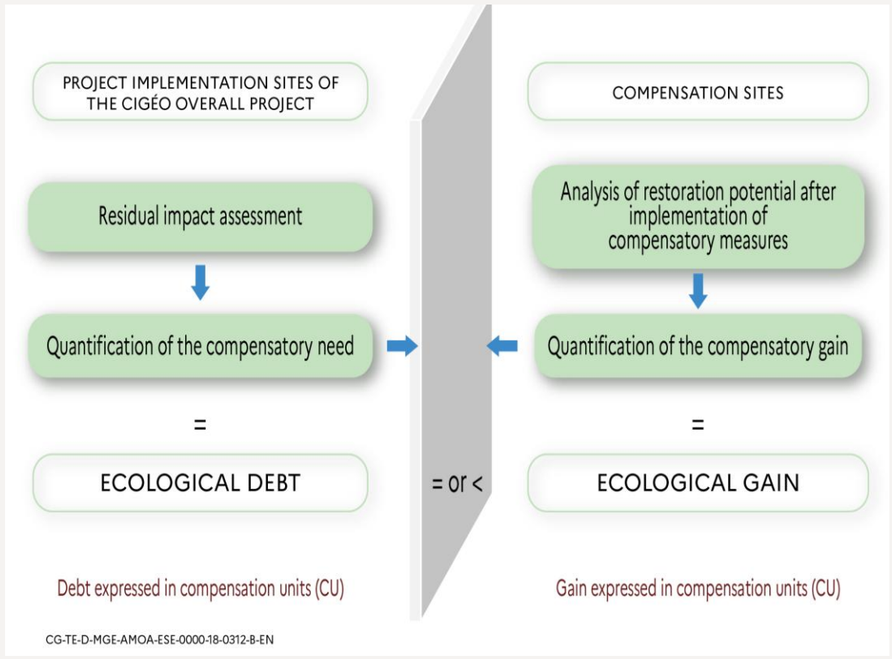


Figure 3-51 Diagram of the habitat gap compensation method

In accordance with regulations, offsetting measures are tailored to achieve the objective of no net loss of biodiversity, or even a net gain. These measures will be specified in the project's upcoming environmental authorisation decrees and must result in a performance obligation.

To ensure the long-term viability of the ecological offsetting program, Andra has committed to acquiring all of its ecological offsetting sites.

The selected compensation sites underwent ecological assessments by various specialised flora and fauna consulting firms, with targeted observations based on pre-identified ecological issues. These preliminary studies provided an evaluation of the different levels of habitat importance, allowing for the determination of their ecological offsetting potential. The ecological compensation sites are presented on figure 3-52.

The various offsetting measures were designed by CDC Biodiversité, taking into account ecological data on the initial state of the natural environment and scientific knowledge regarding the functioning of ecosystems and the biology of the species present. The offsetting measures aim to create new forest habitats (afforestation) and/or increase the carrying capacity of existing forest habitats for the species targeted by the offset, and more broadly for forest species in general.

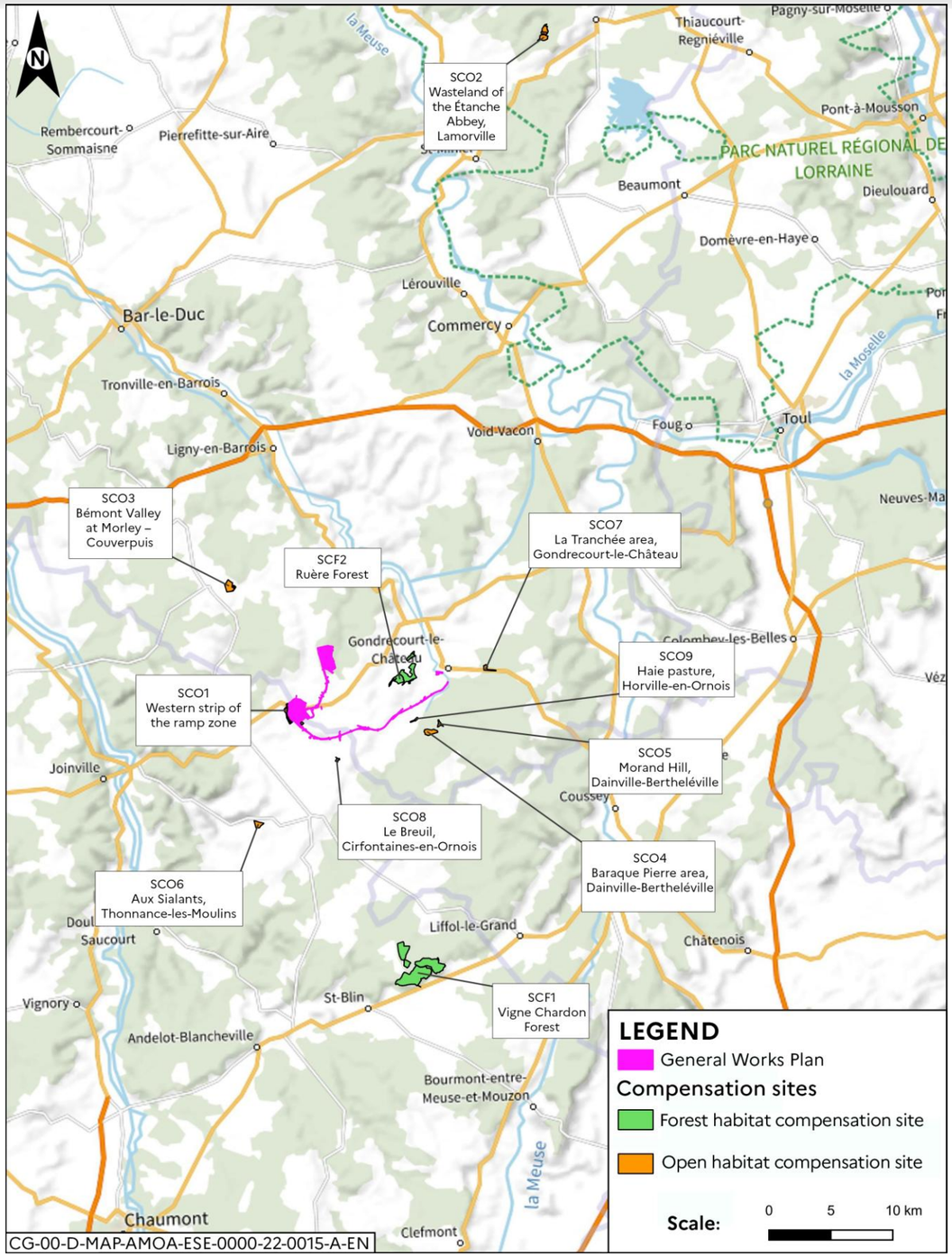


Figure 3-52 Location of ecological offsetting sites

3.6.2.8.1 Ecological offsetting for forested habitats

Two sites have been selected for measures to support species in forested habitats: the Vigne Chardon forest, which has an available area of 531.25 ha, and the Ruère forest, which covers 158.34 ha.

The table 3-11 lists all the offsetting measures implemented as part of the open habitat offsetting sites.

Table 3-11 List of offsetting measures within forested area offsetting sites

Measure code	Measure title
MF-01	Marking and conservation of mature trees (large and very large trees) until their natural death
MF-02	Marking and preservation of mature trees (large and very large trees) damaged by the 1999 storm
MF-03	Marking and in-situ devitalisation of mature trees
MF-04	Felling of trees left on the plot until complete decomposition
MF-05	Creation of cavity starters
MF-06	Management and harvesting of uneven-aged forest stands
MF-07	Introduction of typical forest plant species and indicators of old-growth forests
MF-08	Planting of hardwoods
MF-09	Adaptation of hunting practices to the ecological requirements of species targeted for compensation
MF-10	Conversion of coniferous stands to native hardwood stands
MF-11	Creation of clearings and open areas within forests or at forest edges
MF-12	Creation and preservation of ponds, ruts, and other aquatic habitats in forests or forest edges
MF-13	Management of the Vigne-Chardon ponds in a forest setting
MF-14	Creation and preservation of forest edges

Offsetting measures help create functional habitats for forest bats and birds of old-growth forests. They also yield significant benefits for all species communities dependent on forest environments and/or forest edges.

3.6.2.8.2 Ecological offsetting for open habitats

The sites selected for measures benefiting open-habitat species are listed in the table 3-12 below and located on the figure 3-52 :

Table 3-12 Sites selected for offsetting measures for open-habitat species

Site No.	Site names	Selected site area	Municipalities
SCO1	Western strip in the ramp zone	24 ha	Saudron (dep. 52)
SCO2	Wildlands of the Abbaye de l'Étanche	54.79 ha	Lamorville (dep. 55)
SCO3	Bémont Valley in Morley – Couvertpuis	51.34 ha	Morley (dep. 55) Couvertpuis (dep. 55)
SCO4	A Baraque Pierre in Dainville-Bertheléville	36.71 ha	Dainville – Bertheleville (dep. 55)
SCO5	Cote Morand in Dainville-Bertheleville	10.31 ha	Dainville – Bertheleville (dep. 55)
SCO6	Aux Sialants in Thonnance-les-Moulins	25.5 ha	Thonnance-les-Moulins (dep. 52)
SCO7	At La Tranchée in Gondrecourt-le-Château	15.87 ha	Gondrecourt-le-Château (dep. 55)
SCO8	Le Breuil in Cirfontaines-en-Ornois	5.91 ha	Cirfontaines-en-Ornois (dep. 52)
SCO9	Pâtis de Haie in Horville-en-Ornois	6.81 ha	Horville-en-Ornois (dep. 52)

The table 3-13 lists all the offsetting measures implemented as part of the open habitat offsetting sites.

Table 3-13 List of offsetting measures within open-land offsetting sites

Measure code	Measure title
MO-01	Diversification measures within agricultural plots: • long-term rotational fallow on agricultural plots; • plots rich in large stones within cultivated plots.
MO-02	Implementation of agricultural practices combining permanent soil cover, complex intercrops with high biomass production, no-till farming, and no insecticide treatments
MO-03	Conversion to organic farming in field crops
MO-04	Implementation of extensive agricultural practices on poor calcareous soils aimed at conserving heritage field plants
MO-05	Conversion of degraded croplands or grasslands into natural forage pastures: • on natural wet or mesophilic grasslands; • calcareous grasslands.
MO-06	Restoration of natural grasslands by clearing overgrown and scrub-encroached grasslands, on wet or mesophilic natural grasslands, and on calcareous grasslands
MO-07	Extensive conservation management of natural grasslands through mowing or grazing, on natural wet or mesophilic grasslands, and on calcareous grasslands

Measure code	Measure title
MO-08	Installation of grazing infrastructure: • permanent fences and gates; • watering troughs; • meadow pump.
MO-09	Planting and maintenance of hedgerows in agricultural settings (crops or pastures): • continuous multi-layered hedges composed of typical native species; • continuous shrub hedges composed of typical native species.
MO-10	Establishment of grass strips in agricultural settings: • between two cultivated plots; • at the base of hedges.
MO-11	Thinning cuts and maintenance of a very open woody layer combined with dense herbaceous vegetation: • tree layer; • shrub layer.
MO-12	Restoration and conservation management of stream banks and agricultural ditches
MO-13	Creation and/or restoration of open-water aquatic habitats: • shallow ruts and temporary pools; • permanent ponds.
MO-14	Creation, diversification, and conservation management of tall-grass communities
MO-15	Creation, diversification, and conservation management of reed beds and sedge marshes
MO-16	Creation of a standard-tree orchard on natural grassland
MO-17	Habitat left to evolve naturally
MO-18	Development of rural roads (to serve agricultural plots and grasslands)
MO-19	Survey and protection of harrier nests in agricultural areas
MO-20	Installation of nest boxes and roosting boxes: • nest boxes for small cavity-nesting birds; • nest boxes for nocturnal raptors; • nest boxes for the Hoopoe; • roosts for bats.
MO-21	Creating artificial shelters for small wildlife: • piles of rocks; • piles of wood; • gabions and dry stone walls; • nesting sites for reptiles.

Together, these measures create highly functional habitats for birds in semi-open environments, bats, and mammals in hedgerow and forest edge habitats.

3.6.2.8.3 Other specific offsetting needs.

a) Wetlands

Avoidance measures in site selection and design will ensure that the Cigéo disposal facility does not directly impact any wetlands.

This impact assessment will be updated as knowledge evolves regarding all operations of the Cigéo overall project, as conclusions from ongoing or future public engagement are incorporated, and as the design of the Cigéo overall project is refined iteratively. Studies and modelling will supplement the analysis of the Cigéo overall project's impacts on the wetland's functions. The progress and conclusions of these efforts will be detailed and incorporated into future updates to the environmental impact assessment. In accordance with regulations, if these additional steps were to reveal even minor impacts on the wetlands, despite avoidance and reduction measures, Andra commits to implementing offsetting measures with the objective of achieving functional equivalence by applying a ratio of two and relying on the *"Guide to the National Method for Assessing Wetland Functions" (119)* from the former ONEMA (May 2016). Thus, with a functional equivalence ratio of 2 to 1, the functional gain from the offsetting measure will be at least twice as great as the functional loss caused by the project.

b) Pools

Note the impacts of the Cigéo disposal facility on four non-permanent forest ponds. Since the impact of their destruction is considered moderate, offsetting measures will therefore be implemented for twice the number of affected ponds, depending on the phases of the excavated materials deposits deployment. These ponds are essential for the reproduction of most amphibian species. Indeed, they generally do not reproduce in flowing waters or in bodies of water containing fish.

c) Hairy melic (melica ciliata)

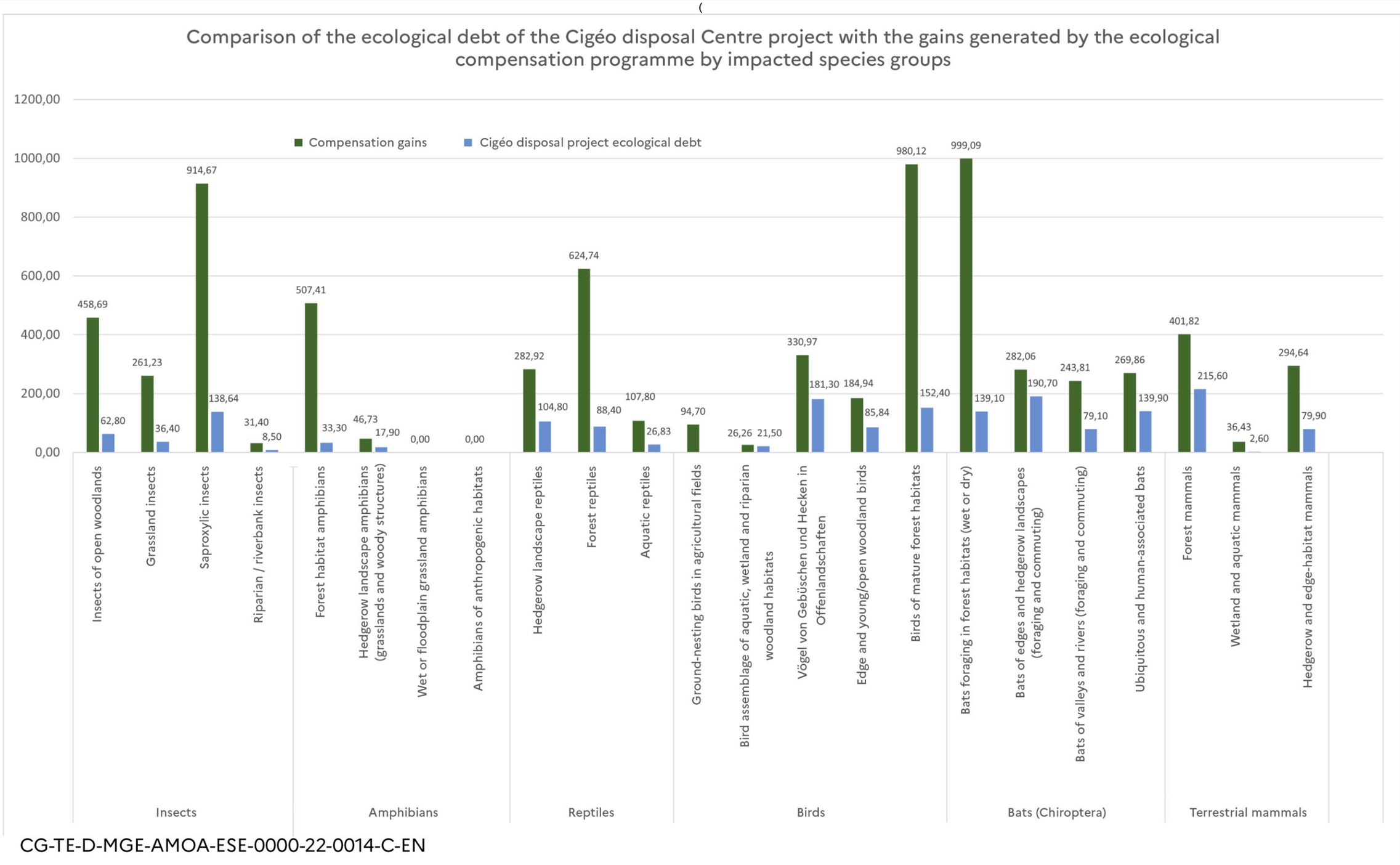
During the 2015–2017 fauna/flora diagnostic studies, three populations of hairy melic in good condition were observed along the connected terminal (ITE)route, in an pioneer open sector of the calcareous grassland on the Montforjue site. In the project's initial design, these sites cannot be avoided during construction given their location and their immediate proximity to the new railway line's route. This species is not found elsewhere in the area. The destroyed plots will be subject to a specific offsetting measure.

3.6.2.8.4 Assessment of the offsetting program

Figure 3-53 below compares the ecological debt of the Cigéo disposal facility project against the gains generated by the ecological offsetting program for each impacted species group.

All habitats of the species groups impacted by the Cigéo disposal facility project are now addressed in the ecological offsetting program. In other words, ecological equivalence has been achieved, with no net loss of biodiversity for all impacted species groups. The ecological debt will be refined based on ongoing supplementary studies by other project owners, and the offsetting program will be adjusted accordingly as needed.

Ecological equivalence has been achieved for the Cigéo disposal facility, with no net loss of biodiversity for all affected communities.



CG-TE-D-MGE-AMOA-ESE-0000-22-0014-C-EN

Figure 3-53 Comparison of the ecological debt of the Cigéo disposal facility project against the gains generated by the ecological offsetting program by impacted species community (in UC)

3.6.3 Compatibility of the Cigéo overall project with planning documents

Given the avoidance and reduction measures implemented, the Cigéo overall project is compatible with the various planning documents applicable to it: action plans for threatened species (in particular bats and the red-backed kite), the Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) for the Grand Est region (103), the Seine-Normandy Water Development and Management Master Plan (SDAGE) and the Rhine-Meuse SDAGE (97–101).

Certain provisions of the urban planning documents (Territorial Coherence Plan for the Pays Barrois, Intermunicipal Local Urban Plan for Haute-Saulx, Local Urban Plan for Gondrecourt-le-Château) are adapted to allow for the construction of the Cigéo disposal facility. This involves explicitly including the Cigéo disposal facility among the exceptions to the application of certain guidelines. For projects not under the ownership of Andra, it will be up to each project owner to ensure, if necessary, that the relevant urban planning documents are brought into compliance.

3.6.4 Natura 2000 Impacts

Regulations stipulate that projects subject to environmental assessment—which is the case for the Cigéo overall project—must undergo an assessment of their impacts on Natura 2000 sites.

Article R. 414-23 of the French Environment Code specifies that the assessment must be proportionate to the significance of the document or operation and to the conservation challenges for the habitats and species present.

The inventory of Natura 2000 sites is based on administrative data concerning natural environments and ecological heritage. The following institutional websites were consulted:

- the websites of the DREAL offices in Lorraine and Champagne-Ardenne administrative régions, now consolidated into the DREAL Grand Est;
- the National Natural Heritage Inventory (INPN) website for viewing the descriptive sheets for the various sites (FDS).

Technical data (initial condition, management, cartographic data) are derived from the review of objective documents available from the operators of each Natura 2000 site.

The assessment of impacts on Natura 2000 sites focuses specifically on the natural heritage of European interest that led to the designation of the sites, that is, the species and habitats listed in the SDF (Standard Data Form) and/or in the ministerial decree designating the site (SCI or SPA) and/or in the validated ecological assessment of the DOCOB.

NATURA 2000 NETWORK

The Natura 2000 network is a collection of European natural sites identified for the rarity or fragility of animal or plant species and their habitats. This network is defined by regulation based on the European “Birds” Directive 2009/147/EC of November 30, 2009 (7) and the European “Habitats” Directive 92/43/EEC of May 21, 1992 (6). The species and natural habitats that, based on these two directives, require the designation of Natura 2000 sites are referred to as **being of community interest**. Certain habitats or species designated **as “priority”** are identified as being at risk of extinction given their highly concerning conservation status. Member States must make particularly intensive conservation and protection efforts for these habitats and species.

The network comprises two types of sites:

- **SPAs (Special Protection Areas)**, which aim to conserve the wild bird species listed in Annex I of the “Birds” Directive, or areas that serve as breeding, moulting, wintering, or stopover sites for migratory birds;
- **Special Areas of Conservation (SACs)**, which aim to conserve the habitat types and animal and plant species listed in Annexes I and II of the “Habitats” Directive. Under the “Habitats” Directive, a natural habitat constitutes an inseparable complex comprising:
  - ✓ fauna, with species carrying out all or part of their various life activities within the area in question;
  - ✓ vegetation;
  - ✓ a site-specific environment (climatic, soil-related, and hydrological conditions).

Regarding the designation of SAC, each Member State submits its proposals to the European Commission in the form of a proposal for a Site of Community Importance (SCI). Following approval by the European Commission, the SIC is designated as such for the European Union and is incorporated into the Natura 2000 network. A national ministerial decree then designates the site as a Special Area of Conservation (SAC). On the other hand, the designation of Special Protection Areas (SPAs)is a national decision, resulting in a ministerial decree, without requiring prior consultation with the European Commission.

This study considers the impacts resulting from the implementation of the various operations and the different phases (construction phase, operation phase, decommissioning phase) comprising the Cigéo overall project.

The Natura 2000 impact assessment is conducted in two stages:

- the preliminary assessment, which is a brief but argued explanation of why the project is or is not likely to have an impact on one or more Natura 2000 sites. If it can be demonstrated at this stage that the project has no impact on one or more Natura 2000 sites, the impact assessment is complete. However, if it is determined that the activity or project is likely to affect one or more Natura 2000 sites, the impact assessment must be expanded;
- the detailed assessment, which involves examining their permanent and temporary, direct and indirect effects, as well as their cumulative effects with those of other activities carried out by the project proponent.

In summary, of the 29 Natura 2000 sites wholly or partially within the area of influence of the Cigéo overall project, 15 are likely to be affected by the Cigéo overall project and have been subject to a detailed assessment; they are presented in the table 3-14.

The analyses conclude that the Cigéo overall project will have no significant impact on the habitats and species of Community interest that justified the designation of the Natura 2000 sites, regardless of the project phases (preliminary work, initial construction, and operation), due to the distance and the implementation of appropriate avoidance and reduction measures.

The absence of a significant impact is justified by the fact that:

- RTE (electricity transmission system operator of France) commits to not carrying out any foundation replacement work and/or pylon structural reinforcement within the Étang de la Horre SPA and SAC, which includes the eponymous National Nature Reserve. Through the implementation of avoidance and reduction measures, none of the operations planned as part of the safety upgrades for the 400 kV transmission line are likely to impact the habitats or species of interest within the Natura 2000 sites crossed;
- the effects associated with emissions (atmospheric or liquid) from the Cigéo disposal facility are minor and have no significant impact on the Natura 2000 sites, particularly the nearest one, the Demange Saint-Joire forest, located 2 km north of the facilities, downwind and downstream of the shaft zone;
- the construction works, particularly in the shaft and ramp zones, will destroy hunting and resting habitats, particularly for bats such as the European barbastelle, the lesser mouse-eared bat, and Bechstein's bat, for which part of the life cycle may take place in the forest, notably requiring tree-based summer roosts. However, the affected areas represent only a very small portion of the available open or forested areas around neighboring Natura 2000 sites, particularly hibernation sites, which are moreover located more than 10 to 15 km away from the Cigéo disposal facility's construction zones. The likelihood of impacting individuals from the populations of these Natura 2000 sites is therefore extremely low;
- The other components of the Cigéo overall project have a lesser impact than the Cigéo disposal facility and are located far enough from the Natura 2000 sites that they do not have a significant impact on the habitats and species of community interest found there (notably bats and birds).

The Cigéo overall project is compatible with local ecological concerns. It does not compromise the integrity of the Natura 2000 sites and is therefore compatible with the management objectives of the relevant Special Areas of Conservation (SACs) and Special Protection Areas (SPAs).

Table 3-14 Natura 2000 sites within the area of influence of the Cigéo overall project - in blue, sites that have undergone a detailed assessment

Natura 2000 site	Type	Objective document	Minimum distance from the project (immediate biodiversity area)	Within a 30 km radius and with bats and birds as the basis for the site's designation	Within the topographic watershed of the Cigéo disposal facility (downstream) and sensitivity to other forms of pollution
FR4100180 **Bois de Demange, Saint-Joire**	SAC	Yes	Within the immediate biodiversity study area (027000 railway line) 1.5 km (Cigéo shaft zone)	**No**	**Yes**
FR2102001 **Former underground quarries of Chevillon and Fontaines-sur-Marne**	SAC	Yes	15 km (Cigéo ramp zone)	**Yes**	**No**
FR4100247 **Perthois Quarries: bat roosts**	SAC	Yes	16 km (Cigéo ramp zone)	**Yes**	**No**
FR2100247 **Grasslands and shrublands of the Joinville region**	SAC	No	10 km (Cigéo ramp zone)	**Yes**	**No**
FR4100181 **Forests of the Méholle Valley**	SAC	Yes	8.5 km (027000 railway line) 11 km (Cigéo connected terminal - ITE)	**No**	**No**
FR4112008 **Meuse Valley**	SPA	Yes	12 km (Cigéo connected terminal - ITEand 027000 railway line) Included (Pylons 257 to 259 of the 400 kV transmission line)	**Yes**	**No**
FR4112009 **Argonne Forests and Ponds and the Ornain Valley**	SPA	Yes	16.7 km (027000 railway line)	**Yes**	**Yes**
FR4100236 **Meuse Valley (Sorcy-Saint-Martin sector)**	SAC	Yes	16 km (027000 railway line) 21 km (Cigéo connected terminal - ITE)	**No**	**No**
FR4100182 **Forests of Gondrecourt-le-Château**	SAC	Yes	0.5 km (Cigéo connected terminal - ITE and 027000 railway line) Nearby (Pylons 232, 233, 239 to 243 of the 400 kV transmission line)	**No**	**Yes**
FR4100154 **Meadows, forests, and the Pagny-la-Blanche-Côte fort**	SAC	Yes	14 km (Cigéo connected terminal - ITE and 027000 railway line)	**Yes**	**No**
FR4100166 **Upper Meuse**	SAC	Yes	22.5 km (027000 railway line) 27 km (Cigéo ramp zone)	**No**	**No**
FR2100323 **Le cul du Cerf in Orquevaux**	SAC	Yes	19 km (Cigéo connected terminal - ITE)	**Yes**	**No**
FR4100191 **Forest habitats and wet meadows of the Mouzon and Anger valleys**	SAC	Yes	22 km (027000 railway line and Cigéo connected terminal - ITE)	**Yes**	**No**
FR4100163 **Toulois Grasslands**	SAC	Yes	25 km (Cigéo connected terminal - ITE and 027000 railway line)	**Yes**	**No**
FR4100230 **Saônelle Valley**	SAC	No	15 km (Cigéo connected terminal - ITE and 027000 railway line)	**Yes**	**No**
FR2100291 **Rognon Valley, from Doulaincourt to the confluence with the Marne**	SAC	Yes	16 km (Cigéo ramp zone)	**Yes**	**No**
FR2100319 **Rognon and Sueurre Valleys and the Crête and Ecot la Combe Forest Massif**	SAC	Yes	24 km (Cigéo ramp zone, connected terminal - ITE)	**Yes**	**No**

Natura 2000 site	Type	Objective document	Minimum distance from the project (immediate biodiversity area)	Within a 30 km radius and with bats and birds as the basis for the site's designation	Within the topographic watershed of the Cigéo disposal facility (downstream) and sensitivity to other forms of pollution
FR4100162 Allamps grasslands and surrounding wetlands	SAC	Yes	22 km (027000 railway line)	**No**	**No**
FR4100216 Pagny-sur-Meuse Marshes	SAC	Yes	22 km (027000 railway line) 25 km (Cigéo connected terminal - ITE)	**No**	**No**
FR2100317 Doulaincourt Forest	SAC	No	20 km	**No**	**No**
FR2100318 Villiers-sur-Marne Woods, Buxières-les-Froncles, Froncles, and Vouécourt	SAC	Yes	22 km (Cigéo ramp zone)	**No**	**No**
FR2100322 Val de la Joux and La Vouette in Roches-sur-Rognon	SAC	Yes	16 km (Cigéo ramp zone)	**No**	**No**
FR2112011 Bassigny	SPA	Yes	20 km (Cigéo connected terminal - ITE)	**Yes**	**No**
FR4112011 Bassigny, Lorraine region	SPA	Yes	28 km (Cigéo connected terminal - ITE)	**Yes**	**No**
FR2100320 Harréville-les-Chanteurs Forest	SAC	Yes	26 km (Cigéo connected terminal - ITE)	**No**	**No**
FR4110061 Pagny-sur-Meuse Marshes	SPA	Yes	22.3 km (027000 railway line) 25 km (Cigéo connected terminal - ITE)	**Yes**	**No**
FR2110091 Étang de la Horre	SPA	Yes	>30 km, but includes pylons 103 to 108 of the 400 kV transmission line	**Yes**	**No**
FR2100332 Étang de la Horre	SAC	Yes	>30 km, but includes pylons 106 and 107 of the 400 kV transmission line	**Yes**	**No**
FR2112001 Pastures and croplands of the Voire, Héronne, and Laines valleys	SPA	Yes	340 m from pylon 115 of the 400 kV transmission line	**Yes**	**No**

Color code: green: SAC, blue: SPA

3.7 Population, employment, economic activities, and housing

SOURCES AND METHODOLOGY

For the initial state: analyses were conducted using data from the Grand Est Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) (103), the Pays Barrois Territorial Coherence Plan (SCoT) (117), as well as data from the French National Institute of Statistics and Economic Studies (INSEE) and the Grand Est Region.

For the impact assessment:

- the data used regarding employment and economic activities are drawn, respectively, from the technical document on input data for regional stakeholders to prepare for the integration of the Cigéo overall project, and from the assessment of costs associated with the implementation of long-term management solutions for high and intermediate level long-lived radioactive waste (123, 124) ;
- Data on population and housing are taken from territorial planning documents (SCoT of the Pays Barrois, intermunicipal local urban planning schemes – PLUi of the Porte de Meuse Community of Communes, Haute-Saulx sector (118) and Val d'Ornois sector (currently being developed (125).

3.7.1 Population

3.7.1.1 Initial state

Environmental issues

The Cigéo overall project is located in an area with a relatively low population density, a net migration deficit, and a rising average age.

High level issue for the region

The immediate study area (up to 50 km around the Cigéo disposal facility) is among the least densely populated areas in the Grand Est region. More than 90% of the municipalities in the 50 km immediate study area (and even more so in the 20 km study area) have fewer than 1,000 inhabitants, whereas this proportion is 81% in the Grand Est region and 72% in France. The average population density is 36.7 inhabitants/km² in the 50 km study area and 19.9 inhabitants/km² in the 20 km study area, which is significantly lower than the regional average (96.6 inhabitants/km²) and the national average (118.8 inhabitants/km²). Saint-Dizier is the most populous municipality in the immediate study area (50 km) and had 24,012 inhabitants in 2017. The immediate study area is a rural zone comprising mainly small villages of a few hundred inhabitants and five towns with more than 1,000 inhabitants, including Ligny-en-Barrois with 4,052 inhabitants and Bar-le-Duc with 14,985 inhabitants (only a small rural portion of the latter municipality is included in the immediate study area). Within the specific study area of the 400 kV Houdreville-Méry transmission line, the vast majority of municipalities (48 out of 56) have fewer than 500 residents. The most populous municipality is Wassy (2,905 residents in 2017).

Compared to the national average, the population structure in the immediate study area shows a clear shortage of the youngest age groups, while the over 65 age group is the most represented. This trend is even more pronounced in the immediate study area, where the proportion of the population aged 65 and over accounts for one fifth of the study area's population, which is on par with regional and national figures.

The demographic trend over the past fifty years has been downward in the immediate study area. This marked decline is explained by a net migration deficit (outflows not offset by inflows) and a decrease in the natural balance (the difference between the number of births and the number of deaths). In fact, net migration has been negative for over fifty years, both at the Grand Est regional level and within the immediate study area, particularly within the 20 km radius closest to the Cigéo disposal facility. Furthermore, the natural balance in the 20 km study area around the Cigéo disposal facility turned negative as early as the 2000s, affecting all municipalities. This situation is described as "concerning" in the Pays Barrois ScoT (117). The average annual population change in the immediate study area shows the same decline: it has been negative since 1975, linked to a strongly negative net migration since the 1968–1975 period and to a change due to the natural balance, which has also been sharply declining since 1990. The immediate study area has therefore recorded more out-migration than in-migration for several decades; this reflects a significant depopulation of the region.

The situation is similar along the 400 kV Houdreville-Méry transmission line: the total population of the 56 municipalities within the study area decreased by 1.3% between 2011 and 2017, representing a loss of 263 residents.

3.7.1.2 The impacts of the Cigéo overall project on the population

Thanks to the jobs created, the Cigéo overall project has a positive indirect impact on the region's demographics starting from the preliminary works phase through the arrival of new residents (effect on net migration) and the rebalancing of the age pyramid, both during the preliminary works and Initial construction phases (temporary presence of these residents) and during the operational phase.

The Cigéo overall project has a direct positive impact on the population

3.7.2 Employment and economic activities

3.7.2.1 Initial state

Environmental issues

The Cigéo overall project is located in a rural area where the number of jobs is declining. Demographic and housing trends make it economically unattractive.

High level issue for the region

In the immediate study area, and particularly in the 20 km study area around the Cigéo disposal facility, the unemployment rate is higher than at the regional and national levels, and the employment rate is lower.

Also within the immediate study area, the unemployment rate is slightly higher than that observed at the regional and national levels, particularly in the 20 km study area, where the increase in the unemployment rate has been the sharpest since 2007. While the number of jobs in France increased before stabilising starting in 2010, the immediate study area has been on a downward trend, which is more pronounced near the Cigéo disposal facility (within a 20 km radius), where the number of jobs has fallen by 36% over the course of 40 years.

Among the working-age population (ages 15 to 64), the most represented socio-professional categories in 2017 were clerical workers, manual labourers, and intermediate professions. The figures show that manual workers are overrepresented in the immediate study area compared to the 20 km study area, which in turn is higher than in the 50 km study area.

In the immediate study area, the findings are similar to those in other study areas, particularly the 20 km study area: the annual unemployment rate is particularly high, reaching 15.27% in 2017, and the number of jobs has declined significantly in the immediate study area over the 1975–2017 period. The overrepresentation of blue-collar workers is also observable in this study area.

This low economic attractiveness goes hand in hand with limited retail and service offerings for the small population. These services are concentrated primarily along the Ornain Valley. Near the current Andra facility in Meuse/Haute-Marne, there is a bakery, a convenience store, two restaurants, an automated gas station, and a gas depot. The middle school in Gondrecourt-le-Château and the school in Échenay, located outside the immediate study area, are the educational institutions closest to the Cigéo disposal facility.

Within the 50 km immediate study area and the 20 km study area surrounding the proposed Cigéo disposal facility, the public administration sector is the largest employer, accounting for more than 40% and 30% of salaried jobs, respectively. Industry has historically been a key sector for the region's socio-economic dynamics, with a strong presence of the metallurgical industry, accounting for 19% of salaried jobs in the 50 km immediate study area around the proposed Cigéo disposal facility, and 31% of salaried jobs in the 20 km study area. By comparison, this sector accounts for 12% of jobs nationwide. Agriculture accounts for 18% of active establishments within the 50 km radius and 24% within the 20 km radius around the Cigéo disposal facility project, demonstrating the agricultural character of the territory affected by the project. However, it remains a minor source of employment, accounting for only between 2% and 4% of salaried jobs.

The Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) (103) sets the following Objective 27: "develop the local economy, rooted in the territories."

An analysis of commuting patterns shows that within the immediate 50 km study area and the 20 km study area, the three municipalities of Bar-le-Duc, Saint-Dizier, and Vitry-le-François concentrate the economic activity of the associated regions and attract the majority of daily commutes by the working population. Transportation options in terms of alternatives to private cars are poorly developed between the three hubs as well as within the immediate study area, where the car is the mode of transportation most widely used by households to get to work.

Given the rural nature of the area crossed by the 400 kV transmission line, the study area specific to this line does not contain any notable centres of activity.

3.7.2.2 The impacts of the Cigéo overall project on employment and economic activities (excluding agriculture and forestry)

The Cigéo overall project has no impact on existing economic activity zones or businesses.

The preliminary works and Initial construction phases, followed by the operational period of the Cigéo overall project, mobilise personnel and create jobs (employees of Andra and other project owners, employees of general contractors and subcontractors), and induced jobs are generated by employees' personal spending (consumption, housing investment, etc.).

Regardless of the period in question, the projected workforce for the Cigéo disposal facility is significantly larger than that required for operations by other project owners.

During the preliminary works phase, the workforce gradually increases. It reaches approximately 2,000 jobs per year during the initial construction phase, before beginning to decline. During these phases, Andra's workforce consists of approximately 40 employees during the preliminary works phase (some of whom have already been recruited in advance by Andra) and nearly 300 during the initial construction phase.

During the operation phase, the number of jobs on-site is expected to stabilise at around 600 people per year, comprising 400 people involved in operations and 200 people for the construction and deployment of underground facilities. Jobs are primarily concentrated in the construction sector (particularly building, public works, and civil engineering), the industrial sector (nuclear and metallurgy) for positions at Andra, other project owners, and suppliers, subcontractors, and service providers, and in the retail/transportation/services sectors for induced jobs. All skill levels are needed: managers, technicians, unskilled workers, etc.

Based on feedback from the Meuse Haute-Marne Underground Laboratory and Andra's Industrial facilities in Aube (CI2A), it is estimated that for every 1.5 jobs created by the centres, one indirect/induced job is generated for each of the three periods.

The Cigéo overall project therefore has a direct and lasting positive impact on employment starting from the preliminary works phase.

Taxes and fees related to the Cigéo overall project contribute to funding local government initiatives for regional development, which is a direct positive impact of the project.

Public interest groups and initiatives carried out under the Territorial Development Project (PDT) developed under the auspices of the Prefect of Meuse, in consultation and collaboration with all relevant regional stakeholders (public authorities, local governments, and operators such as Andra, in particular) and signed at the High-Level Committee meeting on October 4, 2019, contribute to the dynamism and development of the region (initiatives for regional planning and the development of the industrial and economic fabric, to mobilise and foster the skills of local businesses, to support training, etc.). The purpose of this Regional Development Plan (RDP) is to take advantage of the opportunity presented by the creation of the Cigéo overall project to implement a progressive and ambitious strategy for economic and environmental development for the benefit of the two departments of Meuse and Haute-Marne.

Thus, the Cigéo project has a positive indirect impact on the economic revitalisation of the region.

It could have a positive indirect effect as early as the preliminary works phase on the development of services and facilities to meet the needs of the population, in the current context of limited access to certain facilities, particularly healthcare. The development of facilities and services will help increase the region's attractiveness.

In accordance with public procurement principles, Andra works in collaboration with the other project owners to ensure market conditions that promote access for small and medium-sized enterprises (SMEs), small and medium-sized industries (SMIs), and artisans to construction contracts through incentives for first-tier subcontractors or specific support measures (information, meetings between SMEs and first-tier subcontractors, etc.) for SMEs and SMIs. Furthermore, to promote access for local job seekers seeking employment integration, social integration clauses are specified in the contractual documents for construction contracts, in coordination with the employment unit of the Regional Development Project. Details of these measures are presented in chapter 7 of Volume IV of this impact assessment.

The Cigéo overall project has a direct positive impact on employment and economic activities

3.7.3 Housing

3.7.3.1 Initial state

Environmental issues

The Cigéo overall project is located in an area with a high proportion of vacant housing.

High level issue for the region

The immediate study area has housing that is generally older than the average for the Grand Est region, with a sharp decline in new housing construction. The relatively high number of vacant housing units (above the national average) is a consequence of negative net migration and natural balance decline. Nevertheless, despite the population decline, residential expansion is occurring at the expense of agricultural and natural areas, particularly in municipalities located in the first or even second rings of urban centres (Bar-le-Duc, Ancerville, Revigny, Ligny-en-Barrois).

The small towns and villages in the immediate study area share a similar layout, with older housing organised around the main road axis, as illustrated by the figure 3-32 . On the outskirts, and often hidden from view along the main road, lie the newer suburban residential areas. A few isolated farms are located within the study area. As housing demand is stagnating or even declining slightly, very few recent multi-unit housing developments are available.

The existing housing along the study corridor of the 400 kV Houdreville/Méry transmission line consists largely of isolated farms, as well as a few more recent developments such as housing subdivisions.

The Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) sets the objective of "adapting housing to new lifestyles."



Figure 3-54 Ligny-en-Barrois, crossed by the D 966 departmental road through its centre

3.7.3.2 The impacts of the Cigéo overall project on housing

People working on the construction of the overall Cigéo project (preliminary works and initial construction), and later on the operation of the Cigéo disposal facility, may benefit from vacant housing in the area and from new housing units whose construction or renovation is planned in local authorities' urban planning documents. The overall Cigéo project should therefore have a positive indirect effect on reducing the housing vacancy rate and increasing renovation activity. Real estate prices are not expected to rise significantly, but increased market activity should allow local property owners to increase the value of their properties, whether for sale or rent. Furthermore, as the rental market is expected to become more active, the associated increases in rental income should contribute to the renovation of existing buildings.

The Cigéo disposal facility has no impact on existing housing, services, or infrastructure. The risk to residential areas posed by the level crossings on the 027000 railway line is currently being assessed as part of the design studies, with priority given to bypass solutions.

The Cigéo overall project has a direct positive impact on housing

3.7.4 Compatibility with existing planning documents

The Cigéo overall project, whose primary objective is the creation of a radioactive waste disposal facility, is not intended to directly address the objectives of the Grand Est SRADDET (103) and the Pays-Barrois ScoT (117) regarding population and employment; however, it may contribute to achieving these objectives through job creation, the generation of spin-off jobs, tax revenue, and Andra's participation in the Territorial Development Project (PDT). The project therefore represents an opportunity for the economic and demographic revitalisation of the region.

3.8 Agricultural and forestry activities

SOURCES AND METHODOLOGY

The agricultural and forestry data used to establish the baseline are drawn primarily from summary documents prepared by the Regional Directorate for Food, Agriculture, and Forestry (DRAAF) of the Grand Est region and from public databases, in particular the French National Institute of Statistics and Economic Studies (INSEE) and the French National Institute of Geographic and Forest Information (IGN). Some of this data was consolidated and reprocessed by the Grand Est Regional Service for Statistical and Economic Information (SRISE).

Agricultural Activities

The assessment of impacts on agricultural activities and the approach to their compensation is based on the impact analysis developed in the preliminary impact study on the agricultural economy. To prepare this preliminary agricultural study, a working group was formed with representatives from the agricultural sectors of the Departmental Directorates of Territorial Planning, the Departmental Chambers of Agriculture of Meuse and Haute-Marne, and experts. This group met several times between 2017 and 2020. The financial input data were derived from accounting analyses of farm groups, produced by the agricultural management centre (CERFRANCE Adhéo). The French National Institute for Origin and Quality (INAO) was also consulted to assess the challenges facing agricultural production under quality and origin certification schemes (in particular, *Appellation d'Origine Contrôlée-Protégée* and Protected Geographical Indication for cheese).

This work was presented on several occasions to elected officials from the chambers of agriculture, to farmers in the area concerned, and to the Regional Directorate for Food, Agriculture, and Forestry in order to validate each stage of this assessment but also to prepare the associated compensation arrangements.

Silvicultural Activities

To assess the volumes of timber generated during the first phase of clearing, estimates of tree height were conducted in 2015 based on field data, including:

- a mapping of the stands;
- measurement of canopy height using Lidar surveys;
- measurement of basal area for each stand.

This work made it possible, using charts, to create a map cross-referencing tree heights with stand types and to obtain an initial estimate of the volume of standing timber available for harvesting by the local forestry sector.

3.8.1 Agricultural activities

3.8.1.1 Initial state

Environmental issue

Agricultural activity occupies a significant portion of the land and economy of the rural area covered by the overall Cigéo project, which involves various quality and origin certification schemes.

High level issue

The departments of Meuse and Haute-Marne, where the majority of the Cigéo project is located, are heavily oriented towards agriculture. They constitute the extended study area. More than half of the land area in these departments consists of agricultural land, primarily arable land used for field crops. These departments are home to several production areas covered by designations of origin and quality (SIQO): organic farming and wine-growing appellations (Haute-Marne Sparkling Wine PGI) but especially cheese designations such as the Brie de Meaux AOC (controlled geographical indications) and the French Emmental PGI. Agricultural activity is a key issue for these departments and particularly for the territory affected by the implementation of the Cigéo overall project.

The sections of the 400 kV transmission line outside this remote area are also located primarily in rural settings on agricultural land, some of which falls within areas covered by designations of origin and quality (AOC Brie de Meaux, PGI Emmental Français, PGI Haute-Marne Sparkling Wine, as well as AOC Munster and AOC/GI Mirabelle de Lorraine).

As shown on the figure 3-55, more than 60% of the immediate study area—comprising the municipalities of Gillaumé, Saudron, Cirfontaines-en-Ornois, Bure, Gondrecourt-le-Château, Horville-en-Ornois, and Mandres-en-Barrois—is occupied by agricultural land. However, production potential is limited due to the nature of the soils, which are shallow and low in organic matter. Large-scale farms are highly mechanised and provide few jobs. The land is used primarily for growing cereals (barley, wheat, etc.). Livestock farming is not very significant in this area.

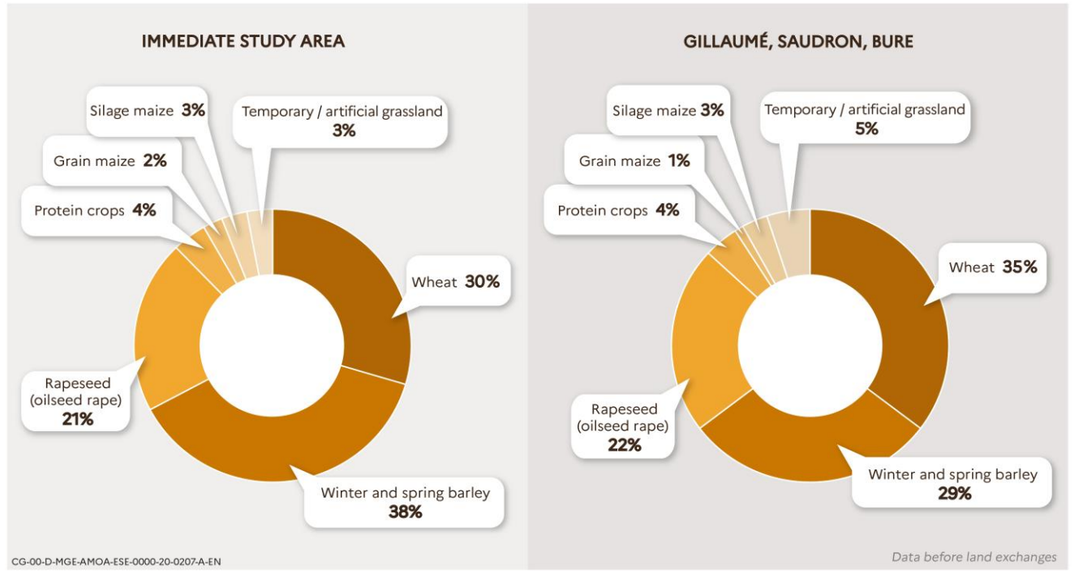


Figure 3-55 *Average distribution of different crops on arable land in the immediate study area (2011–2015 average)*

Production at several dairy farms is geared towards making Brie de Meaux, supporting the operations of several nearby cheese dairies. Few farms currently operate under "organic farming" standards. No other production is covered by a quality or origin identification label (SIQO). There are no vineyards within the Haute-Marne PGI area in the immediate vicinity.

Traces of pollutants and radioactivity are measured in agricultural products, which are primarily of natural origin and representative of an area far from current industrial and nuclear activities. Some radioactive elements of artificial origin from known sources, such as fallout from atmospheric nuclear weapons testing or nuclear accidents like Chernobyl, have been recorded in line with levels measured at the national level (89).

The immediate study area comprises 388 ha of agricultural land, of which more than 300 ha were subject to early land exchanges with the "Non-profit organisation focused on rural land planning and rural settlement initiatives" (Safer) and are currently being used by Andra for alfalfa cultivation.

About forty other farmers are also currently active in the immediate study area. Most of their land is used for crops, primarily barley and wheat. Small cattle farms are located on pastures covering less than 10 ha. Milk from three farms is used in the production of Brie de Meaux.

3.8.1.2 Impacts and Associated Measures

The Cigéo overall project is situated in a rural environment dominated by agricultural land.

The impacts of the Cigéo overall project on agricultural activities are potentially significant given the agricultural land consumed by the Cigéo disposal facility. The change in land use (approximately 580 ha, taking into account areas dedicated to ecological compensation measures) impacts not only the affected farms but also the entire agricultural sector.

Various measures can help avoid the use of agricultural land, such as distributing the repository's facilities between agricultural land with limited production potential and forested areas, or reusing existing infrastructure. Details of these measures are presented in chapter 8.1 of Volume IV of this impact assessment.

The potential project areas of the Cigéo overall project have a minor impact on several production areas under the SIQO (Official Quality and Origin Identification Mark) program. The location of the facilities avoids the core of these certified areas, and land use within the most affected area—the *Brie de Meaux Appellation d'Origine Contrôlée*—accounts for less than 0.03%. No existing vineyards are affected.

Land exchanges carried out over several years have made it possible to avoid the loss of agricultural land for each of the farms concerned. The long-term viability of these farms is currently assured, and the restoration of agricultural routes has been studied in consultation with the users.

The agricultural area within the potential project zone currently owned by private landowners is approximately 70 ha, used by 43 farmers, 25 of whom have already benefited from land swaps in recent years. About 45 ha are located within the buffer zone established to account for uncertainties at this stage of the Cigéo overall project regarding the final location of the facilities. This consists mainly of arable land located along the inter-site link and the connected terminal off into the municipalities of Bure, Gondrecourt-le-Château, Horville-en-Ornois, and Mandres-en-Barrois. The maximum area to be exchanged is 8.3 ha for one of the farms, corresponding to 12% of its usable agricultural area. For the other farms (42), the agricultural land affected is less than six hectares per farm and represents less than 5% of their utilised agricultural area. The average area per farmer is 1.8 ha, which is small compared to the size of farms in the sector (over 100 ha). All agricultural access routes necessary for farming activities have been restored.

Furthermore, numerous measures are in place to minimise releases into the environment (air, water, etc.) so as not to impact the quality of agricultural products (filtration of air emissions, water treatment, and specific management of effluents containing traces of radioactivity, use of eco-friendly products, etc.). Product analyses are conducted regularly to ensure that the Cigéo overall project has no impact on product quality and to preserve the image of local agriculture.

Despite the various avoidance and reduction measures implemented, the residual impact of the Cigéo overall project remains significant on the agricultural economy, primarily for upstream sectors (agricultural machinery and supply companies, etc.) and downstream sectors (collection agencies, cooperatives, etc.).

The operations of other project owners, which consume less agricultural land, have a residual impact that is significantly lower than that of the Cigéo disposal facility when applying the same principles.

The residual effects of the Cigéo overall project on the agricultural economy were assessed in close collaboration with local stakeholders, particularly the chambers of agriculture, cooperatives, and the expertise of the Adhéo management centre. This assessment is based on an estimate of the losses in added value for the sectors resulting from the removal of agricultural land from production, the reduction of production areas within appellation zones, and changes in farming practices due to environmental mitigation measures.

The impact on agricultural sectors corresponds to an estimated total financial loss of €4,394,850.

This economic impact is subject to collective agricultural compensation aimed at strengthening the local agricultural economy.

The collective agricultural economic compensation will be based on funding projects that generate new added value. These projects aim in particular to modernise and develop production tools for the dairy and cheese industry; promote the diversification of agricultural production (production of plant and animal proteins, mushroom cultivation, etc.) and develop sustainable production and value-added activities (production of biomass energy and agro-materials).

For the implementation of the collective agricultural compensation, Andra acts as the project owner in place of the project owners of the other operations within the Cigéo overall project.

This compensation is intended to support the development of innovative projects with no significant negative impact on the environment. The effectiveness of the compensation will depend on the full utilisation of the fund and will not be limited to a specific timeframe.

The final amount of the collective agricultural compensation was set at 4.4 million euros to cover the maximum agricultural area affected by the Cigéo project and account for uncertainties regarding the timing of the implementation of compensation projects. The entire sum was deposited at the beginning of 2023 with the *Banque des Territoires* (a subsidiary of the *Caisse des Dépôts et Consignations*) to fund the compensation fund.

The Cigéo overall project has a minimal residual impact on agricultural activities following the implementation of collective agricultural compensation measures.

Furthermore, the Cigéo master plan takes into account the guidelines of the Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET).

3.8.2 Forestry activities

3.8.2.1 Initial state

Environmental issues

The study areas are located in a heavily forested region, home to large managed forests whose production is on the rise.

The immediate agricultural and forestry study area (potential intervention zone) covers less than 15% of the total forest area in the two main municipalities concerned: Mandres-en-Barrois and Bonnet. The forests, which are of average quality, have not been harvested for several years.

Moderate issue

The Grand Est region ranks among the most forested regions in France (see Figure 3-56). Given the extent of forested areas in Meuse and Haute-Marne, a significant economic sector has developed around forest production and wood utilisation.

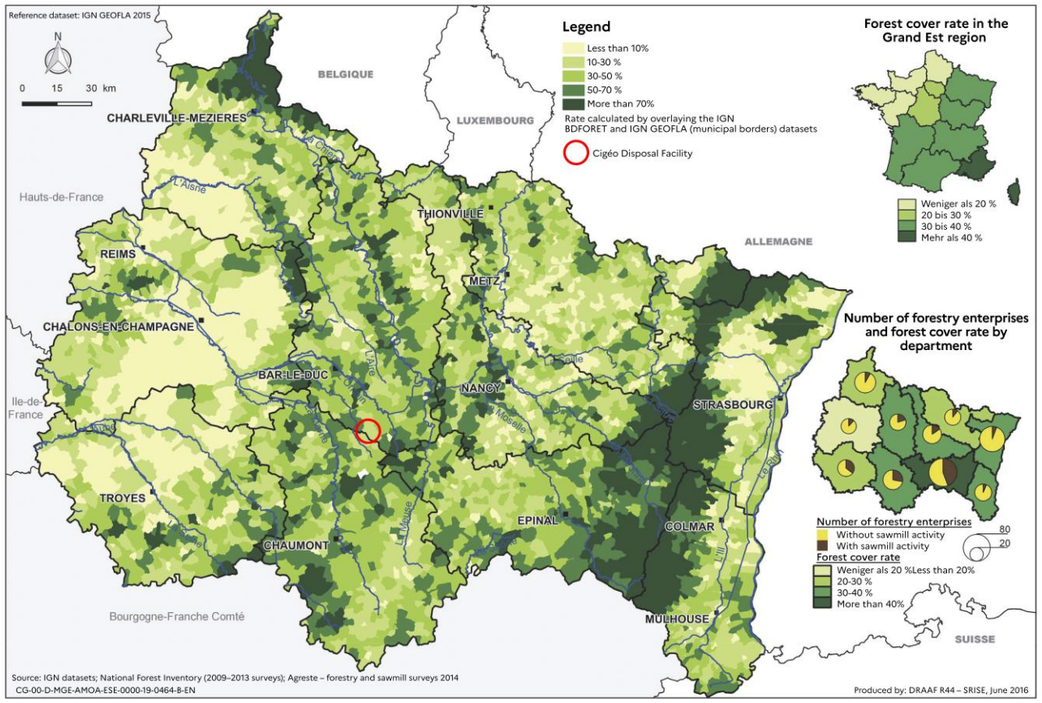


Figure 3-56 Forest cover rate in the Grand Est region

The sections of the 400 kV transmission line passing through forest cover less than 20 km of the 124 km to be secured.

The forests in the immediate study area—the Lejuc Wood in Mandres-en-Barrois and the Le Marquis Wood in Bonnet—are predominantly composed of hardwoods. They were partially affected by the 1999 hurricane.

The forested area covered by the immediate study area is approximately 250 ha. The forest stands consist mainly of young trees and saplings with no particular commercial value.

3.8.2.2 Impacts and Associated Measures

Given the area of exploitable forest land that must be cleared to allow for the installation of surface facilities in the shaft zone and the storage of excavated material during the excavation of underground structures, the potential impact of the Cigéo overall project on silvicultural activities is significant.

For other operations, the forested areas that cannot be avoided based on the selected options are very limited. Their use has no significant impact on forestry activities.

In total, nearly 136 hectares of the Meuse forest will no longer be usable following the clearing required for archaeological investigations prior to the start of construction of the Cigéo disposal facility.

Although this cleared area is significant, the stands, which were damaged by the 1999 storm, have no particular market value. Thus, although the clearing will result in a large quantity of wood being brought to market over a short period, the local market is not destabilised.

In the forested areas designated for ecological compensation, forestry activities continue. The silvicultural and ecological management protocols, which are specified in the management documents, are nevertheless adapted to allow for the implementation of various measures to promote biodiversity. Local companies responsible for the regular forestry work required to implement environmental compensation measures are provided with specific training on sustainable and ecological forest management.

Despite the implementation of avoidance and reduction measures (e.g., site selection, phased planning of land use in forested areas, landscaping carried out by local forest nurseries), the Cigéo overall project has a significant residual impact on forestry activities, necessitating the implementation of forest offset measures. Details of the measures are presented in Chapter 8.2 of Volume IV of this impact assessment.

In this regard, the Meuse Departmental Directorate of Territories has set a compensation multiplier coefficient equal to two, established according to a grid of criteria (economic role/future value, wood quality, ecological role, social role, municipal forest cover rate).

Andra wishes to prioritise silvicultural improvement work consisting of reforesting plots already designated for forestry operations but that have been degraded, and to promote the development of biodiversity. About sixty projects were selected following a call for proposals launched by Andra in late 2017, near the potential operational zone of the Cigéo disposal facility, to revitalise local silvicultural activities and promote biodiversity. These projects represent nearly 560 hectares available for reforestation, part of which could be used for silvicultural compensation. After the areas to be reforested and the reforestation plans have been approved by the Departmental Directorates of Territories, an agreement is established between Andra and the forest owner to define the terms of reforestation and the maintenance of the plantations. This agreement specifically outlines Andra's responsibility for managing the plantations over a five-year period and the owner's obligation to include the parcel in a management plan. During the first five years, Andra may delegate the maintenance of these plantations to a third party under conditions defined with the owner based on the owner's desired level of involvement.

The budget for forest compensation for the first phase of land clearing (reforestation and/or contributions to the Forest Structural Fund) is estimated, based on Andra's experience in recent years, at 2.3 million euros. The amount should be specified by the Meuse Departmental Directorate of Territorial Planning during the review of the application for authorisation to clear the shaft zone in particular.

The organisation, and in particular the planning of these reforestation projects, ensures—given the scale of the areas involved—that the forestry sector and forest nursery operators are not destabilised.

The Cigéo overall project takes into account the guidelines of the Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) (103), the Grand Est Region's 2018–2027 Regional Forest and Wood Program (126), as well as those of the Regional Forest Management Plans for Lorraine and Champagne-Ardenne (127).

Following this forest compensation, the Cigéo overall project has a low residual impact on forestry activities.

3.9 The networks

3.9.1 Initial state

Environmental issues

A network of various utility lines and associated easements is present within the immediate study area. Development and upgrade projects are currently underway for some of these (fibre optics). Several high-pressure natural gas pipelines and high- and extra-high-voltage power lines (including the Houdreville-Méry transmission line) cross this study area.

Moderate issue

The identified networks are:

- the 400 kV Houdreville-Méry transmission line, which crosses the immediate study area;
- the DN200-1987 Aingeville–Trois-Fontaines-l'Abbaye gas transmission pipeline, oriented northwest–southeast, which crosses the immediate study area from Savonnières-en-Perthois to Lezéville;
- several power lines and gas pipelines intersect and cross the northern part of the immediate study area in the Ligny-en-Barrois sector and south of Saudron;
- several high-voltage lines are also listed within the specific study area of the 400 kV Houdreville-Méry transmission line.

These networks are shown on the map in figure 3-57.

While some networks are underdeveloped in the immediate study area (underdeveloped public sewer systems, low-efficiency drinking water systems [leaks]) and poorly interconnected (fibre-optic networks under development), several projects to develop and upgrade the networks are included in the planning documents (Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET), Ten-Year Network Development Plan, Territorial Master Plan for Digital Development, and the "Losange" Plan for Fibre Optics).

The SRADDET's objectives regarding networks are to accelerate the digital revolution in the region and to optimise and adapt energy transmission networks.

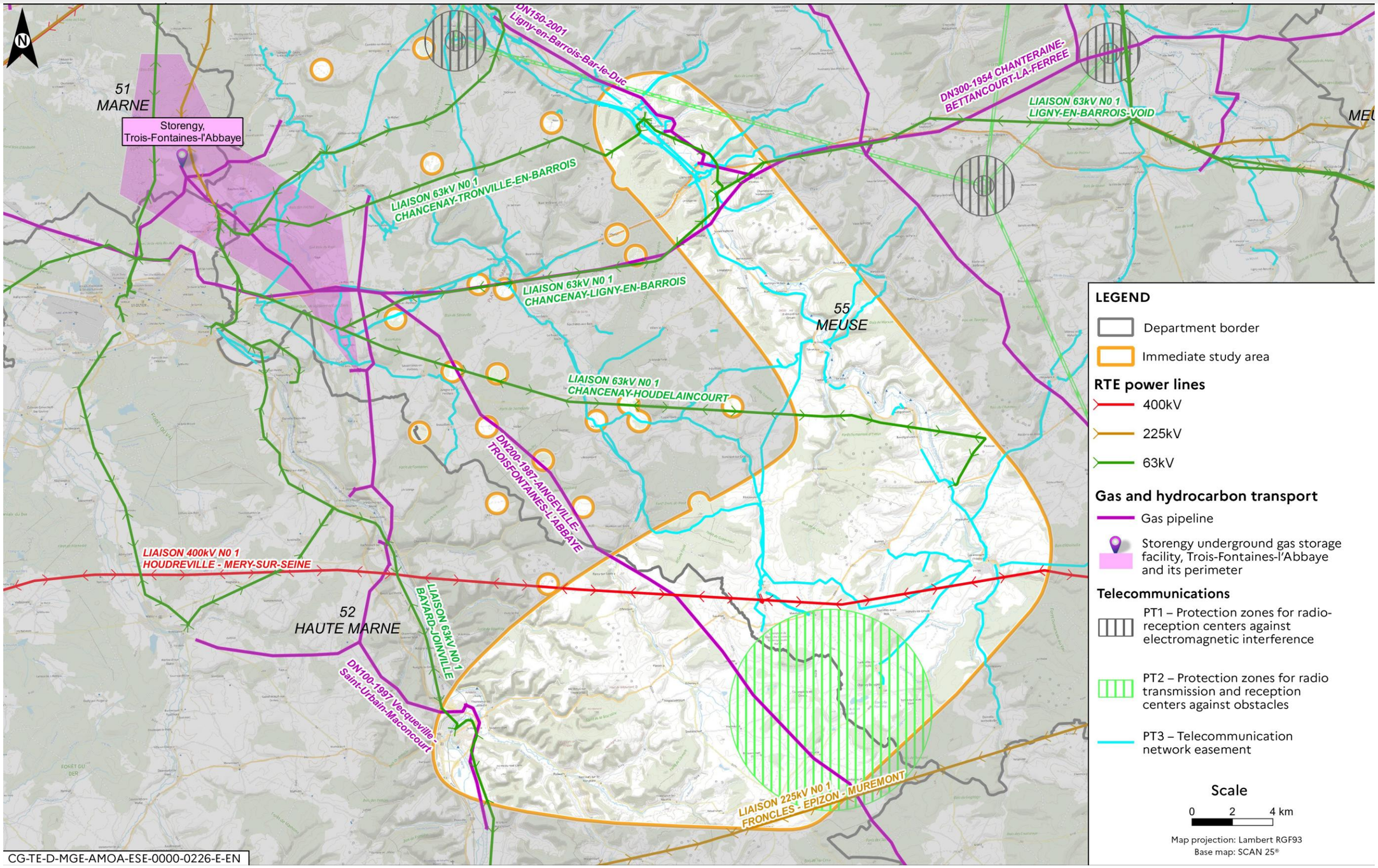


Figure 3-57 Location of networks in the immediate study area

3.9.2 Impacts and associated measures

3.9.2.1 Existing networks

During the construction phases (preliminary works and initial construction), existing networks located on or near the Cigéo overall project may be rerouted and works to connect the Cigéo disposal facility to existing networks—whether to be created (water supply) or secured (400 kV transmission line)—may require temporary network outages.

Nevertheless, the avoidance and reduction measures implemented help limit the resulting disruptions. Details of these measures are presented in Chapter 9.2 of Volume IV of this environmental impact assessment:

- the identified networks are taken into account during the analysis of alternatives for drinking water supply routes, during the siting of environmental characterisation and monitoring facilities, as well as in the selection of the variant for the electrical substation and the deviation of the D60/960 departmental road, as part of an avoidance approach;
- procedures for notifying users and operators of existing networks of planned work and providing advance notice of temporary service interruptions are in place for the other operations of the Cigéo overall project.

Thus, the residual impact on existing networks is very low.

The Cigéo overall project has a very low residual impact on existing networks that could be affected.

3.9.2.2 The creation and securing of networks

In addition, the Cigéo overall project involves the creation of new networks and the reinforcement of certain existing networks, including:

- the reinforcement of the 400 kV Houdreville-Méry transmission line, including the replacement of the current guard cable with a guard cable incorporating an optical fibre;
- the construction of the 400/90 kV electrical substation; and the creation of underground power transmission networks connecting the shaft and ramp zones to the substation;
- the construction of the drinking water supply network for the Cigéo disposal facility.

The work to secure the 400 kV transmission line, including the replacement of the current guard cable with a guard cable incorporating an optical fibre, helps prevent power outages caused by extreme weather events, supports regional development, and benefits all users of the line. This has a positive impact.

The 400/90 kV electrical substation, built for the project's needs, could, in the medium and long term, be used by the region through new connections to it. This represents an opportunity for the region.

The drinking water supply works for the Cigéo disposal facility will allow for the restructuring of the networks and the improvement of local distribution to ensure its reliability for the region.

RTE's electrical facilities and operations are already integrated into the Ten-Year Power Grid Development Plan, and are consistent with the Pays Barrois Territorial Coherence Plan (SCoT) (117) and the Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) (103).

The Cigéo overall project has a positive impact on the security and optimisation of existing networks and on regional development.

3.10 Radioactive and conventional waste

3.10.1 Radioactive waste

» RADIOACTIVE WASTE

According to the French Environment Code, **radioactive waste** is defined as "radioactive substances for which no further use is planned or envisaged, or which have been reclassified as such by the administrative authority" (Article L. 542-1-1 of the French Environment Code). This waste is produced by industries that utilise the properties of radioactivity. Depending on how it is produced and its nature, radioactive waste contains, within it or on its surface, radionuclides (uranium, radium, cobalt, etc.) that emit harmful radiation. Radioactive waste is therefore considered a hazardous substance that must be managed in a manner that protects human health, safety, and the environment.

3.10.1.1 Initial state

Environmental issues

None of the current management methods allows for the definitive, very long-term and safe disposal of French High-Level (HLW) and Intermediate-Level Long-Lived (ILW-LL) radioactive waste.

High level issue

The management of radioactive materials and waste is governed by the French National Plan for the Management of Radioactive Materials and Waste (PNGMDR) 2022–2026 (128), which is the subject of Decree No. 2022-1547 of December 9, 2022 (129), provided for by Article L. 542-1-2 of the French Environment Code and establishing the requirements of the French National Plan for the Management of Radioactive Materials and Waste (129), and of the Order of December 9, 2022 (55) issued pursuant to Decree No. 2022-1547 of December 9, 2022, as provided for in Article L. 542-1-2 of the French Environment Code, and establishing the requirements of the French National Plan for the Management of Radioactive Materials and Waste.

The French Environment Code (Article L. 542-1-2 II) has established three main guidelines that the PNGMDR and its implementing decree, which sets forth its requirements, must adhere to:

1. The reduction of the quantity and harmfulness of radioactive waste is sought, in particular through the reprocessing of spent fuel and the treatment and conditioning of radioactive waste;
2. Radioactive materials awaiting processing and final radioactive waste awaiting disposal are stored in facilities specially designed for this purpose;
3. After temporary storage, final radioactive waste that cannot, for reasons of nuclear safety or long-term radiation protection, be stored at the surface or at shallow depths, is stored in a deep geological repository.

The 2022-2026 French National Program for the Management of Radioactive Materials and Waste (PNGMDR) (130) sets out 41 objectives divided into nine strategic areas (Governance, Energy Policy, Radioactive Materials, Spent Fuel Storage, Very Low-Level Waste Management, Low-Level Long-Lived Waste Management, High-Level and Intermediate-Level Long-Lived Radioactive Waste Management, Management of Specific Waste Categories, transversal issues) and broken down into 65 actions.

Within France, radioactive waste is currently managed as follows:

- three industrial facilities managed by Andra handle Very Low-Level Waste (VLLW) and Low and Intermediate-Level Short-Lived (LILW-SL) waste. They are located in the Manche administrative department (the CSM, which has not received any waste since 1994, is currently in the decommissioning and closure phase) and in the Aube administrative department (the Cires and CSA, currently in operation);
- For Low-Level Long-Lived Waste (LL-LLW), currently stored at waste-generating sites, management options—including a shallow-depth storage project—are under study;

- in the absence of an available disposal facility for their final disposal, the High-Level Waste (HLW) and Intermediate-Level Waste Long-Lived (ILW-LL) produced by French nuclear activities are stored in dedicated facilities at the various producers' sites. The objective is for this waste to be subsequently transported to the Cigéo disposal facility.

3.10.1.2 Impact and associated measures

3.10.1.2.1 Sustainable management of HLW and ILW-LL in deep geological repositories

The Cigéo disposal facility is designed to accommodate French HLW and ILW-LL in a manner that ensures their long-term safety. This is a positive impact of the project, which thus meets the objectives set by the 2022-2026 French National Plan for the Management of Radioactive Materials and Waste (PNGMDR) (128), particularly those of Article D. 542-90 of the French Environment Code.

The Cigéo overall project, which constitutes the French solution for the final disposal of HLW and ILW-LL, has a positive impact on the sustainable management of these waste categories.

3.10.1.2.2 Management of radioactive waste generated

The Cigéo disposal facility generates radioactive waste during its operation period, in connection with the facility's nuclear activities. This includes, in particular, waste potentially generated during operations, such as inspections of transport packaging—notably radioactive waste packages—and maintenance and refurbishment of certain pieces of equipment. For example, this may include gloves, protective suits, tools, and ventilation filters.

The radioactive waste produced consists of solid or liquid waste of Very Low Level (VLL) or Low and Intermediate Level, primarily Short-Lived (LILW-SL). No High- and Intermediate-Level Long-Lived (HLW, ILW-LL) radioactive waste will be generated by the activities carried out at the Cigéo disposal facility. The estimated annual quantities of solid radioactive waste (VLLW and LILW) are less than 41 tons.

During the operation of the Cigéo disposal facility, some liquid effluents, depending on their source or use, may contain very low levels of radioactive substances. This is the case when they originate from:

- from underground, from the mine drainage collection system of the High-Level Waste cells that have been in contact with waste packages;
- on the surface, from areas where nuclear waste may be generated, such as condensates from the internal energy recovery units of the EP1 surface nuclear building.

These effluents are referred to as "non-conventional liquid effluents." They are collected and sent to an external facility dedicated to their treatment. The annual volume of "non-conventional liquid effluents" is approximately 90 m³/year (i.e., approximately 90 t/year) during the first decades of the BNI's operation through 2080. Measures to reduce the volume of this waste are implemented (waste zoning plan and scheduling of facility requirements), as well as sorting. After conditioning, inspections, and radiological characterisation, this waste is sent to appropriate and authorised management streams. The other operations of the overall project do not produce radioactive waste. Details of the measures implemented are presented in Chapter 10.3 of Volume IV of this impact assessment.

Thus, with regard to the volumes of radioactive waste generated and their management, all requirements set forth in the PNGMDR 2022-2026 are met.

The Cigéo disposal facility will have a low residual impact regarding the production of radioactive waste. Given the management measures implemented for this waste, it is not likely to have an impact on the environment.

3.10.2 Conventional waste

3.10.2.1 Initial state

» CONVENTIONAL WASTE

For a basic nuclear installation, **conventional waste** refers to non-radioactive waste. By extension, in this impact assessment, all non-radioactive waste is also referred to as conventional waste. This conventional waste includes categories of waste typically generated by human activities (construction waste, office waste, household waste, etc.).

Environmental issue

Only one household waste treatment facility is identified in the immediate study area, and numerous facilities are present at the regional level.

Moderate issue

Conventional waste management in the Grand Est region is governed by the Regional Waste Prevention and Management Plan (PRPGD) (131), annexed to the Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) approved on January 24, 2020 (103), in line with established national plans. The PRPGD sets objectives and proposes rules regarding waste prevention and management.

Numerous sorting/transfer, storage, treatment, and recovery facilities are identified at the regional level. Only one facility is identified within the immediate study area. This is the household waste treatment unit (UTOM) located in Tronville-en-Barrois at the northern edge of the immediate study area.

3.10.2.2 Impacts and Associated Measures

The Cigéo overall project, and primarily the disposal facility, generates inert waste, non-hazardous waste, and hazardous waste. Other operations within the Cigéo overall project also produce these types of waste, but in smaller quantities.

The disposal facility also generates a significant amount of Callovian-Oxfordian claystone extracted during the excavation of the underground facility.

During the preliminary works phase, for inert excavated material resulting from earthworks, priority is given to its reuse at the Cigéo disposal facility (balancing the excavated material/backfill balance), thereby avoiding the generation of inert waste. The same objective is pursued for the other operations of the Cigéo overall project. The quantity generated during this phase is on the order of 100 tons, spread over five years.

During the initial construction period, the volume of conventional waste at the Cigéo disposal facility is estimated at approximately 250,000 tons spread over 10 years, 90% of which is inert waste (primarily concrete).

During the operations period, the production of various types of waste (excluding waste from buildings restorations and backfill) is estimated at around 5,100 tons per year. Restorations of buildings may lead to a temporary increase in waste volumes, which cannot be estimated at this stage of the studies.

Regarding the other project owners, the total volume of excavated material from the four operations combined is estimated at approximately 500·000 m³. The estimate for backfill volumes is equivalent. Thus, the actual volume of inert waste generated depends on the potential for reuse across the various operations and should be specified by the project owners in subsequent versions of the environmental impact assessment. Regarding other types of waste, the quantities cannot be estimated at this stage of the studies.

Measures to reduce waste at the source are implemented: scheduling the construction of structures to account from the outset and as much as possible for changing needs of the project over the long term, as well as the adaptability and scalability of the facilities; selecting materials based on their durability; and so on. In addition, waste sorting at the source is implemented starting in the preliminary works phase, as close as possible to the production areas. Waste management platforms are established during the Initial construction phase, in the ramp and shaft zones, respectively. Various collection points are also set up during the operation period.

Conventional waste originating from within the nuclear facility's perimeter comes exclusively from so-called conventional waste zones in which the waste produced cannot be contaminated or activated, including during its transfer to the disposal site.

Conventional waste generated within the nuclear facility's perimeter undergoes radiological screening before being transferred to conventional industrial waste disposal sites.

Andra continues to explore ways to reduce waste generation throughout the design phase, and this priority is specified in the contractors' specifications. Reducing waste volume at the source is also a priority for the project owners of other operations within the Cigéo overall project.

Waste is directed to appropriate, approved, and authorised disposal pathways, with priority given to valorisation and reuse, particularly for inert and non-hazardous waste. To limit the environmental impact of waste transport, local treatment facilities in the Grand Est region are prioritised. No cross-border transfer of waste is planned.

The so-called "vive" excavated materials deposit, accounting for approximately 40% of the total volume of excavated Callovo-Oxfordian claystone, is used, after processing, as backfill material for the sealing and permanent closure of the disposal cells, the galleries of the underground facility, logistics support areas, disposal areas, and surface-underground connections, once the Cigéo disposal facility has ceased operations.

The volume of so-called "dead" excavated materials deposit, corresponding to the Callovo-Oxfordian claystone excavated and not reused for sealing the radioactive waste disposal galleries, is estimated at 60% of the 11 million m³ of excavated materials deposit at the end of the operation period. Andra plans to recycle this "dead" excavated material through channels outside the disposal facility. In the event that the recycling channels fail or if their long-term viability is called into question during the facility's operation, Andra would need to expand the excavated materials depositarea by 2070–2080.

Various recycling options are being considered for other types of waste (metals and scrap from the steel industry, recycling of wood from land clearing, etc.).

Despite the measures taken, the amount of waste generated by the Cigéo overall project remains significant. The ongoing design studies aim to further reduce the production of this waste, and waste management is a key focus in the contracts with the various construction companies. Given the management measures implemented for this waste, its environmental impact is low.

The management of conventional waste generated is consistent with the Energy Transition for Green Growth Act, the National Waste Management Plan, the National Waste Prevention Plan, and the waste-related objectives of the SRADDET.

The Cigéo overall project generates a significant amount of waste. However, given the management measures implemented for this waste, the residual environmental impact is low.

3.11 Risks and Vulnerability to Major Accidents or Disasters

3.11.1 Initial state

Environmental issue

Issues related to natural hazards are presented in the specific thematic chapters of this non-technical summary.

The immediate study area, and *a fortiori* the close study area, do not contain any basic nuclear installations (BNI) or Installations Classified for the Protection of the Environment (ICPE) known as Seveso facilities, which present the most significant technological risks.

The main risks identified in the close study area are related to the presence of Installations Classified for the Protection of the Environment (ICPE) distributed throughout the territory, with a few facilities affecting the immediate study area but none that are Seveso-classified or have a Technological Risk Prevention Plan (PPRT), the transport of hazardous materials, with routes of higher risk potential crossing the immediate study area—primarily at its periphery—and the presence of Class B and C dams, whose zone of influence covers municipalities at the northern and southwestern edges of the immediate study area, as well as three municipalities in the eastern part, though for a low risk (Class C).

Moderate issue

3.11.1.1 Risks of natural origin

Based on an analysis of the Departmental Major Risk Files (DDRM) for Meuse and Haute-Marne (91, 92), the natural hazards to which the project may be vulnerable are:

- flood risk (see Chapters 3.5.1.3 and 3.5.1.1 of this non-technical summary);
- landslide risks (including mining-related) and seismic risks (see Chapter 3.4.2 of this non-technical summary);
- climate-related risks (such as storms, tornadoes, cyclones, heat waves, extreme cold, or lightning) (see Chapter 3.2.1 of this non-technical summary).

The Meuse Departmental Major Risk Files (DDRM) is currently being updated to include the risk of forest fires.

3.11.1.2 Anthropogenic risks

Anthropogenic risks (related to human activity), to which the project may be vulnerable, identified following an analysis of the Departmental Major Risk Files (DDRM) for Meuse and Haute-Marne, are:

- nuclear risk;
- industrial risk;
- risks associated with the transport of hazardous materials;
- the risk of dam failure;
- the risk associated with the discovery of munitions.

No basic nuclear installations (BNIs) are identified in the close study area, let alone the immediate vicinity; the nearest is the Aube Disposal Facility (CSA), a storage facility for short-lived low- and intermediate-level waste (LILW-SL) managed by Andra, located approximately 70 km away. Air Base 113, located in Saint-Dizier, where nuclear weapons are stationed, is identified as potentially posing a nuclear risk.

No Seveso- Installations Classified for the Protection of the Environment (ICPE)—i.e., facilities posing the highest technological risks— nor any technological risk prevention plan (PPRT) zone associated with such facilities, are identified in the close study area, much less in the immediate study area or in the specific study area of the 400 kV Houdreville-Méry transmission line. Sixty-three non-Seveso ICPEs are identified in the immediate study area. The majority are located near the 027000 railway line.

Several municipalities in the close study area are affected by the risk of hazardous materials being transported by road or pipeline (natural gas transport):

- the roads posing a risk of hazardous materials being transported in the immediate study area are the departmental roads D60/960, D66, and the national highway N4. Railway line 027000 also crosses several roads at risk of hazardous materials transport, including national highways N135 and N4, as well as departmental roads D60 and D960;
- Four high-pressure natural gas pipelines are identified within the immediate study area.

Among the railway lines identified within the close study area, those identified in the DDRMs as having the highest potential for hazardous materials transport are lines 020000 (Haussignemont–Chaumont) and 070000 (Paris–Strasbourg)

Within the close study area, the following municipalities are affected by the presence of dams:

- ✓ Demange-Baudignécourt, Houdelaincourt, Saint-Joire, and Tronville-en-Barrois are affected by the presence of three Class C structures (the lowest risk class among the three existing dam classes);
- ✓ Joinville, Chevillon, Antigny-le-Grand, Antigny-le-Petit, Curel, Vecquevillen, and Thonnance-lès-Joinville are affected by three Class B dams.

The Meuse Departmental Major Risks Files (DDRM) (92) mentions the risk of discovering old munitions. Only three municipalities are affected by a low probability of discovering explosive devices: Demange-Baudignécourt along the old 027000 railway line, Montiers-sur-Saulx, and Stainville.

The Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET (103)) for the Grand Est region also identifies, within its scope, the challenge of preventing and reducing public exposure to risks and nuisances.

3.11.2 Vulnerability to major accidents and disasters, and assessment of the consequences of accidental situations on the environment and human health

Vulnerability to risks of major accidents and disasters (risks external to the Cigéo overall project), as well as accidental situations within the Cigéo overall project, due to their potential consequences on the environment and human health, primarily concern the Cigéo nuclear facility and the transport of hazardous substances or waste packages (by road or rail).

The risks associated with the power supply operation (for which the substation must be the subject of design studies), as well as with the water supply operation (whose facilities have not yet been defined), will be specified in an updated version of the environmental impact assessment.

3.11.2.1 Vulnerability to the risk of major accidents and disasters

Vulnerability is analysed with regard to risks external to the Cigéo overall project that could constitute external threats leading to accident scenarios. These risks are listed in the Departmental Major Risk Files for Meuse (2019) and Haute-Marne (2017) (91, 92) .

These include:

- risks of major accidents and disasters of natural origin, such as floods, ground movements (including mining-related), earthquakes, and weather events (storms, heat waves/extreme cold);
- risks of major accidents and disasters of anthropogenic origin, such as industrial, nuclear, dam, hazardous materials transport, and military equipment incidents.

Vulnerability to major accident or disaster risks is taken into account during the initial design phase through the implementation of design measures to control these risks.

In light of these risks, the main design provisions implemented to mitigate them are listed below:

- a impermeable protective structure against rising groundwater reinforces the protection of the disposal facility's surface nuclear installations. This system protects, in particular, the nuclear rail terminal and the EP1 above-ground nuclear building from rising groundwater;
- the design of the underground and surface facilities (orientation of the disposal cells excavated parallel to the direction of the major horizontal stress, geotechnical reconnaissance campaigns, adaptation of excavation methods for underground structures and construction methods for surface facilities, adaptation of building and structure foundations to the geotechnical context) helps limit their vulnerability to ground movement risks;
- the structures and equipment necessary to maintain safety functions and/or protection objectives are designed to withstand an earthquake;
- scientific knowledge indicates that an earthquake originating from one of the major nearby faults (Poissons, Gondrecourt, Vittel, Marnes, etc.) has no impact on the properties of the Callovian-Oxfordian;
- nuclear facilities are designed to operate continuously over a very wide range of temperatures, including temperature increases due to climate change;
- sensitive facilities are designed to withstand violent wind gusts and tornadoes, as well as impacts from projectiles generated by a tornado;
- structures and equipment that could be impacted by risks posed by transportation routes in terms of thermal effects and overpressure (tanker trucks carrying flammable products traveling on roads near the Cigéo disposal facility) are located sufficiently far from sources of danger and are specifically designed to withstand such risks.

3.11.2.2 Risks associated with the Cigéo BNI

Risk management in Basic Nuclear Installations (BNI) is a priority, based on the principle of defence in depth, which involves establishing multiple independent layers of defence, each capable of taking over after the failure of the previous one, in order to prevent the occurrence of an incident or accident and to limit its consequences for the population and the environment.

Thus, the creation of the BNI requires the completion of a risk management study, which is attached to the Creation Licence Application (DAC).

This study outlines the inventory of risks posed by the proposed facility, as well as an analysis of the measures taken to prevent these risks and the specific measures designed to limit the probability of accidents and their effects. Its content is commensurate with the significance of the hazards posed by the facility and their foreseeable effects, in the event of an accident, on public safety, health and healthiness or the protection of nature and the environment.

The methodology and study guidelines are based primarily on the regulations applicable to all BNIs, the fundamental safety rules (RFS), and the guidelines pertaining to BNIs.

The safety analysis is based on a risk analysis and an analysis of operating scenarios, enabling the identification of those scenarios the facility may face, their grouping according to likelihood, and verification that the technical and organisational measures ensuring their control allow for the protection of interests, that is, the protection of safety, public health and healthiness, as well as the protection of nature and the environment.

These situations cover normal operation and degraded operation, design-basis incidents and accidents, as well as more complex accident scenarios (extended design-basis scenarios) that may result from multiple cumulative events or extreme weather events (particularly based on lessons learnt from the Fukushima accident).

A summary of the risks and accident scenarios related to the construction and operation of the Cigéo disposal facility is presented in the risk management study (see "Document EPU7 – Risk Management Study for the Creation Licence Application of the Cigéo Basic Nuclear Installation (BNI) – For Information" (132).

The accident scenarios resulting from the risk analysis are primarily related to the dropping of radioactive waste packages, fires near waste packages, or situations linked to external hazards (e.g., earthquakes). These scenarios are:

- accident scenarios deemed plausible but which do not pose significant radiological impacts on public and the environment;
  - ✓ the fall of a primary package following a handling crane failure;
  - ✓ a fire involving a package transfer cart in the surface-ground nuclear building.
- accidental situations that are less plausible but would be the most severe in terms of maximum dose to public and the environment (severe accidental situations):
  - ✓ A fall of an open ILW-LL transport package during unloading at the surface-ground nuclear facility;
  - ✓ ignition of a package of bituminous waste inside a disposal package.

An estimate of the doses received by public and the environment is performed at various distances from the BNI's ramp and shaft zones, under the most unfavourable weather conditions and using conservative assumptions. To demonstrate the robustness of the safety approach, the estimate of doses received by the public and the environment is compared to the protection objectives set by Andra, which are based on the recommendations issued by the International Commission on Radiological Protection (ICRP) " ("Document EPU7 – Risk Management Study for the Application File for Authorisation to Establish the Cigéo Basic Nuclear Installation (BNI) – For Information" (132). In the event of an accident at the Cigéo BNI, the analysis of accident scenarios, even the most severe ones, shows that the protection objectives are not exceeded and that they do not lead to the need for public protection measures over time and space, such as sheltering.

3.11.2.3 Other risks associated with the Cigéo overall project

3.11.2.3.1 Risks associated with the transport of packages

Radioactive waste packages shipped to the Cigéo disposal facility are transported in shipping containers whose robustness and operational transport conditions (labelling, marking, number of packages per railcar/truck, etc.) are adapted to the risks associated with the radioactive substances they contain, in accordance with current regulations governing the transport of hazardous materials.

In the event of a transport accident, regardless of the type of accident (road or rail), the transport packaging for radioactive waste packages is designed and tested to withstand severe accident conditions (such as a drop from a height of nine metres onto a rigid surface).

A transport plan for radioactive waste packages is drawn up by the shipper (the producers) and specifies the route to be taken and the details of the journey (parking, accommodation, special conditions). Prefectures and gendarmerie (military police force) units are notified of the convoys' movements. Convoys are tracked in real time via geolocation, and any deviation from the transport plan triggers an alert.

Carriers have a Transport Emergency and Response Plan that enables them to respond to a transport incident or accident. To this end, a crisis management system is in place 24 hours a day, 7 days a week, which includes, among other things, alerting public authorities (fire department, emergency medical services, French Nuclear Safety and Radiation Protection Authority (ASNR), etc.) and providing them with the information necessary for their response. This crisis management system aims to limit the consequences and implement any measures necessary to protect the public.

In addition, public authorities define response plans in the event of an accident at the national and local levels. The ASNR assists the authorities responsible for rescue operations.

3.11.2.3.2 Risks associated with the transport, receipt, and distribution of fuels

The construction and operation of the Cigéo disposal facility require the use of fuels for vehicles, machinery, and combustion facilities.

The most feared accident involving the transport of hazardous materials is a leak from the fuel delivery truck, which has a capacity of about 15 m³, leading to fuel spilling onto the ground and the dispersion of fuel vapours into the air. In the presence of an ignition source, this leak could cause a fire (thermal effects) or an explosion (overpressure effects).

In the event of a spill, accidental pollution would be collected in the stormwater system and directed to a containment basin. Thus, accidental pollution on the site would not reach the environment or waterways.

In the event of a fuel fire, the thermal effects associated with flame radiation would be limited and would not be felt in buildings outside the site. The plume of toxic smoke would rise rapidly due to the temperature and disperse quickly at high altitude.

An explosion of fuel vapours would generate a blast that would propagate as an air pressure wave.

The thresholds for thermal effects and overpressure remain within the boundaries of the Cigéo disposal facility.

3.11.2.3.3 Risks associated with boiler rooms

The primary function of the boiler rooms is to treat the air (temperature and humidity) for the facilities at the Cigéo disposal facility. They also provide domestic hot water.

There are two boiler rooms at the Cigéo disposal facility, one located in the ramp zone and the other in the shaft zone. Each of these boiler rooms includes a main biomass boiler fuelled by wood chips and three auxiliary boilers fuelled by gas (Liquid Petroleum Gas - LPG) during the coldest periods.

The feared accident scenario during the transport and receipt of LPG is a leak from the delivery tank or a rupture of the unloading hose. In the presence of an ignition source, this leak could cause a flaming jet or the ignition in open air of a "cloud" of gas, producing thermal effects and overpressure effects. Furthermore, in the event of a sudden rupture of the tank, a violent, explosive vaporisation of the LPG contained in the tank may occur, also producing thermal effects and overpressure effects. Inside the boiler room, a leak in an LPG pipe or a failure in a boiler's LPG supply system can lead to the dispersion of flammable gas within the room. In the presence of an ignition source, this leak can cause a fire or an explosion in the room.

Thermal and overpressure effects diminish with distance. The comprehensive risk management measures in place ensure that the potential consequences of these accidental situations are controlled. No effects would be felt outside the Cigéo disposal facility.

The wood chips that will fuel the biomass boilers are combustible materials that, in the event of a fire, are likely to ignite and thus provide a fuel source. They are stored in an underground silo located inside the boiler rooms and equipped with firewalls. If, despite these preventive measures, a fire was to occur, the thermal effects would be very limited.

The thresholds for thermal effects and overpressure remain contained within the boundaries of the Cigéo disposal facility.

3.11.2.3.4 Risks associated with non-radioactive hazardous substances

Non-radioactive hazardous substances may be used at the Cigéo disposal facility. They will be delivered and stored in small or very small containers.

A feared accident scenario involves a leak from a container leading to the spillage of these substances onto the ground. In areas where flammable substances are stored or handled, in the presence of an ignition source, such a spill could cause a fire or even an explosion. Furthermore, in the event of simultaneous spills of incompatible substances, dangerous chemical reactions may occur (release of heat and/or harmful, even toxic, substances).

A set of risk control measures has been implemented, including the storage of hazardous substances in containment tanks, taking into account incompatibility rules and in suitable rooms.

The thresholds for thermal and overpressure effects remain within the boundaries of the Cigéo disposal facility.

3.11.2.3.5 Risks associated with electrical installations/premises

The feared accident scenarios related to the presence of these electrical installations are potential oil leaks at electrical substations, fires and the explosion of hydrogen released during the charging of batteries for material-handling equipment and electric vehicles.

Adherence to best practices in the design and operation of these installations helps control risks and limit the potential consequences of such accidents.

Oil leaks, thermal effects, and overpressure thresholds remain contained within the boundaries of the Cigéo disposal facility.

3.11.2.3.6 Risks associated with explosives that may be used for earthworks

Explosives may be used during the preliminary works phase for earthwork operations. The impacts in terms of overpressure depend on the quantities of explosives involved in accident scenarios. Compliance with regulations governing the use of explosives helps control risks and limit the potential consequences of an accident.

The thresholds for overpressure effects remain within the boundaries of the Cigéo disposal facility.

3.11.2.4 Impacts on existing natural hazards

The analysis of the impacts of the Cigéo overall project on natural hazards covers flood, landslide, and climate risks. This analysis is conducted in light of the design provisions implemented to prevent and reduce the aggravation of existing risks.

3.11.2.4.1 Impacts on flood risk due to rising groundwater levels

Avoiding sensitive areas or conducting earthwork operations involving excavation during periods of peak groundwater levels, along with the appropriate design of protective structures against rising groundwater and surface-underground connections (particularly waterproofing and drainage systems), as well as the implementation of a groundwater management system during earthwork operations, help limit the impacts that the construction of the Cigéo disposal facility may have on the groundwater table and thus on the risk of groundwater rise.

3.11.2.4.2 Impacts on the risk of flooding due to river overflow

Avoiding, to the extent possible, high-risk areas or carrying out work during periods of peak water levels (conducting work near temporary watercourses during dry periods), appropriate measures to limit impervious surfaces (and thus runoff) as well as the implementation of appropriate quantitative water management help limit a potential increase in the existing flood risk. The discharge rates of conventional wastewater will not be such as to significantly impact the hydrology of the receiving watercourses (the Bureau, Orge, and Ormançon rivers), given that discharges into the watercourses are determined by the seepage rates of the basins (up to a maximum of 3 L/s/ha for a 10-year rainfall event and 6 L/s/ha for a 100-year rainfall event). Furthermore, the Cigéo disposal facility has a seepage rate of only about 17% (seepage-controlled area at the end of initial construction relative to the total area of the potential impact zone).

Thus, the hydraulic modelling concludes that there will be no increase in flood risk during the Initial construction phase and during the operation period of the Cigéo disposal facility for the three watercourses concerned. The residual impacts of the Cigéo disposal facility on water storage capacity in flood-prone areas and on downstream flood risk are low.

3.11.2.4.3 Impacts on the risk of ground movement

The phased deployment of the disposal facility helps avoid the risk of settlement resulting from the collapse of cavities following the construction of the tunnels, which could affect the layers above. The methods used for excavating underground structures and constructing surface facilities are adapted to the local context, based on geotechnical surveys. These measures help limit the impacts that the construction of the Cigéo disposal facility may have on the risks of clay swelling and shrinkage, cavities, and settlement.

3.11.2.4.4 Impacts on the climate risk

The Cigéo overall project, which is located in a sparsely urbanised rural environment, could have impacts on local weather conditions through changes in temperature (heat emissions), wind (obstruction of wind flow), ambient humidity (vapor release), and local sunlight. However, given the reduction measures presented in the section on atmospheric conditions, the potential impacts of the Cigéo overall project on weather conditions and associated risks are very low. Finally, the water recycling systems planned for the ramp zone and shaft zone of the Cigéo disposal facility help mitigate the risk of drought. Based on these factors, the Cigéo overall project does not exacerbate existing climate risks, particularly those related to heavy rainfall (which could cause flooding).

3.11.2.5 Compatibility with planning documents

The activities and facilities of the Cigéo overall project and the work to secure the 400 kV transmission line are compatible with the PGRI for the Seine-Normandy basin. The work to secure the 400 kV transmission line (eastern section starting from Gondrecourt-le-Château) is compatible with the PGRI for the Rhine-Meuse basin (133).

The Cigéo overall project is consistent with the requirements of the PPRIs relevant to the various operations.

The consideration of risks and the vulnerability of the Cigéo overall project to major accidents and disasters is consistent with the objectives, rules, and supporting measures of the SRADDET (103).

Transportation infrastructure

» SOURCES AND METHODOLOGY

Road traffic: A road traffic model—for the Cigéo disposal facility—was developed by CEREMA in 2021 (Center for Studies and Expertise on Risks, the Environment, Mobility, and Planning). For operations by other project owners, estimates were made based on the planned earthworks.

3.11.3 Initial state

Environmental issues

The immediate study area is located in a region far from major transportation infrastructure. The departmental road network provides access to the immediate study area in connection with the national highway network; however, public transportation service remains very limited, leading to the widespread predominance of car use for daily travel. Regional rail service exists but does not provide direct service to the area.

The immediate study area is crossed by a former railway line between Gondrecourt-le-Château and Joinville and the 027000 railway line, which is no longer in use, as well as by the D60/960 departmental road, which has low traffic volume.

Moderate issue

The Cigéo overall project is located far from major transportation infrastructure, as shown on the figure 3-58 . The nearest airport and train station are more than 50 km away. The 400 kV Houdreville-Mery transmission line crosses various infrastructure along its 124 km route: roads, railways, and canals.

3.11.3.1 The rail network

Several rail transport infrastructures are included in the close study area. Among them, some are included in the immediate study area because they are part of the Cigéo overall project. These are:

- 027000 rail line, which historically connected Gondrecourt-le-Château to Nançois-Tronville. The section between Gondrecourt-le-Château and Ligny-en-Barrois has been closed to rail traffic since 2014. As of now, no trains run on the 027000 rail line;
- south of the 027000 railway line, in Gondrecourt-le-Château, there is a logistics hub, followed by a former connected terminal (ITE) that has been decommissioned for several decades.

3.11.3.2 The road network and paths

The road infrastructure network in the close study area consists of the following major routes: National Route N 67 (Saint-Dizier – Chaumont), National Route N4 (Paris – Strasbourg), the A31 highway to the east, which connects the French-Luxembourg border to Beaune from north to south, and Departmental Route D60 (Haute-Marne), extended by Departmental Route D960 (Meuse). Departmental Road D60/960, part of which lies within the immediate study area, connects Joinville to Houdelaincourt from west to east via the Cigéo disposal facility; this route constitutes another link to the main transportation network. It is classified as a high-traffic road and a preferred route for special-purpose transport. It carries an average of 800 vehicles per day. Also included are the D966 departmental road, followed by the D127 departmental road, which connect the site selected for the Cigéo disposal facility to the major transportation routes.

The close study area also includes numerous smaller-scale road infrastructure elements such as rural roads and paths, as well as farm roads.

Public transportation options are relatively limited. Only one bus line is included in the immediate study area: it follows the Ornain Valley from Bar-le-Duc to Gondrecourt-le-Château.

The immediate study area does not include any infrastructure for non-motorised transportation (bicycles, scooters, rollerblades, etc.). Hiking trails are presented in the “3.13.3” chapter of this non-technical summary.

3.11.3.3 The river network

Three canals are identified within the close study area: the Marne-Rhine Canal to the west and the Meuse Canal to the north, as well as the canal between Champagne and Burgundy to the west. These three canals are primarily used for recreational boating. Only the Marne-Rhine Canal crosses the immediate area.

3.11.3.4 The aviation network

There are two civilian airfields within the close study area: the Joinville-Mussey airfield, 20 km southwest of Bure, and the Neufchâteau airfield, 30 km southeast of Bure. They are used for recreational and tourism activities.

Several aviation infrastructure facilities are located in the extended study area, including the 113th Air Base in Saint-Dizier (37 km northwest of Bure), which is subject to an external aviation easement for clearance zones (T7), the constraints of which may apply to facilities of the Cigéo overall project within the relevant portion to the west of the immediate study area.

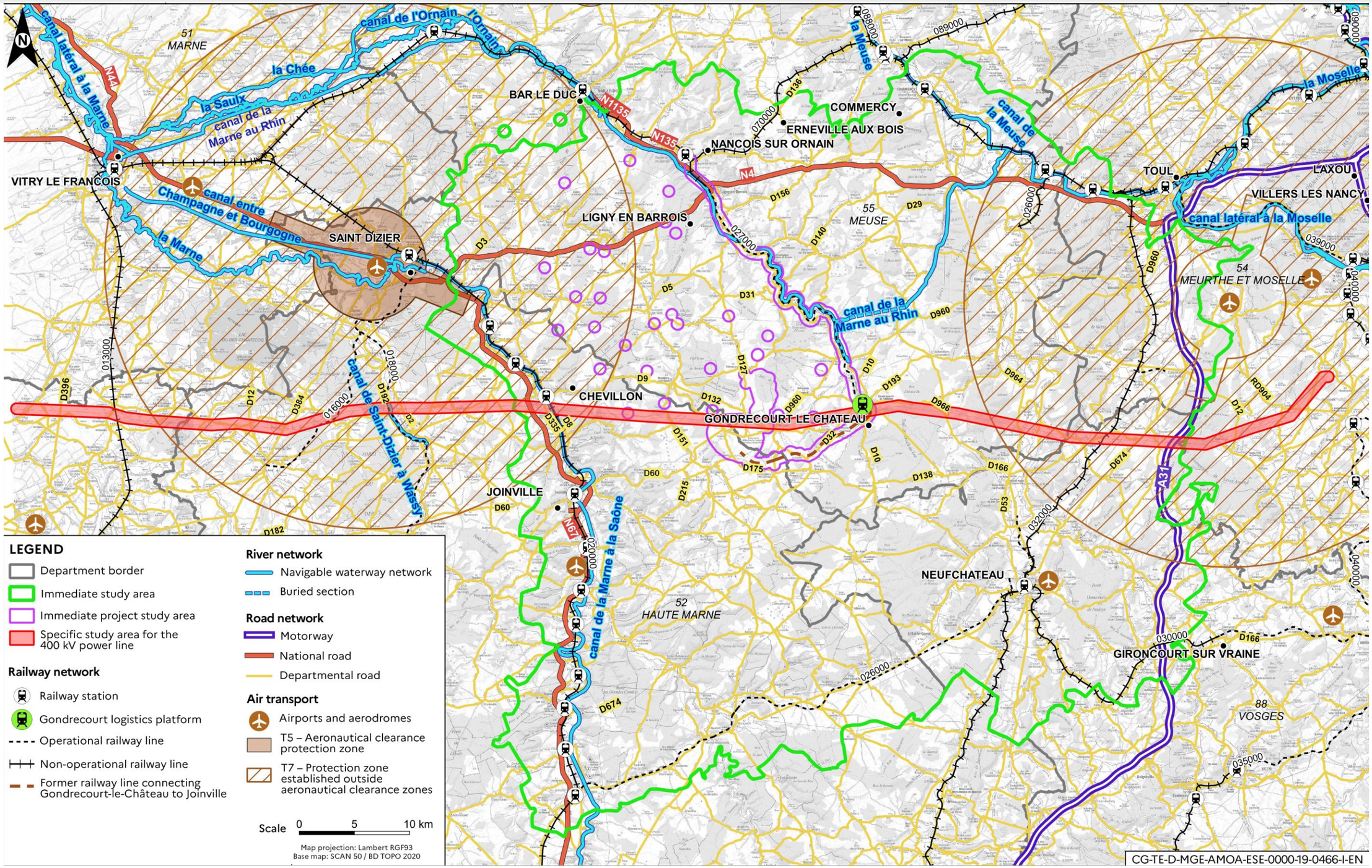


Figure 3-58 *Key transportation infrastructure within the close study area and the specific study area for the 400 kV transmission line*

3.11.4 Impacts and measures related to transportation infrastructure and traffic

3.11.4.1 The rail network

3.11.4.1.1 Rail network infrastructure

Early planning regarding the location of the various components of the Cigéo overall project, as well as the reuse of existing railway infrastructure, has made it possible to avoid impacts on the railway network.

The Cigéo overall project does not result in any physical disruption of existing railway infrastructure.

Rail infrastructure reuses, as much as possible, the footprint of former disused infrastructure (for the connected terminal, including the Gondrecourt-le-Château logistics hub) or infrastructure that is no longer in service (for the 027000 railway line). Only a 4-km section of the connected terminal is built between Cirfontaines-en-Ornois and the ramp zone.

Regarding the 027000railway line, decisions regarding level crossings will be finalised following the preliminary consultation on the line's revamping project, to be conducted in 2021, with SNCF Réseau as the project owner. The modernisation work on the level crossings and their potential areas of intervention will be specified at a later date depending on the solution selected, which will be the subject of further studies and an update to this impact assessment.

The very low level of impact on the railway network's infrastructure does not require the implementation of specific reduction measures.

3.11.4.1.2 Rail traffic

The work to connect the connected terminal and 027000 rail line to the national rail network will have a limited temporary impact in terms of service interruptions on the line, to ensure that the actual connection work is not performed "while trains are running."

Whether during the Initial construction phase, during which traffic is estimated at eight train passes per day (six for the Cigéo disposal facility and two for potential uses such as grain transport by the SNCF), or during the operation period, when the maximum average traffic would be six trains per month (shipments of radioactive waste), the rail traffic generated by the Cigéo overall project is not likely to have a significant impact on local rail traffic, much less on a national scale.

The very low level of impact on rail traffic does not require the implementation of specific reduction measures (nor offsetting measures).

The Cigéo overall project has a very low residual impact on the rail network and its traffic.

3.11.4.2 The road network

3.11.4.2.1 The road network and paths

Work on the Cigéo overall project will result in modifications to the existing road network starting from the preliminary works phase due to the intersection of existing road infrastructure and the construction of new infrastructure as part of the Cigéo overall project.

Major roadways (highways, national roads) are avoided. To prevent the disruption of new roadways, the new railway infrastructure reuses the footprint of former railway infrastructure as much as possible.

The potential project areas of the Cigéo overall project intersect with several types of roads: county roads (notably Departemental Road D60/960), rural roads, and farm roads.

To minimise disruption to vehicle traffic in the area and to the operation of agricultural and forest plots located on either side of the infrastructure, interrupted roads are restored "in situ" (at the same location as the existing structure) *via* grade-separated crossings (rail bridge or road bridge) or at-grade crossings (level crossings), or by diverting traffic to nearby roads equipped with a crossing structure. More specifically, the D60/960 departmental road is restored via a deviation, maintaining its current functionality, service level, and safety standards. Traffic on the departmental road is not interrupted thanks to the prior opening of the deviation before the closure of the section of the departmental road located within the potential work zone of the ramp zone. Two options for this deviation are currently being studied by the Haute-Marne Departmental Council. Following public participation in the project's development, the selected solution will be further refined through technical and environmental studies.

The implementation of these reduction measures allows for the restoration of the affected roadways, ensuring that existing access points remain unchanged. Only a few routes are modified in specific locations (notably the deviation of the D60/960 departmental road). Thus, the residual impact of the Cigéo overall project on the road network is minor and permanent.

The Cigéo overall project has a minor residual impact on the road network and trails

3.11.4.2.2 Road traffic and traffic conditions

The construction periods (preliminary works and initial construction) and the operation of the disposal facility, and to a lesser extent other operations of the Cigéo overall project, generate road traffic involving both light and heavy-duty vehicles.

Reduction measures are implemented to limit the impact on traffic. An on-site connection is created so that the necessary vehicle traffic between the shaft and ramp zones of the Cigéo disposal facility does not use public roads. Regarding the transport of radioactive waste packages, the producers are studying the methods for transporting the waste packages, but delivery by rail is preferred to reduce risks, impacts, and nuisances. Delivery by truck is possible but must be justified and limited. Details of the measures are presented in Chapter 12 of Volume IV of this impact assessment.

The traffic impacts of the Cigéo overall project, after accounting for traffic diversion measures, are assessed using traffic models for the Cigéo disposal facility and preliminary estimates of the number of heavy-duty vehicles required for other operations. The impact of the Cigéo disposal facility on the major transportation network (A31 highway, N4 and N67 national roads) is minimal. The overall increase in total vehicle volume does not exceed 10%, and the traffic mix (passenger car/heavy vehicle ratio) will change little, even on National Route N67, which will nevertheless carry a significant portion of the traffic generated by the shaft and ramp zones. The county roads providing access to the Cigéo overall project from the region's major transportation corridors are also currently capable of handling the resulting increases in traffic. During the preliminary works phase, work on the power supply, upgrading of the 027000 railway line, deviation of the D60/960 departmental road, and water supply infrastructure is expected, according to initial estimates, to have a relatively limited impact on traffic. In terms of traffic congestion, no new bottlenecks are expected to arise with the implementation of the Cigéo overall project.

The Cigéo overall project has no significant impact on public transportation and non-motorised modes of transport.

The expected traffic from special-purpose convoys related to the Cigéo disposal facility is estimated, during peak traffic years, at approximately 20 and 30 convoys per year, respectively during the construction and operational phases. The number of special-purpose convoys related to other operations of the Cigéo overall project will be specified in subsequent versions of the environmental impact assessment.

The Cigéo overall project will result in a significant increase in road traffic passing through certain towns near the project site (notably Bure, Saudron, Mandres-en-Barrois, Houdelaincourt, and Mauvages), raising safety concerns for road users (drivers, cyclists, and pedestrians).

From a traffic perspective, the impact of the Cigéo overall project on the D60/960 departmental road is very low, limited to a very marginal increase in travel time given the length of the planned detour, which is a few kilometres longer than the current departmental road.

To reduce road traffic levels, companies are encouraged to use rail for freight transport. Furthermore, Andra is studying access for light and heavy-duty vehicles to the entrances and exits of the shaft and ramp zones to prevent traffic queues from backing up on the D60/960 departmental road and thus the associated risks of congestion.

Regarding road safety, Andra, the State, and the relevant public authorities will verify the capacity of existing infrastructure to accommodate increased traffic and the passage of oversized convoys, while ensuring the safety of residents, motorists, and other road users.

After implementing reduction measures, the residual impact on road traffic, traffic conditions, and road safety will be minor, direct, and permanent. Therefore, no offsetting measures are proposed.

The Cigéo overall project generates an increase in traffic but has a minor residual impact in terms of congestion and road safety.

Since not all operations of the Cigéo overall project are at the same stage of development, additional information will be provided in subsequent versions of the impact assessment regarding the impacts and measures affecting the road network and its traffic.

3.11.4.3 Waterway network and traffic

Due to its location and characteristics, the Cigéo overall project has no impact on the river network. Indeed, it does not cause any disruption or modification of existing river infrastructure and does not involve the creation of new river infrastructure.

Rail freight is prioritised to avoid transshipment. The use of waterways for freight is limited to a few occasional shipments (such as specific parts for the 400/90 kV substation). Thus, the impact on river traffic and navigation conditions is very low.

The Cigéo overall project has a very low residual impact on river traffic

3.11.4.4 The airport network and its traffic

Due to its location and characteristics, the Cigéo overall project has no impact on the airport network. Indeed, it does not cause any disruption or modification of existing airport infrastructure and does not involve the creation of new airport infrastructure.

The use of air transport for freight is not envisaged within the scope of the project. The construction and operation of the Cigéo overall project may, to a very marginal extent, result in some passenger travel by air, but air traffic is not altered as a result.

Thus, the impact of the Cigéo overall project on airport traffic is indirect, permanent, and very low.

Given the low level of impact, no reduction measures are proposed. The residual impact is very low.

The Cigéo overall project has a very low residual impact on airport traffic.

3.11.5 Compatibility of the Cigéo overall project with plans, schemes, and programs related to transport infrastructure

The Regional Transport Infrastructure Plan is integrated into the Grand Est Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) (103). The SRADDET sets out three objectives related to transportation: developing intermodality and new forms of mobility; optimising traffic flows and becoming a leader in multimodal logistics; and modernising all modes of transportation infrastructure to improve regional connectivity.

The Grand Est State-Region Planning Contract (CPER) (134) encourages the continued improvement, renovation, reliability enhancement, and modernisation of transport infrastructure (road, rail, and waterway).

The immediate study area is not subject to an Urban Transportation Plan (PDU) or a Local Transportation Plan (PLD).

The Cigéo overall project has no major impact on the main road network; it is designed to limit the impact of heavy-duty vehicle traffic and to promote a shift towards rail transport. The revamping of the 027000 railway line contributes to the renovation of the national rail network.

Thus, the development and rehabilitation of transportation infrastructure within the framework of the Cigéo overall project are consistent with the objectives and regulations of the SRADDET.

The Cigéo overall project is also consistent with the guidelines of the 2021–2027 Lorraine State-Region Planning Contract (CPER) (135).

The site of the Cigéo overall project is not subject to an Urban Mobility Plan (PDU) or a local mobility plan. Therefore, no compatibility analysis with these documents is necessary.

3.11.6 The foreseeable consequences of the Cigéo overall project's infrastructure on potential urban development

Transport infrastructure can have several types of potential impacts on urbanisation:

- a direct impact through changes in land use due to its footprint;
- an indirect impact by facilitating access to areas that may then be opened up to urbanisation (induced urban development).

The direct land use for the construction of transportation infrastructure (4 km of connected terminal, terminal, rail freight terminal, nuclear freight terminal, inter-site link, D60/960 departmental road deviation, and road realignments) is examined in the chapters 3.3 (land), 3.6 (natural environment), and 3.8 (agricultural/forestry) of this non-technical summary.

The infrastructure dedicated to the operation of the Cigéo disposal facility, which is not open to the public (connected terminal, rail freight terminal, nuclear freight terminal, and private infrastructure for the inter-site link), along with the 027000rail line, is intended for the transport of radioactive waste and packages. Occasional grain train traffic may occur on the 027000 railway line. This infrastructure is not likely to lead to increased urbanisation.

With regard to the infrastructure open to the public included in the Cigéo overall project:

- road restoration works are not likely to induce any urbanisation; their sole purpose is to restore the roads intercepted by the project;
- the public road included in the inter-site link, given its purpose (access to the shaft zone and service to agricultural plots) and its location, is not likely to cause a significant change in urbanisation;

- Depending on the route selected for the D60/960 departmental road deviation, it is possible that the land enclosed between the deviation and the existing urban area (the village of Saudron or the Cigéo disposal facility) may lose its agricultural value. This is particularly the case for the nearby route variant that passes north of the ramp zone, but also, to a lesser extent, for the longer northern route option. However, the opening of these areas to urban development, should it occur, would be linked to the attractiveness of the Cigéo disposal facility (creation of housing or a business park) and not solely to the deviation itself. Nevertheless, this expansion of urban development onto agricultural and natural plots is not currently provided for under the current urban planning documents.

No avoidance measures are proposed, as these infrastructure projects are essential.

The expansion of urbanisation may not exceed the areas designated for this purpose in the urban planning documents. Any potential additional expansion will be subject to a prior update of the current urban planning documents. For the record, the harmonisation of urban planning documents formalised by the declaration of public interest for the Cigéo disposal facility has no bearing on this analysis, insofar as it does not expand the areas to be developed but rather adapts zoning classifications and regulations to permit only the construction of the Cigéo disposal facility's structures (notably its transport infrastructure: inter-site link and connected terminal).

For municipalities with an urban planning document, unless the municipalities open new areas for development, the infrastructure of the Cigéo overall project has a very limited impact on development. For municipalities without urban planning documents, and therefore subject to national urban planning regulations, the principle of limited buildability applies: given the absence of urbanised areas in the immediate vicinity of the infrastructure being created, there will be no urban development in these sectors. The residual impact is therefore very low. As such, no compensatory measures are proposed.

The Cigéo overall project has a very low residual impact on potential urban development.

3.11.7 Ecological issues and potential risks associated with land use, agricultural, and forestry developments related to transportation infrastructure

For the inter-site link and the -connected terminal, located primarily in agricultural areas, Andra has carried out land-use arrangements by mutual agreement using agricultural land reserves established by the Safer and Andra, on plots that remain in operation under short-term leases until they are transferred. The ecological impacts are therefore low to very low; they primarily concern the functionality of corridors through the maintenance, and if possible the enhancement, of the green (hedges, etc.) and, where applicable, blue belt networks. The few forested plots involved are accounted for as part of the forest compensation program. For this offsetting, Andra wishes to prioritise silvicultural improvement work on degraded plots and promote the development of biodiversity.

Since the characteristics of the D60/960 departmental road deviation are not currently known, potential land readjustment operations will be specified once the selected route is defined, following public participation. The various options under consideration primarily concern agricultural parcels. By applying the approach already initiated by Andra—involving amicable land exchanges of agricultural parcels currently in use—the ecological stakes are low for agricultural land readjustments, as are the ecological risks.

For railway line 027000, there are no or very few planned land readjustments—agricultural or forestry—as little work is required outside the railway footprint, with the exception of potential modifications to engineering structures, which will be defined following public participation in the project's development. The impacts are very low in quantitative terms, and applying the same approach as Andra, the risks are very low.

For the Cigéo overall project, the ecological impacts and risks associated with land, agricultural, and forestry developments are low.

3.11.8 An assessment of the energy consumption resulting from the project's operation, particularly due to the travel it generates or helps to avoid

SOURCES AND METHODOLOGY

Three assessments of **energy consumption** were conducted, each comparing two scenarios:

- a first assessment is based on the difference between a scenario in which the Cigéo overall project is implemented, along with the transportation infrastructure program selected to support the Cigéo disposal facility (see the description of this program in Volume II of this impact assessment), and a scenario in which the Cigéo overall project is not implemented;
- a second assessment is based on the difference between a scenario in which the Cigéo overall project is implemented, but in which new infrastructure is limited by reusing existing transport infrastructure as much as possible, and the scenario in which the Cigéo overall project is not implemented;
- A third assessment is conducted by comparing two scenarios in which the Cigéo disposal facility is implemented:
  - ✓ in one case, the selected transportation infrastructure program is implemented;
  - ✓ in the other case, this program is not implemented, and the required infrastructure is limited by reusing existing transport infrastructure as much as possible.

Implementing the transportation infrastructure program planned in the Cigéo overall project makes it possible to limit the energy consumption resulting from the operation of this infrastructure, thanks to a reorganisation of travel patterns.

The resulting energy savings are estimated at approximately 12,000 tons of oil equivalent, from the Initial construction phase through to the decommissioning of the Cigéo disposal facility.

This infrastructure program, which takes into account the successive consultations with local stakeholders, reduces expected energy consumption by more than 20% compared to what would be required if existing transportation infrastructure were used to its fullest capacity to handle the traffic generated by the Cigéo disposal facility (both in its immediate vicinity and between the facility and the rest of France).

This reduction stems primarily from the modal shift from road transport to rail for the transport of construction materials, equipment, and radioactive waste. This modal shift is made possible by revamping the 027000 railway line between Nançois-sur-Ornain and Gondrecourt-le-Château and constructing a connected terminal (ITE) into the ramp zone of the Cigéo disposal facility.

3.11.9 The collective costs of pollution and nuisances and the resulting benefits for the community

3.11.9.1 The collective costs of pollution and nuisances

The implementation of the transportation infrastructure program included in the Cigéo overall project serves to limit the collective costs of pollution and nuisances generated by the operation of these infrastructures.

The collective costs in question are those for which monetisation methods are currently available in France: air pollution, greenhouse gas emissions, noise, transport safety (accidents), and traffic congestion.

The estimated societal costs avoided thanks to the selected infrastructure program amount to 3.5 million euros, from the preliminary work priod through to the decommissioning of the Cigéo disposal facility. The program thus reduces societal costs by 10% (15% for external environmental costs alone) compared to what would have been observed if existing transportation infrastructure had been used to its fullest extent.

3.11.9.2 The monetised socio-economic analysis (or cost-benefit analysis)

The monetised socio-economic analysis of a transportation project assesses its value to the community by expressing, in monetary terms, the benefits it provides (time savings for motorists, reduced vehicle operating costs, fewer traffic accidents, reduction in environmental impacts) and then comparing them to its costs (initial infrastructure investment, infrastructure maintenance costs). It takes into account all stakeholders, public or private, who are directly or indirectly affected by the project.

For the transportation infrastructure selected for the Cigéo overall project, the cumulative net benefits (benefits minus costs) amount to 42.5 million euros $_{2018}$. The benefits generated are therefore, overall, greater than the total costs: the project appears to be beneficial to the community. Sensitivity tests confirm this result.

This favourable result stems from a combination of two factors:

- the modal shift towards rail enabled by the direct rail service to the Cigéo disposal facility, itself made possible by the revamping of the 027000 rail line and the construction of the connected terminal (ITE);
- the reduction in average distances traveled by motor vehicles in the vicinity of the Cigéo disposal facility.

The primary benefit stems from the reduction in heavy-duty vehicle traffic or special road convoys resulting from the modal shift. The second significant benefit is the time saved by motorists due to the construction of the D60/960 departmental road deviation and the development of the inter-site link. Another notable benefit is the reduction in greenhouse gas emissions (CO_2).

The transportation infrastructure selected for the Cigéo overall project is therefore beneficial to the community from a socio-economic perspective.

3.12 The living environment

PUBLIC ACCESS BUILDING

Under French law, **a public access facility (ERP)** refers to public or private venues that welcome customers or users other than employees (salaried workers or civil servants), who are themselves protected by occupational health and safety regulations.

This includes a very large number of establishments such as movie theaters, theaters, libraries, schools, universities, hotels, restaurants, hospitals, train stations, and various places of worship, whether they are permanent or temporary structures (marquees, inflatable structures).

3.12.1 Initial state

Envronmental issues

The immediate study area is primarily located in a rural zone, subject to little pollution, in a quiet to moderately quiet area. The lighting from the Andra Center in Meuse/Haute-Marne (CMHM) and the town of Ligny-en-Barrois stands out from other sources of light pollution. Population density is low, and a few sensitive facilities (excluding the Cigéo disposal facility area) or public access buildings (ERP) are identified within the immediate study area.

Moderate issue

The villages closest to the Cigéo disposal facility are Saudron (less than 200 metres from the ramp zone), Bure (approximately 2 km from the shaft and ramp zones), Gillaumé (approximately 1 km from the ramp zone), Gondrecourt-le-Château (crossed by the connected terminal), Horville-en-Ornois (a few hundred metres from the connected terminal), Cirfontaines-en-Ornois (1 km from the connected terminal), Chassey-Beaupré (approximately 1.5 km from the connected terminal), Ribeaucourt (approximately 1.5 km), and Mandres-en-Barrois (approximately 2 km from the ramp zone). The 027000 railway line passes through the built-up areas of various municipalities.

A few sensitive establishments or public-access facilities (ERP) are identified within the immediate study area. The closest sensitive establishments are the Échenay school, southeast of the access tunnel area, and the Houdelaincourt school, along the 027000 railway line, both of which are outside the immediate study area. The public access facilities closest to the Cigéo disposal facility are the Hôtel-restaurant du Bindeuil, the bakery, the EDF archives, and the existing Andra facilities (public reception building, eco-center, and technology center) in Bure.

Most of the immediate study area is located in a rural zone, subject to few nuisances.

In the southern part of the immediate study area, traffic (particularly on the D60/960 departmental road) and agricultural activities are the main sources of noise and vibrations. Light emissions from the Andra Center in Meuse/Haute-Marne (CMHM) differ from other sources of light pollution in the study area, which consist mainly of public lighting in the villages. The 400 kV Houdreville-Méry transmission line is the main source of electric and magnetic field emissions.

The northern part of the immediate study area (the Ornain Valley, through which the 027000 railway line runs, which has had no traffic since 2019) and particularly the Ligny-en-Barrois sector, experiences slightly more disturbances due to its more urban character. High-voltage power lines, which are sources of electric and magnetic fields, are also present. Ligny-en-Barrois, the largest town in the immediate study area, stands out from other sources of light pollution.

The red safety-lights at the top of the wind turbine towers near the immediate study area are also visible.

The 400 kV Houdreville-Méry transmission line is located primarily in rural agricultural areas with sparse development. The main sources of noise are therefore agricultural machinery, as well as vehicles traveling on the various roads crossed by the 400 kV transmission line. The areas surrounding the Houdreville-Méry power line can generally be considered to have moderate background noise levels. No significant external sources of vibration have been identified.

Public access facilities, healthcare facilities (vulnerable population), buildings, and areas designated for residential development are mapped on the figure 3-59 and the figure 3-60).

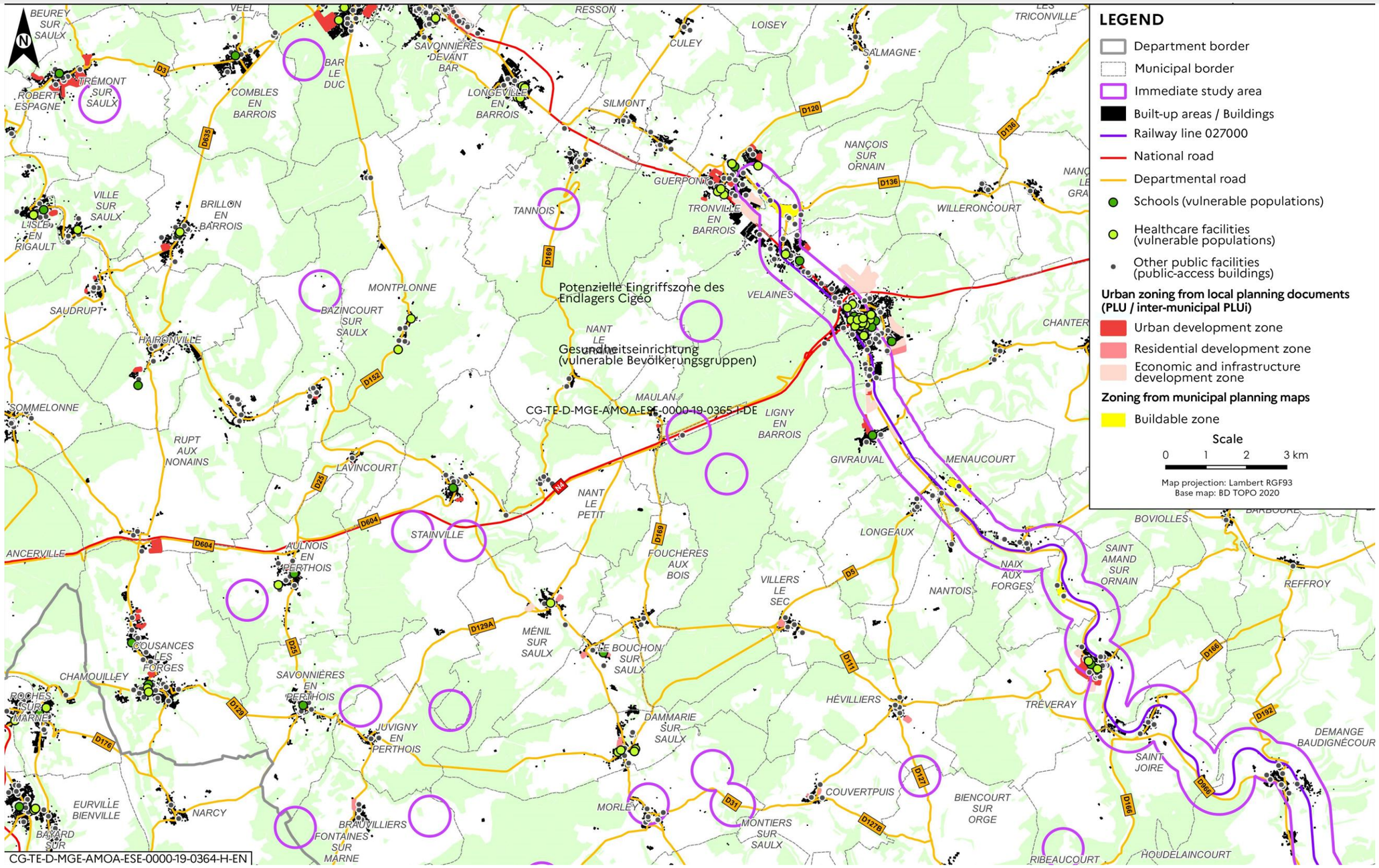


Figure 3-59 *Public access facilities, vulnerable populations, buildings, and areas designated for housing development in the northern part of the immediate study area.*

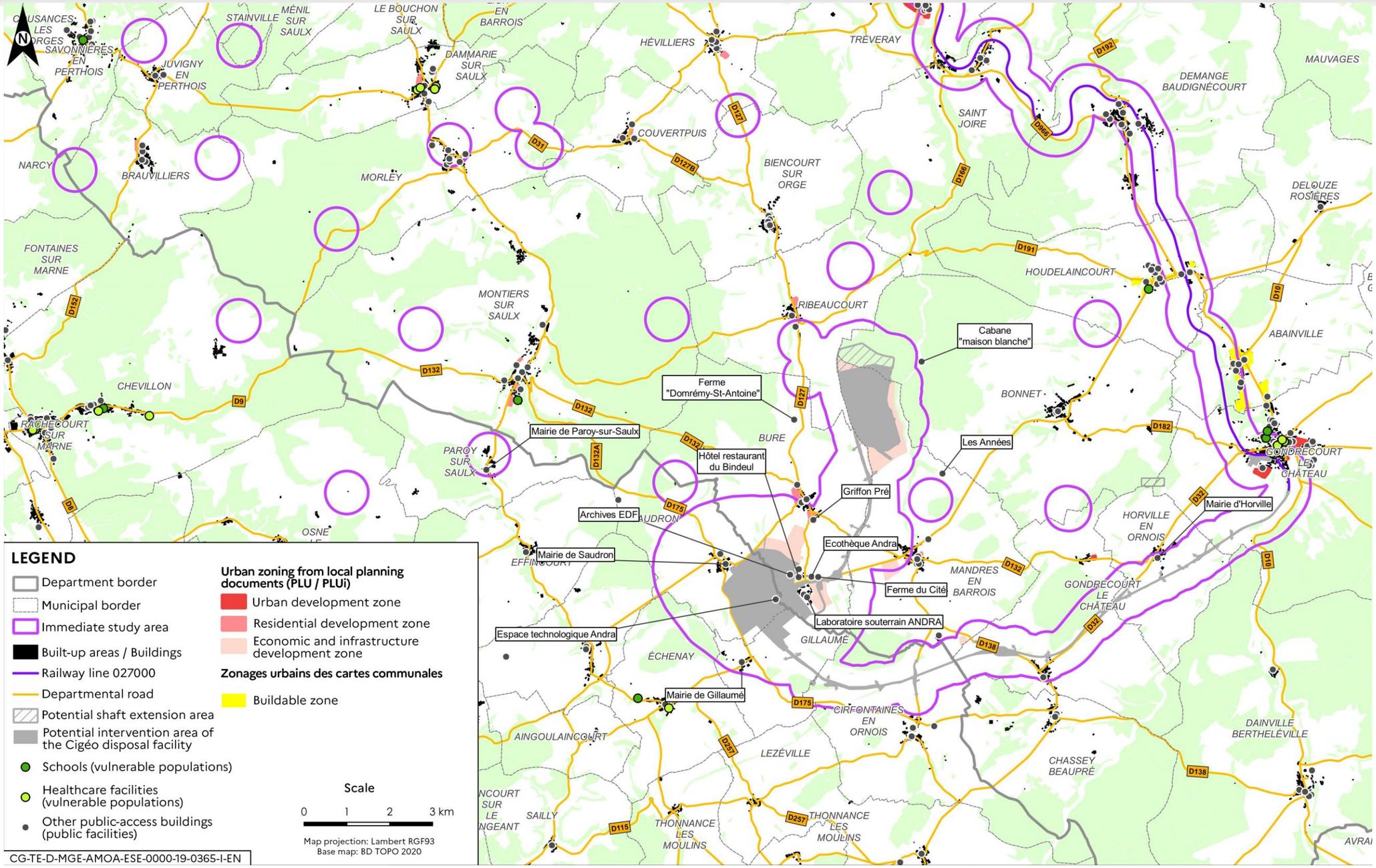


Figure 3-60 *Public access facilities, vulnerable populations, built-up areas, and areas designated for development for housing units identified in the southern part of the immediate study area.*

3.12.2 Impacts and associated measures

3.12.2.1 Noise impacts and associated measurements

Operations related to the Cigéo overall project, and in particular the Cigéo disposal facility, are sources of noise pollution.

Reduction measures are implemented: the Cigéo overall project has been located away from urban areas; trains will operate only during the day (6 a.m. – 10 p.m.), with very few exceptions; and a conveyor system is installed to connect the connected terminal (ITE) to the freight terminal in the shaft zone to avoid road traffic.

3.12.2.1.1 The preliminary construction phase

During the preliminary works phase, the main sources of noise are construction machinery and vehicles used for various operations. Noise pollution is limited as much as possible.

The areas causing the most significant noise pollution are the shaft and ramp zones of the Cigéo disposal facility, due to the duration and scale of the work. Since the shaft zone is far from residential areas, it is the ramp zone that has the greatest impact on nearby residential areas (Bure, Saudron, Gillaumé, and the Hôtel du Bindeuil).

For the other operations of the Cigéo overall project—power supply, the deviation of the D60/960 departmental road, the revamping of the 027000 railway line, and the water supply—the number of construction vehicles is much lower and the durations are much shorter (the anticipated duration of work ranges from 1 to 3 years). Only a few pieces of equipment are used simultaneously on these sites. They move along the section under construction as each specific project for these facilities progresses.

Various noise reduction measures are implemented: suspension of work likely to disturb the neighbourhood between 10 p.m. and 7 a.m. (in the event that night work is necessary, exemptions will be requested in accordance with local regulations), site organisation, use of “lynx cry” type warning devices, use of quieter construction equipment, acoustic protection for the 400/90 kV substation, noise restrictions in certain areas of the site, and a semi-buried conveyor on the inter-site link. In addition, a perimeter embankment is constructed southwest of the ramp zone east of Saudron, and a noise barrier is built near the Hôtel du Bindeuil.

After implementing these measures, the expected noise levels during this phase remain within ambient noise levels but higher than at present. The disturbances are limited to daytime hours, as no nighttime activity is planned. The residual impacts are therefore moderate.

After these measures are implemented, the expected noise levels during this phase will remain within ambient noise levels but will be higher than current levels. The residual impacts are therefore moderate.

The residual acoustic impacts of the Cigéo overall project during the preliminary works phase are moderate.

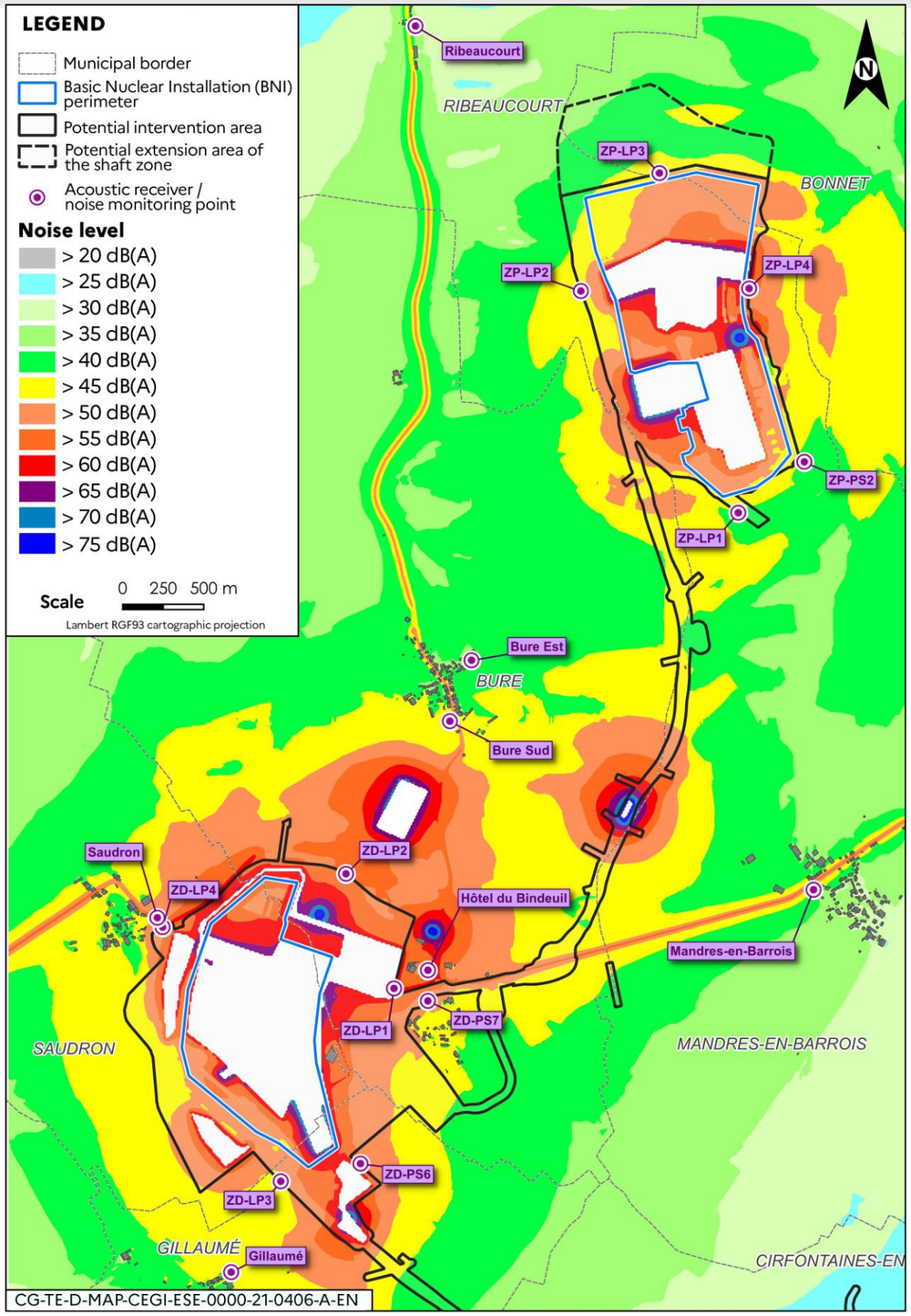


Figure 3-61 Noise Map – Preliminary Development – All Sources (Daytime)

3.12.2.1.2 The initial construction phase

During the initial construction phase, the inter-site link, the connected terminal, railway line 027000, departmental road D60/960, and power supply operations—including the 400/90 kV substation—are in operation. Their noise levels are below regulatory thresholds.

The 400 kV Houdreville-Méry transmission line does not generate any additional noise pollution compared to the initial state. Freight traffic is low on the national rail network, so the acoustic impact of this operation is low.

Work in the shaft zone and the ramp zone remains the primary source of noise pollution.

Various noise reduction measures, already implemented during the preliminary works phase, will be maintained. An acoustic barrier near the Hôtel du Bindeuil and another extending from the embankment previously described have been modelled. However, the technical solutions selected to limit noise pollution in certain construction zones, particularly the noisiest ones or those closest to residential areas, will be refined by the contractors at the time of the detailed definition of work methodologies. Details of the measures are presented in Chapter 13 of Volume IV of this impact assessment.

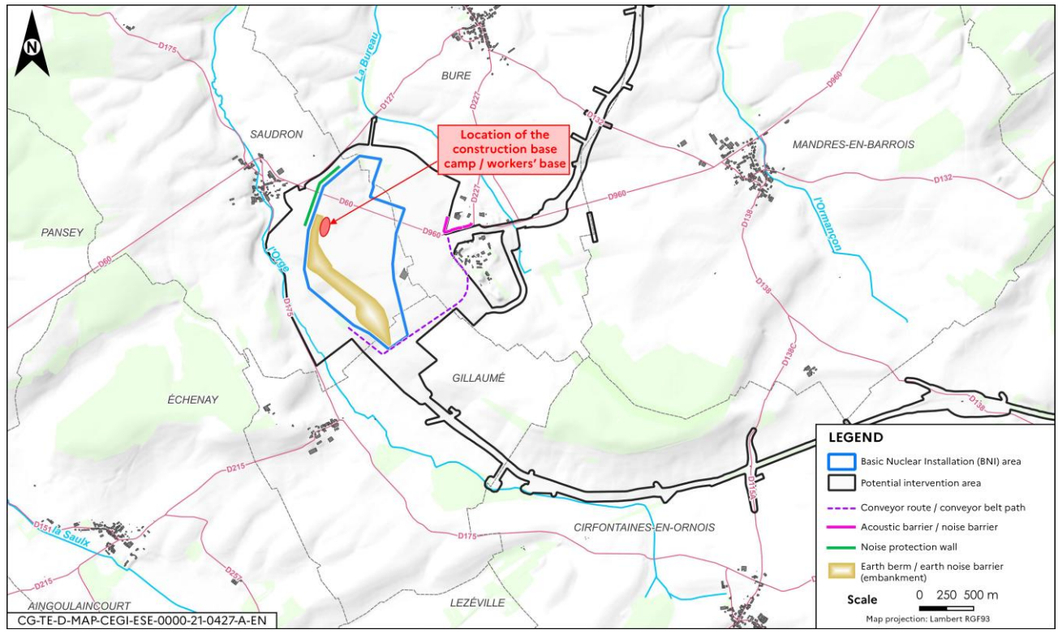


Figure 3-62 Location of noise reduction measures

After implementation of the reduction measures, noise levels during the initial construction phase will be below regulatory thresholds but higher than current levels. The residual impacts are therefore moderate.

The residual noise impacts of the Cigéo overall project during the initial construction phase are moderate.

3.12.2.1.3 The operational phase

During the operation phase, all facilities of the Cigéo overall project are in operation. The main noise sources are related to the operation of the ramps and shaft zones and the 400/90 kV substation.

Various noise abatement measures are implemented: installation of silencers on the ventilation units and a noise barrier. Details of the measures are presented in Chapter 13 of Volume IV of this environmental impact assessment.

After implementing these measures, operational noise levels in areas with regulated noise exposure are below regulatory thresholds; while higher than in the initial state, they are lower than during the preliminary works and initial construction phases. The residual impacts are therefore low. Rail and road traffic for the transport of radioactive waste packages is low on the national network; consequently, the noise impact of package transport operations is low.

Monitoring of noise emissions from the Cigéo disposal facility, which was established during the preliminary works phase, will continue during the initial construction and operational phases to confirm the effectiveness of the proposed noise reduction measures, the noise levels achieved, and compliance with regulatory thresholds.

The residual acoustic impacts of the Cigéo overall project during the operational phase are low

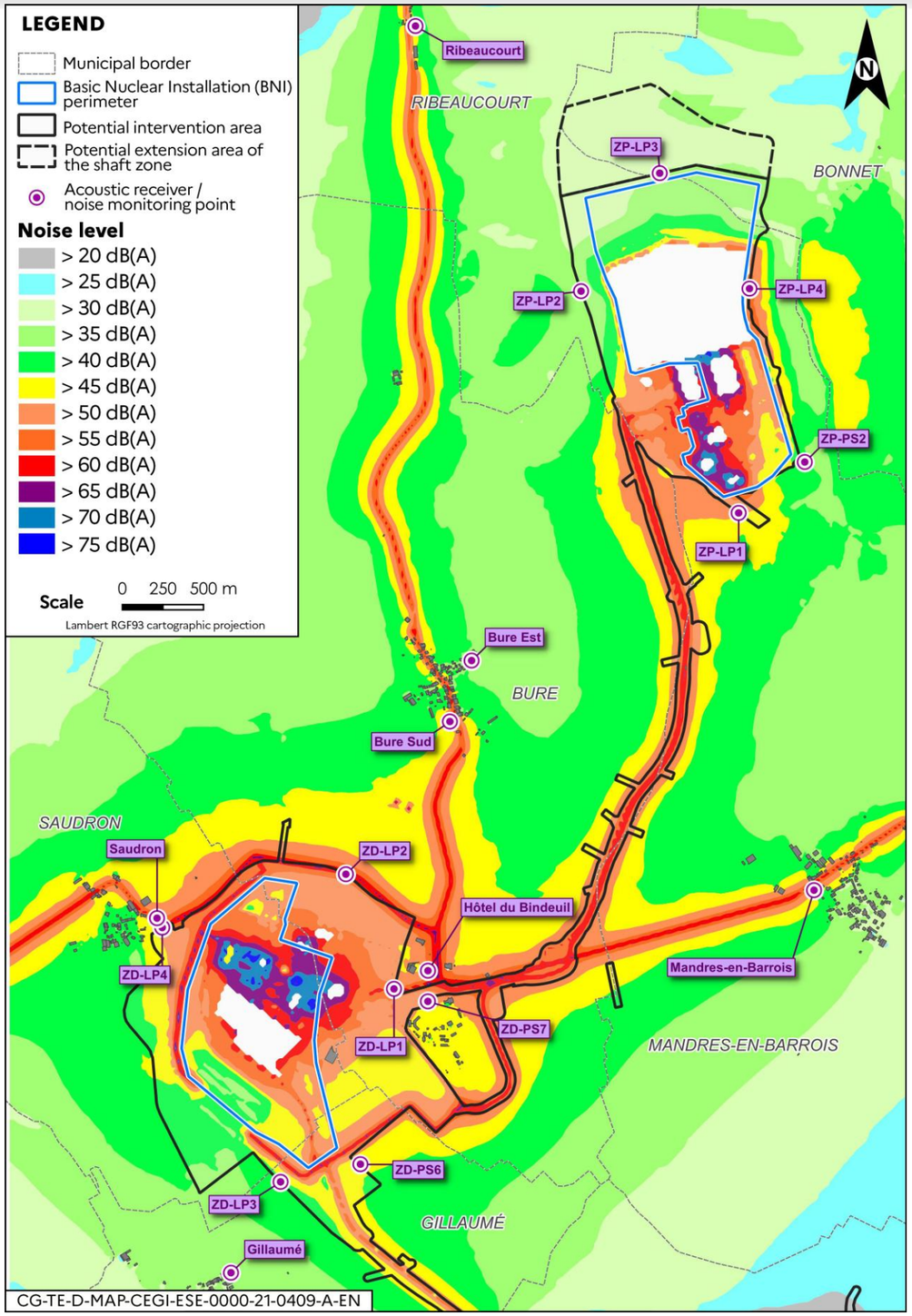


Figure 3-63 *Noise map after avoidance and reduction measures – Initial construction – All sources of the Cigéo overall project (Daytime)*

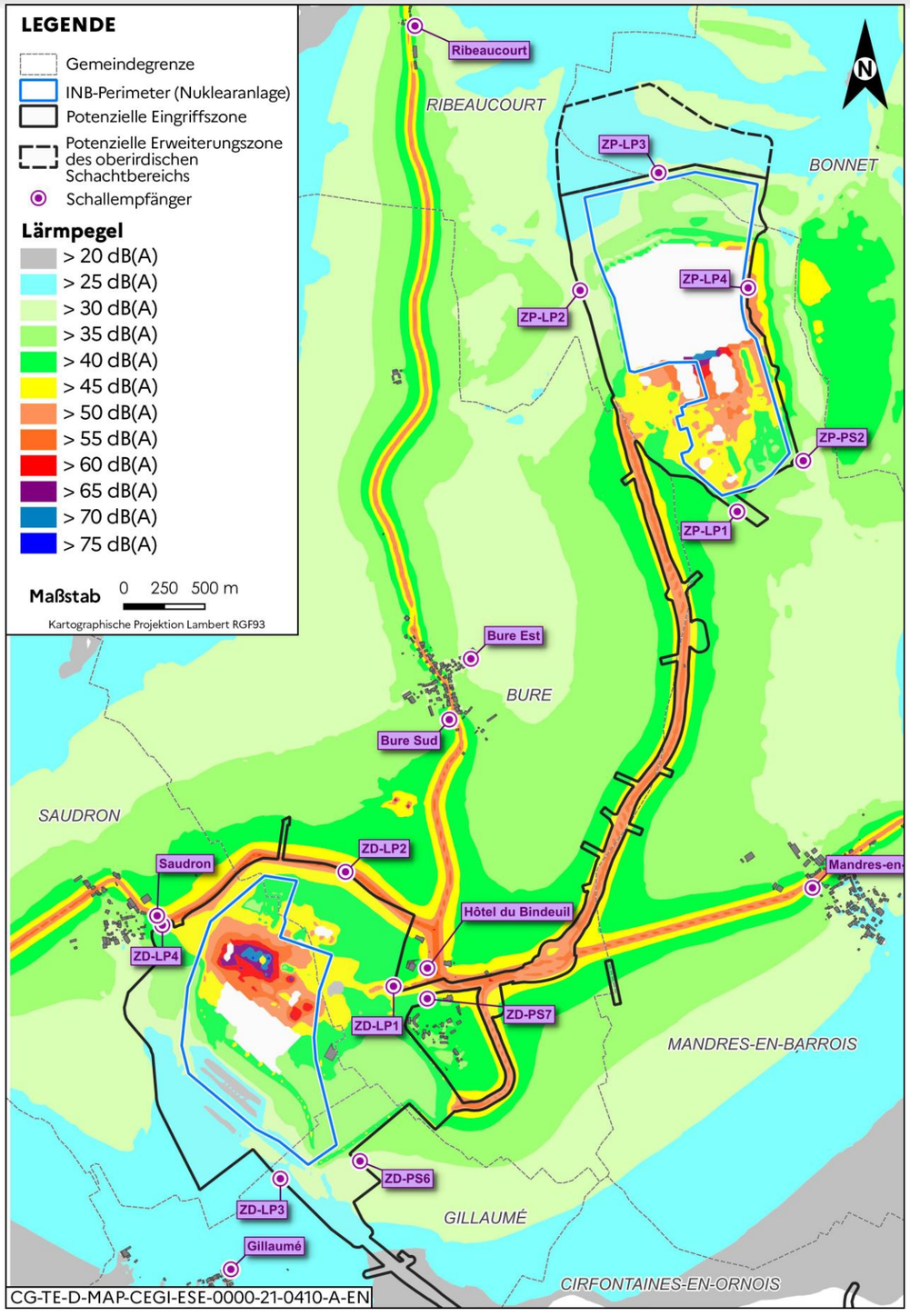


Figure 3-64 *Noise map after avoidance and reduction measures – Initial construction – All sources of the Cigéo overall project (nighttime)*

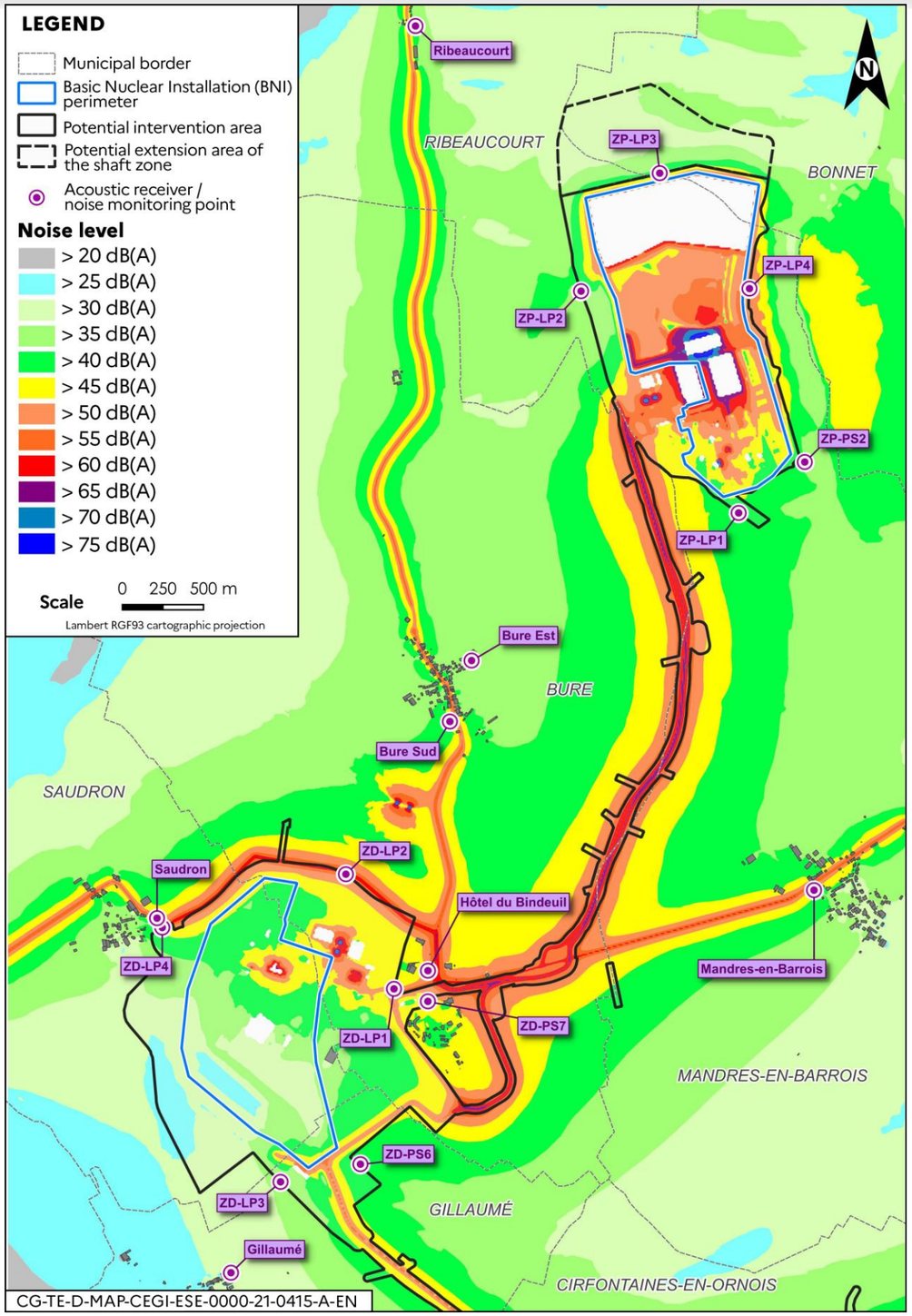


Figure 3-65 *Noise mapping after avoidance and reduction measures – Operation – All sources (Daytime)*

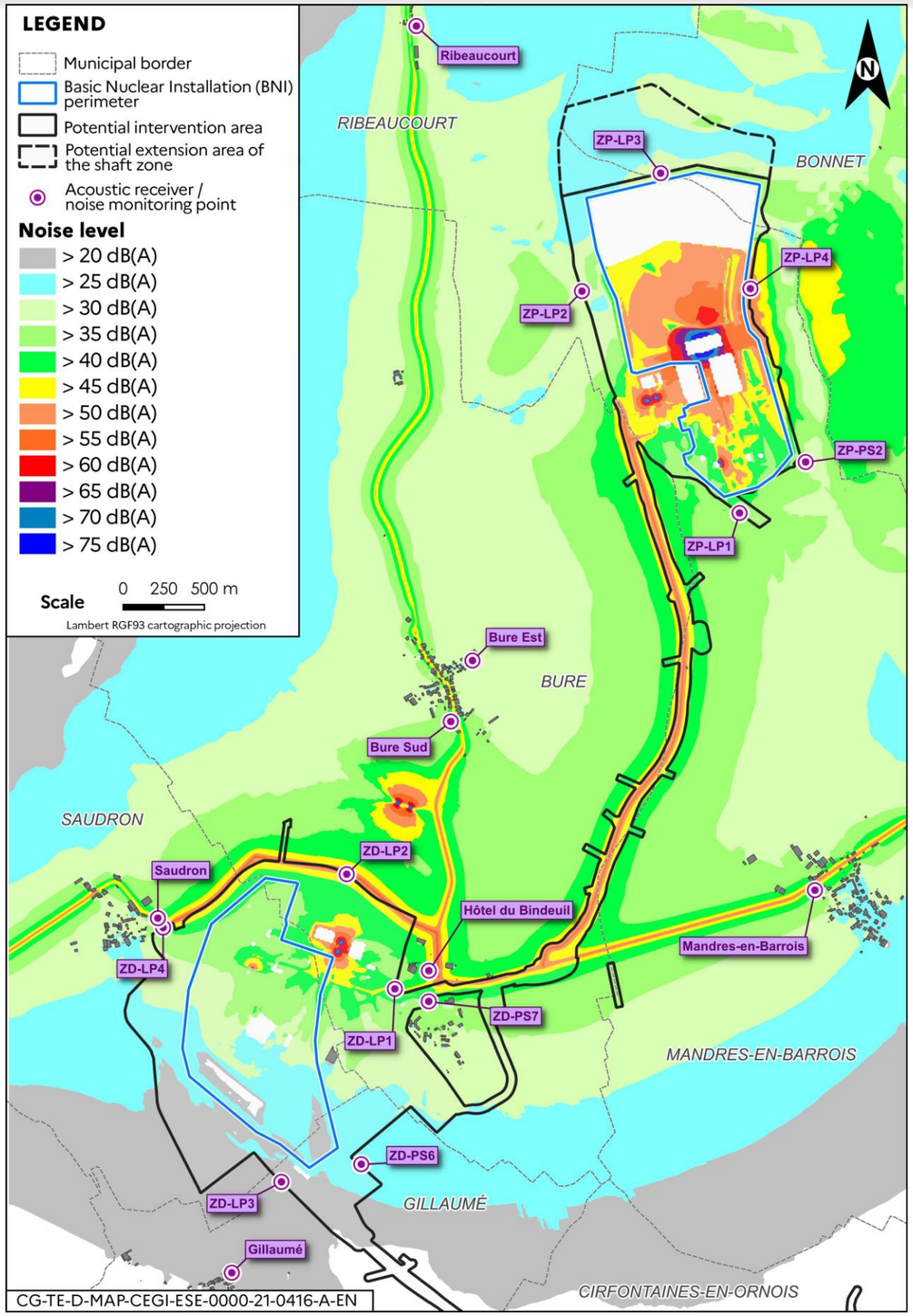


Figure 3-66 *Noise mapping after avoidance and reduction measures – Operation – All sources (Nighttime)*

3.12.2.2 Impacts related to vibrations and mitigation measures

The Cigéo overall project generates vibrations related to the use of explosives, construction equipment, and train traffic.

Reduction measures have been implemented: the Cigéo project site was selected away from urban areas, and train operations are limited to daytime hours (6 a.m. – 10 p.m.), with very few exceptions.

3.12.2.2.1 The preliminary works phase

During the preliminary works phase, the areas causing the most significant disturbances are the shaft and ramp zones of the Cigéo disposal facility, due to the duration and scale of the work. The main sources of vibrations are the operation of the concrete plant in the ramp zone area, construction machinery, and blasting.

For the other operations of the Cigéo overall project—power supply, the deviation of the D60/960 departmental road, the revamping of the 027000 railway line, and the water supply—the number of construction vehicles is much lower and the durations are much shorter (the anticipated duration of work ranges from 1 to 3 years). Only a few pieces of equipment are used simultaneously on these sites. They move, along with the work trains for the connected terminal and the 027000 railway line, along the section under construction as each of the specific projects for these facilities progresses.

3.12.2.2.2 The initial construction phase

During the initial construction phase, the inter-site link, the connected terminal, 027000railway line, departmental road D60/960, power and water supplies are in operation. Power and water supplies operations do not generate vibrations.

During these phases, vibrations from the various operations do not cause damage to built structures. Vibrations associated with the use of construction machinery and blasting are perceptible in the buildings closest to the ramp zone (Hôtel du Bindeuil, EDF archives, Ferme du Cité, Andra buildings); the shaft zone is further away from residential zones.

Since the underground facility is located at a depth of approximately 500 metres, no vibrations from the tunnelling machinery are felt from the surface.

There are structures located less than 100 metres from the tunnel and they are therefore likely to experience vibrations. These will be listed in subsequent impact studies.

Various vibration-reduction measures are implemented: suspension of work likely to cause disturbance to the neighbourhood between 10 p.m. and 7 a.m. (in the event that night work is necessary, exemptions will be requested in accordance with local regulations), a speed limit of 20 km/h on roads within the construction zones of the Cigéo overall project (compliance with traffic laws on public roads), speed limits for trains, stationary equipment isolated from the ground and equipped with shock and vibration absorption devices, and adjustments to blasting operations. Details of the measures are presented in Chapter 13 of Volume IV of this impact assessment.

Efforts to further optimise vibration reduction measures (design optimisation, construction optimisation, etc.) will continue during subsequent design phases to reduce vibrations for nearby residents. These optimisations will be presented in successive updates to this environmental impact assessment for the Cigéo project.

3.12.2.2.3 The operational phase

During the operational phase, all operations of the Cigéo overall project are in full swing. The main sources of vibration remain: the use of construction equipment (though to a much lesser extent than in previous phases), rail and road traffic, as well as certain equipment necessary for the operation of the Cigéo disposal facility (fans, pumps). The mitigation measures are therefore the same as for previous phases, with the addition of equipment floor isolation and the installation of shock-absorbing devices. During this phase, vibrations from the various operations do not cause damage to buildings. They are barely perceptible in the homes closest to the ramp zone.

Rail and road traffic for the transport of radioactive waste packages is low on the national network, so the vibrational impact of package transport operations is low.

The residual impact of the Cigéo overall project on the vibration environment is low.

3.12.2.3 Lighting impacts and associated measures

The Cigéo overall project, and primarily the Cigéo disposal facility, generates light emissions during the preliminary works phase, but especially during initial construction and operation.

Avoidance measures are implemented: selection of a site for the Cigéo overall project away from urban areas, train operations limited to daytime hours (6 a.m. – 10 p.m.), with very few exceptions; no lighting along the inter-site link and the connected terminal facility, the 027000 railway line, the water supply line, and the D60/960 departmental road deviation. Details of the measures are presented in Chapter 13 of Volume IV of this impact assessment.

Despite these avoidance measures, the preliminary works phase generates temporary light emissions primarily due to construction and safety lighting and vehicle headlights, whether for the Cigéo disposal facility or other operations within the overall project. Regarding operations by other project owners, the number of construction vehicles is nevertheless much lower than in the shaft and ramp zones and over much shorter durations (from 1 to 3 years). The vehicles move along the construction route as the operations for each of the specific sites progresses.

During the initial construction phase and the operational phase, lighting in the shaft and ramp zones will significantly alter the lighting conditions of this rural area; for the ramp zone, this is in addition to the current light emissions from the Andra center in Meuse/Haute-Marne. The other operations of the overall project do not generate light emissions.

For all phases, work likely to cause a disturbance to the neighbourhood is suspended between 10 p.m. and 7 a.m. (should night work be necessary, exemptions will be requested in accordance with local regulations).

Certain light sources are nevertheless maintained for safety or security reasons. Andra implements lighting that is tailored to the needs and environmentally responsible, in order to minimise these emissions as much as possible. Regarding operations by other project owners, construction site lighting is limited to what is strictly necessary and adapted to the work to be performed. Furthermore, landscape mitigation and integration measures (preservation of wooded strips, land levelling work, installation of a highly vegetated embankment, planting of groves or wooded screens in the ramp zone, and planting of groves in the shaft zone) help reduce the impact of light on nearby residents. However, regarding the plantings, they will not be mature until the operational phase.

After implementing these measures, the residual impacts during the preliminary construction phase are low. They are visible from the Hôtel du Bindeuil and the homes in the villages of Saudron and Gillaumé, as well as the southern part of the shaft zone (Mandres-en-Barrois).

The residual impacts of the Cigéo overall project on the light environment during the preliminary development phase are low.

The residual impacts during the initial construction and operational phases are moderate, particularly because the study area in its initial state has little lighting. These emissions are visible from the Hôtel du Bindeuil and several villages (Gillaumé, Saudron, Mandres-en-Barrois).

The residual impacts of the Cigéo overall project on the light environment during the initial construction and operational phases are moderate.

3.12.2.4 Impacts related to odours and associated measures

The Cigéo overall project generates odour emissions, primarily linked to atmospheric emissions from construction machinery and vehicles, the use of chemicals, the potential presence of putrescible waste—particularly from food service areas—the operation of restaurants, and the stagnation of rainwater or wastewater in basins.

The shaft zone, the inter-site link, the alternative locations for the 400/90 kV substation, and the deviation of the D60/960 departmental road are located away from residential areas. Furthermore, the surface water management structures are located away from inhabited areas.

One avoidance measure and one reduction measure are implemented: the selection of a site for the Cigéo overall project away from urbanised areas and the use of elevated discharge outlets. Reduction measures primarily addressing air quality, soil pollution, surface water, and conventional waste indirectly help limit odours that will not be perceptible to nearby residents: regularly maintained machinery and vehicles, stormwater and wastewater management measures, waste management measures, etc.

The residual impacts of the Cigéo overall project on the olfactory environment are very low.

3.12.2.5 Impacts related to electric and magnetic fields and associated measures

The connected terminal facility and the 027000 railway line are not electrified. The water supply and the deviation of the D60/960 departmental road do not generate electromagnetic fields. The electrical installations of the Cigéo overall project emit electric and magnetic fields.

The work to secure the 400 kV high-voltage line from Houdreville to Méry does not alter the strength of its electromagnetic field. It therefore does not generate any additional electromagnetic fields compared to the current line. Extra-high-voltage lines have a magnetic field strength of 0.16 microtesla at a distance of approximately 100 meters from the line's axis. Electricity distribution facilities generate the strongest fields. Consequently, this value is lower near a transformer and even lower near an underground power line. Magnetic fields diminish rapidly with distance.

The decision to locate the 400/90 kV substation in the immediate vicinity of the 400 kV Houdreville-Méry line avoids the need to install a long stretch of 400 kV overhead power lines, thereby reducing electric and magnetic fields. The electric and magnetic fields generated by the two new sections of the 400 kV transmission lines required for connection to the 400/90 kV substation are similar to those generated by the existing section of the Houdreville-Méry line. Above-ground electrical structures (transformer stations, delivery stations, overhead power lines) have been positioned away from residential areas, thereby avoiding exposure of the population. The facilities are designed and operated in accordance with regulations. The presence of an external coaxial metal shield connected to ground on the 90 kV underground lines significantly reduces electric and magnetic fields.

Monitoring measures (direct and independent measurements of electric and magnetic fields) are planned by RTE as part of a control and surveillance plan to verify that emission limit values are met in all areas where people may be continuously exposed to electric and magnetic fields. Furthermore, if stray voltages are detected on third-party facilities, specific studies are conducted and technical measures are implemented to eliminate or limit these voltages.

Given the 500 metres depth of the Cigéo disposal facility's underground installation and the power sources used, the magnetic field generated at the surface is in fact very weak, particularly when compared to the natural magnetic field or that generated by surface power sources.

The residual impacts of the Cigéo overall project on electric and magnetic fields are very low.

3.13 Landscape, cultural heritage, tourism, and outdoor activites

3.13.1 Landscape

SOURCES AND METHODOLOGY

The landscape analysis is based on a study of the topography, the hydrological network, vegetation patterns, the road network, and the location of frequented, inhabited (villages, hamlets, isolated dwellings), recreational (hiking trails, etc.), and heritage sites.

This detailed landscape analysis makes it possible to identify and evaluate the iconic elements that define a place: local landscape features (relief, geomorphology, hydrography…), landscape components (characteristics of natural vegetation cover, features of the agricultural landscape, networks, built landscape…), and visual relationships (visual perceptions at the scale of the broader landscape and at the scale of the immediate landscape).

The landscape impact assessment is conducted by operations on the one hand (the Cigéo disposal facility and operations by other project owners), detailing impacts by sub-operations, and then through a visual approach (distant and close-up perception). This assessment also incorporates the evolution over time of the Cigéo overall project and its various life cycle phases.

The project's impacts on the landscape were assessed through the creation of a visibility map (see Figure 3-70), topographic cross-sections, and photomontages created at significant vantage points (see Figure 3-68 and figure 3-69). The visibility map identifies all areas from which project components are visible prior to the implementation of landscape measures. Its creation is based on a morphological analysis of the territory, site visits, photographic documentation, a 3D model, and an analysis of frequented areas. The topographic cross-section highlights the key role of topography in impact assessment, as well as the role of landscape features that would be created as part of the implemented measures. Photomontages illustrate the project's integration from various viewpoints and throughout all its life stages.

3.13.1.1 Initial state

The immediate study area is part of three landscape subunits, shown on the figure 3-67:

- the open agricultural landscape, covering the southern part of the study area (areas of the upper Barrois plateau), including the Cigéo disposal facility, the electrical substation, and the deviation;
- the semi-open valley landscape, specifically the Ornain Valley**,** in the northern part, where the 027000 railway line runs;
- the closed forest landscape, for the southern part of the study area (Barrois plateau).

Environmental issues

The immediate study area is situated on the Barrois plateaus and in the Ornain Valley. The Barrois plateaus feature an open, rolling agricultural landscape dotted with groves and small, sparsely populated villages featuring churches, castles, wash houses, etc., which serve as visual landmarks in the landscape. The Ornain Valley is organised around the river and the Marne-Rhine Canal, which meander through the clay soils. This open, unobstructed landscape is exposed to visual perception and cross-visibility.

High level issue

Within a distinctly rural setting, the area where the Cigéo project is located features a rolling plateau topography, drained by watercourses flowing into valleys of varying depths.

The landscape analysis reveals the following characteristics:

- the Barrois plateau to the south, much more open, features a very open landscape offering numerous distant views;
- the presence of "wooded hillocks" also on the elevated plateau to the southeast serves as distinct visual landmarks in the landscape. They are an integral part of this area's identity;
- Despite their limited number, the villages, with their easily visible church steeples, are mostly situated in open areas on the plateau and thus offer mutual visibility that varies depending on the undulations of the terrain (from close to distant). The villages at the bottom of the valleys, on the other hand, are concentrated within a more confined linear area and thus offer more frequent sightlines;
- The Ornain Valley offers multiple views due to the juxtaposition of the Marne-Rhine Canal, the railroad tracks, the road network, and the denser urban fabric at the valley floor;
- The slopes create a succession of visual openings and closures in the landscape, thereby giving rhythm to the routes traveled.

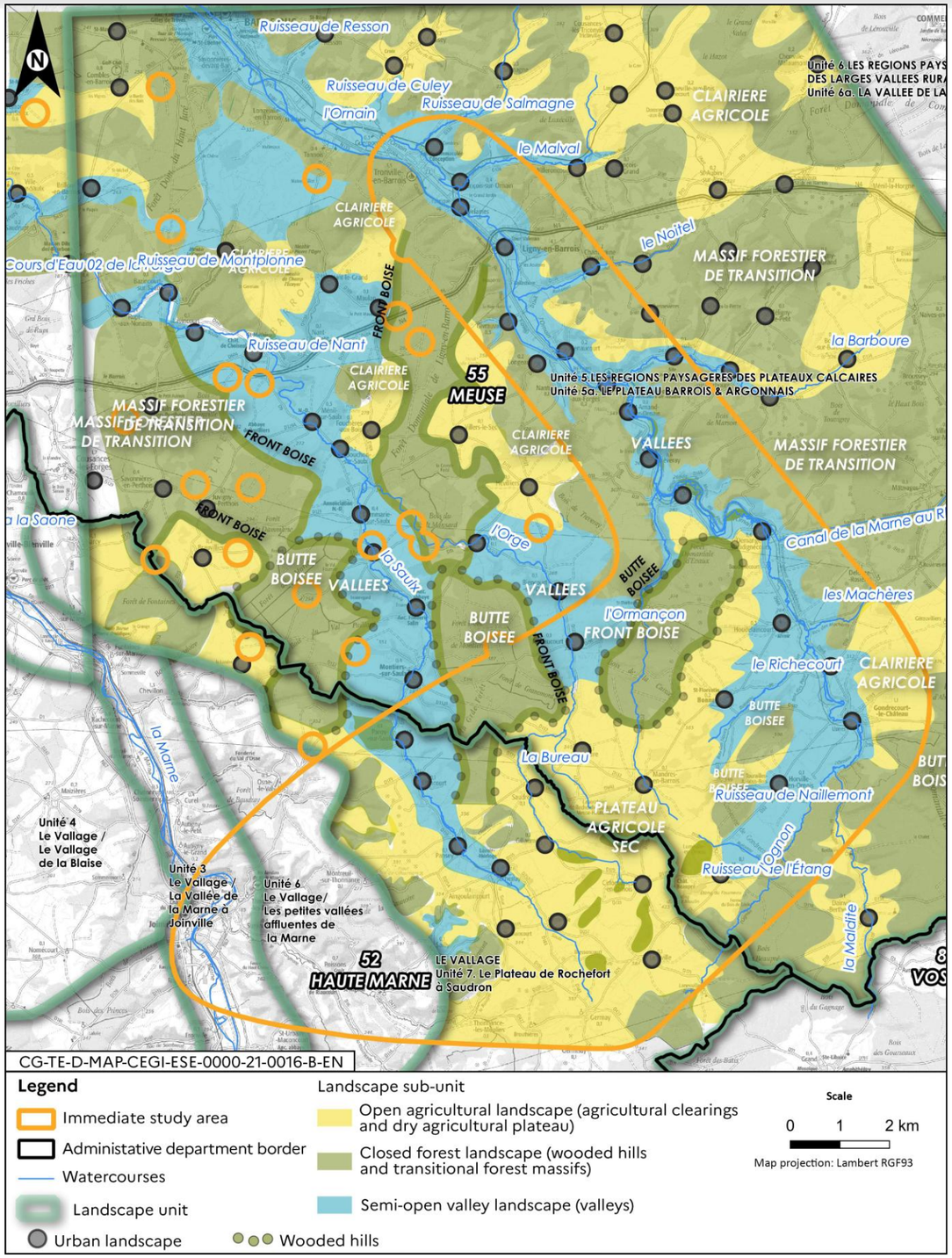


Figure 3-67 Summary of landscape subunits within the close study area

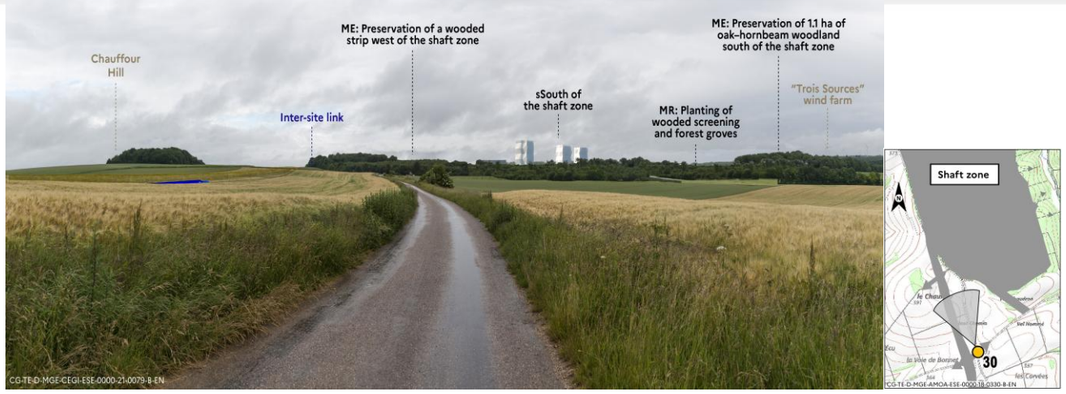


Figure 3-68 *Example of a photomontage: view of the southern part of the ZP from the intersection of the Bonnet Road and the Roman Road in Bure, and location of the viewpoint*

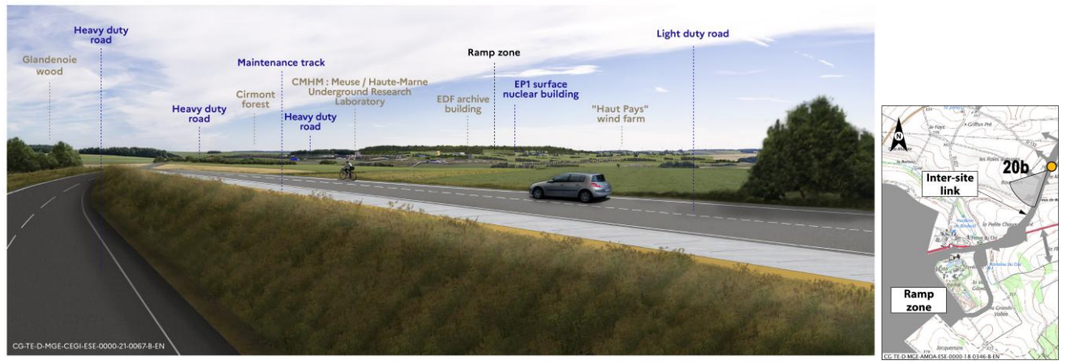


Figure 3-69 *Example of a photomontage: view of the LIS from the junction with Departmental Road D132 between the villages of Bure and Mandres-en-Barrois and location of the photograph*

3.13.1.2 Impacts and associated measures

The Cigéo overall project is located in a rural and forested environment dotted with small villages.

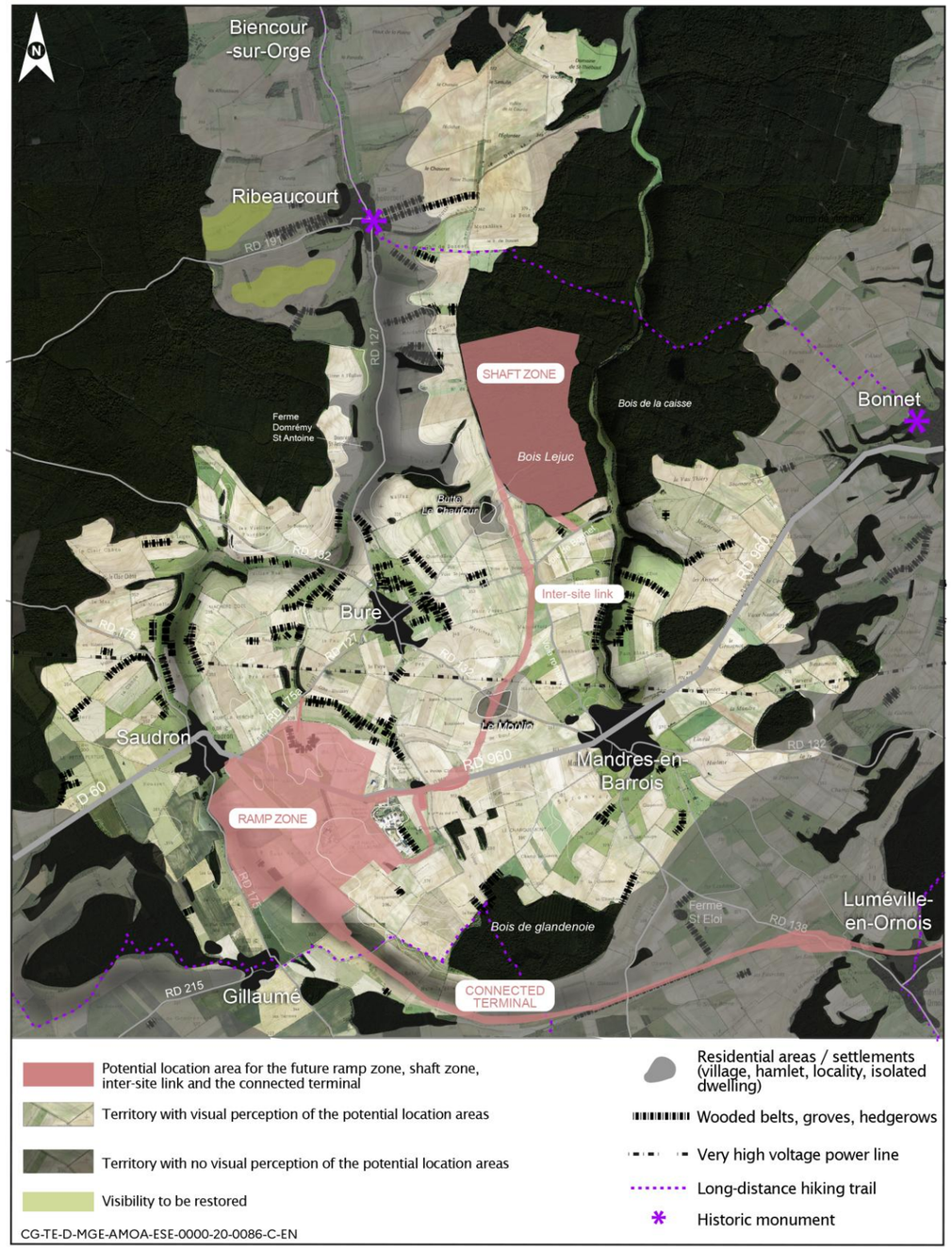


Figure 3-70 *Visibility map*

3.13.1.2.1 The Cigéo disposal facility

For the Cigéo disposal facility, the shaft and ramp zones and the inter-site link are the operations likely to have a significant impact on the landscape, whether viewed from a distance or up close to the facilities and structures. The shaft zone is located in a wooded area, while the access tunnel area and the inter-site link are located in an agricultural area. The connected terminal (ITE) reuses a large portion of a former railway line along its route (10 km), which limits the impact of this operation on the landscape. Only the 4-km section to be constructed, extending from Luméville-en-Ornois to the access road area, as well as future restoration work, will have a moderate impact on the landscape due to the creation of embankments and crossing structures (studies are underway, and their results will be incorporated in the next update).

Starting from the project's design phase, landscaping has been planned to minimise the visual impact of the Cigéo disposal facility. To this end, avoidance measures—such as preserving wooded strips to the west, north, and east of the shaft zone and maintaining 1.1 hectares of oak-hornbeam forest in this same area—help limit views of the disposal facility from the surrounding area.

However, during the preliminary works phase, work carried out in the access road area and on the inter-site link will reconfigure the open agricultural landscape. Views of the site, which may be close up and originate from inhabited areas (the village of Gillaumé), are unobstructed. Earthworks (deposit, installation of platforms), as well as the associated machinery and construction facilities, are visible from numerous vantage points, both near and far.

In the shaft zone, clearing creates a gap in the wooded massif that is visible from both near and far from the south of the shaft zone, despite the retention of certain wooded strips to the north, east, and west.

Reduction measures, such as levelling work, the creation of a highly vegetated embankment, the planting of groves or wooded screens in the ramp zone, or the planting of groves in the shaft zone, promote the integration of the Cigéo disposal facility into its surroundings. Nevertheless, the effectiveness of these reduction measures depends on the growth rate of the plantings and requires time.

During the initial construction phase, work continues and structures such as those housing the shafts in the shaft zone, accompanied by cranes, become visible. Within a sparsely populated rural landscape, the disruption caused by the site's construction is noticeable. The trees remain too young to fully fulfil their role as a filter or screen.

During the operational phase, the plantings are developing and eventually mature. The artificial nature of the Cigéo disposal facility's infrastructure is mitigated by the presence of vegetation. The proposed landscape designs are similar to those found in the surrounding landscape. Wide viewing cones are blocked, preventing a close-up view of the industrial facilities in the ramp zone (villages of Gillaumé and Saudron) or the shaft zone (no view of the discharge site and limited visibility from Mandres-en-Barrois). Structures visible from a distance within the region are integrated into green settings from which only the shaft headframes protrude. Use of the inter-site link is minimal, and the proposed network of hedges and wooded strips reduces the impact associated primarily with vehicle traffic.

3.13.1.2.2 Operations by other project owners

The power supply project includes various components (see Chapter 2.4.2 of Volume II of this impact assessment), among which only the construction of the substation is likely to have significant temporary and permanent effects, which will be mitigated by the prior integration of a landscape study into the substation's design process. The other operations associated with the power supply are likely to impact the surrounding landscape only temporarily during the construction phase.

The water supply project will have an impact on the landscape that is limited to the immediate surroundings, temporary, and limited to the duration of the construction work.

The revamping of railway line 027000 involves restoring this largely unused line to service. The impacts on the immediate landscape will be primarily temporary, as they are related to the construction work. The renovation of engineering structures along this line may have a permanent impact on the landscape. Their visual impact will be limited, and their residual impact will be rendered negligible as part of the ongoing project development and following public participation.

Similar to the operations of other project owners, the deviation of the D60/960 departmental road will have temporary effects related to earthwork and permanent effects related to its operation. Generic measures, such as shaping the earthworks or limiting the footprint, will reduce their impact on the landscape.

No facilities are currently planned by the producers for the shipment and transport of radioactive waste packages; therefore, no impact on the landscape is expected at this level.

The main landscape impact of the Cigéo overall project occurs around the Cigéo disposal facility. It ranges from low to high during the preliminary works and initial construction phases, then becomes low during the operational phase once the landscape plantings have matured.

3.13.2 Cultural heritage

SOURCES AND METHODOLOGY

Archaeology

The inventory of archaeological sites and remains was based on various databases, including the Mérimée database (POP platform), the database of the French National Institute for Preventive Archaeological Research (INRAP), and the national archaeological map of the Regional Directorate for Cultural Affairs (DRAC).

This public data was supplemented by the results of a Lidar survey (laser remote sensing), which helped identify indications of archaeological remains.

Historical and Architectural Heritage and Listed Sites, Classified Sites

The list of classified/registered sites was compiled by consulting the DREAL Grand Est website and the Heritage Atlas. Notable heritage sites were identified using the Heritage Atlas. The inventory of listed or classified historic monuments was compiled using the Architecture-Mérimée database (POP platform) and the Heritage Atlas.

Notable heritage elements that are not protected were identified within and near the immediate study area through bibliographic research or specific surveys depending on the area.

CLASSIFIED SITES, REMARKABLE HERITAGE SITES, AND HISTORIC MONUMENTS

Classified sites are places whose exceptional character warrants protection at the national level: remarkable features, or sites where one wishes to preserve the remains or the memory of the events that took place there. No modification of a classified site is permitted without the express authorisation of the minister responsible for such sites.

Listing, on the other hand, is a recognition of a site's quality that warrants monitoring of its development, in the form of consultation with the Architecte des Bâtiments de France regarding any work undertaken there.

Remarkable Heritage Sites (SRP) were established by the Law of July 7, 2016, on freedom of creation, architecture, and heritage (136). This measure aims to protect and highlight the architectural, urban, and landscape heritage of our regions.

Remarkable Heritage Sites replace the former protection mechanisms:

- preserved sectors;
- zones for the protection of architectural, urban, and landscape heritage (ZPPAUP);
- areas for the enhancement of architecture and heritage (AVAP).

A **historic monument** is a building or movable object granted special legal status intended to protect it, due to its historical, artistic, architectural, as well as technical or scientific significance.

The **protection of** listed or registered **monuments** extends beyond their immediate vicinity. For buildings subject to this regime, whether listed or registered, a buffer zone with a radius or width of 500 metres around the monument—or one adapted to the actual areas of visibility—is established, creating an easement enforceable against third parties.

3.13.2.1 Archaeological heritage

3.13.2.1.1 Initial state

Environmental issue

The immediate study area contains numerous archaeological remains, attesting to a long history of occupation and settlement. Archaeological surveys, followed by excavations, if necessary, are likely to be conducted.

A significant issue in the western part of the immediate study area (an area that has been subject to surveys) and potentially significant in the rest of the immediate study area (based on bibliographic data).

Three archaeological sites classified as “Historic Monuments” overlap the northern part of the immediate study area where the 027000 railway line runs. These three sites are part of the remains of “Nasium,” an ancient Gallo-Roman city.

To the south of the close study area, near the Cigéo disposal facility, there are no archaeological sites. Nevertheless, the national archaeological map from the Regional Directorate of Cultural Affairs (DRAC) and LiDAR surveys indicate the presence of traces and remains. These are isolated features such as hearths, ditches, etc. An ancient road dating from the Gallo-Roman period is also located within the immediate and close study areas: the Roman road. A large portion of the footprint in the ramp zone and part of the connected terminal have already undergone archaeological surveys. These surveys revealed the presence of a Neolithic site and the remains of a Gallo-Roman villa.

3.13.2.1.2 Impacts and associated measures

Andra and the project owners of the Cigéo overall project are complying with regulations regarding preventive archaeology. Archaeological surveys have already been conducted in the potential work zones of the ramp zone and part of the connected terminal (ITE). Conducted by the French National Institute for Preventive Archaeological Research (Inrap), these surveys revealed the presence of remains, leading the Regional Directorate for Cultural Affairs (DRAC) to mandate excavations in certain areas. These excavation mandates are detailed in prefectural decrees, and work cannot begin until these decrees have been implemented.

Archaeological surveys followed by excavations (if deemed necessary by the DRAC) will also be undertaken in the potential siting area of the Cigéo disposal facility that has not yet been surveyed (primarily the shaft zone and the inter-site link, as well as certain residual areas of the connected terminal (ITE) and the ramp zone) as well as within the footprints of other operations under the Cigéo overall project (deviation of the D60/960 departmental road, 400/90 kV substation, etc.) once their precise locations are known, following public consultation and design studies.

The conduct of preventive archaeological surveys followed by excavations leads to an assessment that the overall impact of the Cigéo project on the archaeological heritage is moderate, due to the handling of remains during the archaeological excavations.

The residual impact of the Cigéo overall project on archaeological sites is moderate.

3.13.2.2 Historical and architectural heritage and listed sites, classified sites

3.13.2.2.1 Initial state

Environmental issue

A few historic monuments are identified within the close study area. Most of these monuments are located in the villages crossed by the 027000 railway line in the Ornain Valley. Only three historic monuments are located near the Cigéo disposal facility, and none have their protection zone crossed by the immediate study area.

Low to moderate level issue along the 027000 railway line and the 400 kV transmission line.

Low level issue for the Cigéo disposal facility

No notable heritage sites, protected areas, heritage enhancement zones, or architectural, urban, and landscape heritage protection zones are identified within the close study area of the Cigéo overall project.

Nevertheless, the close study area contains several historic monuments (see Figure 3-71). The majority are located in the Ornain Valley. These are also included within the immediate study area near the 027000 railway line and the Gondrecourt-le-Château logistics hub. There are no historic monuments between the Thonnance-lès-Joinville water intake and the Cigéo disposal facility.

South of the close study area, within the Barrois limestone landscape, historic monuments are rarer: the church of Bonnet, the church of Ribeaucourt, and the Chassey-Beaupré Estate. None are included in the immediate study area.

One classified site is present within the project’s close and extended study areas. This is the municipal park of Ligny-en-Barrois. It is located near the northern end of the 027000 railway line.

The study area for the 400 kV Houdreville-Méry line crosses the protection zones of eight historic monuments.

3.13.2.2.2 Impacts and associated measures

The close study area includes 35 historic monuments (including 8 classified and 27 listed), one listed site, and one site of outstanding heritage value.

During the project’s design phase, the locations for the new facilities required for the Cigéo overall project were selected so as not to encroach on the protection zones of any historic monuments.

However, this avoidance measure excludes operations that reuse existing footprints, namely a large portion of the connected terminal (ITE) path, including the Gondrecourt-le-Château logistics platform and the entire 027000 railway line. These two operations inevitably cross the protection zones of seven historic monuments.

The 02700 railway line crosses the protection zones of:

- the **archaeological site of the Nasium sanctuary**, a listed historic monument in Saint-Amand-sur-Ornain;
- the **Roman ruins of Nasium**, a listed historic monument located in Naix-aux-Forges;
- **the church of Ligny-en-Barrois**, the **Hôtel des Fermes**, **the Porte Dauphine**, and **La Chiennerie,** all listed historic monuments located in the municipality of Ligny-en-Barrois.

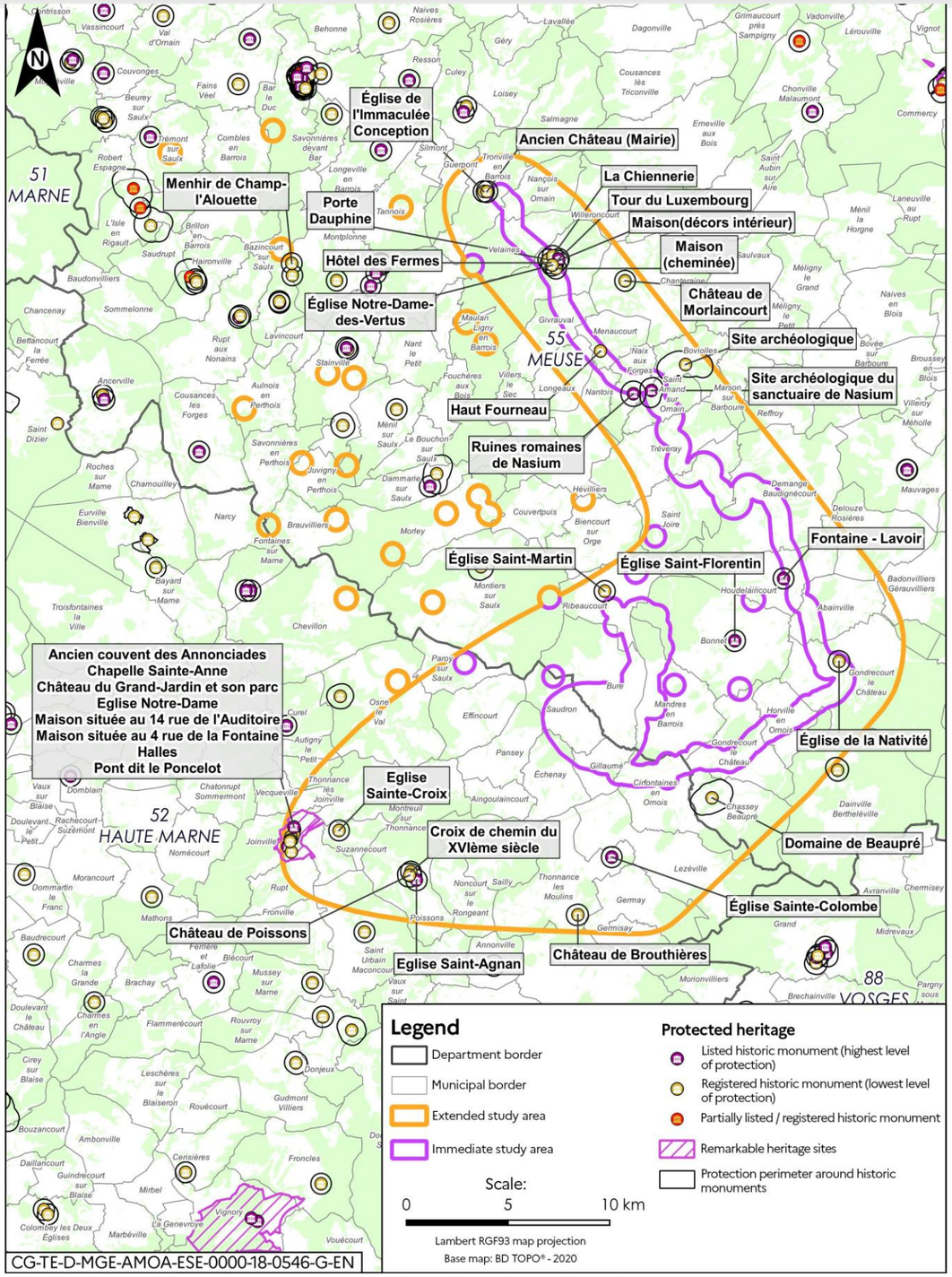


Figure 3-71 Location of historical heritage sites within the immediate study area

The planned developments are similar to the current state (railway line, stormwater management basins, signage, restoration work):

- existing footprints are reused to the greatest extent possible;
- historic monuments whose protection zones are intersected are located in urban areas.

Thus, the impact of the revamping of the 027000 railway line by SNCF Réseau on architectural heritage is direct, at most moderate depending on the engineering works approved through consultation, and temporary during the preliminary works phase (construction of the line). The impacts are minor and permanent during the initial construction phase (operation of the line). The Gondrecourt-le-Château logistics hub crosses the protection zone of the Church of the Nativity of the Virgin, a listed historic monument. The purpose of this hub remains similar to its current use and does not require any installations likely to alter the landscape around the church.

The historic monuments closest to the shaft and ramp zones are the Church of Saint-Martin in Ribeaucourt (a listed historic monument), the Church of Saint-Florentin in Bonnet (a classified monument), and the Domaine de Beaupré in Chassey-Beaupré (a listed monument). During the summer months, no visual overlap is expected due to vegetation and the terrain. The Chassey-Beaupré estate and the church in Bonnet also have no visual overlap with the terminal facility.

As for notable unprotected heritage sites, no elements will be impacted by the Cigéo overall project.

The impacts of the Cigéo overall project on heritage sites are therefore minor.

The residual impact of the Cigéo overall project on historic monuments, classified/listed sites, notable heritage sites, and unprotected notable heritage is low.

3.13.3 Tourism and outdoor activities

3.13.3.1 Initial state

Environmental issue

The immediate and surrounding study areas where the Cigéo overall project is to be implemented have very little infrastructure to accommodate tourists. The main tourism and recreational activities are outdoor pursuits such as hiking, hunting, and fishing.

Low level issue

The close study area is located in a rural area far from major transportation infrastructure. Tourism and outdoor activities in the region consist mainly of outdoor pursuits such as hiking, fishing, hunting, foraging, and gathering firewood.

Two long-distance hiking trails (GR), the GR714 and GR703, three short-distance hiking trails (PR), and the Marne-Rhine Canal Greenway traverse the immediate study area.

Cultural facilities (cinemas, theaters, museums), sports facilities (gyms, stadiums, equestrian centers), and tourist accommodations (hotels, guesthouses, inns) are few in number within the close study area. The majority are concentrated in the Ornain Valley. South of the study area, there is only one hotel and the Andra facilities that welcome the public to the Underground Laboratory, the Ecothèque, and the Technology Center, with a total of nearly 10,000 visitors per year.

No heritage sites are listed within the study area. The nearest one is located 50 km away: the Butte de Montsec site.

The study area for the 400 kV transmission line crosses three long-distance hiking trails (GR): the GR654, the GR703, and the GR714.

3.13.3.2 Impacts and associated measures

The clearing of the Lejuc forest to make way for the substation reduces the hunting area and leads to the permanent cessation of firewood collection and foraging.

Driven hunts from south to north in the Lejuc Woods are organised prior to clearing to keep game within the forested area and reduce potential damage to agricultural land.

Furthermore, to prevent the loss of the aforementioned uses, the Lejuc Woods (approximately 220 ha), located in Mandres-en-Barrois, were exchanged with the municipality for the Caisse Woods (approximately 300 ha) located in the neighbouring municipality of Bonnet. The municipality of Mandres-en-Barrois has become the owner of a larger forested area, allowing it to maintain residents' rights to collect firewood, forage, and hunt.

A path and a small bridge were built by Andra over the Ormançon River in 2018 to allow residents to easily and quickly reach this new communal forest, the Bois de la Caisse.

The potential project area for the Cigéo overall project intersects three long-distance hiking trails (GR): the GR 703, the GR 714, and the GR 754, as well as a short-distance hiking trail (PR), which are interrupted by the path of the connected terminal (ITE), the path of the 027000 railway line, and the Marne-Rhine Canal greenway that passes under the 027000 railway line. Improvements are made to ensure the continuity of the trails where they are interrupted by the Cigéo disposal facility. Thus, the construction of a railway bridge and two level crossings, along with the rehabilitation of a road bridge, will ensure the restoration of the GR 703 and the short-distance hiking trail (PR) located in the municipality of Cirfontaines-en-Ornois.

A wooded strip maintained north of the shaft zone keeps the GR 714 trail at a distance from this zone.

During the preliminary works and initial construction phases, the Cigéo disposal facility generates economic activity (see Chapter "3.7 " of this non-technical summary) that also benefits the lodging and restaurant sectors.

During the operational phase, the disposal facility will have visitor reception facilities (for visitors from France and abroad) that will enhance the industrial tourism offering and have a positive impact on hotel occupancy and other hospitality establishments.

The residual impact of the Cigéo overall project on tourism development is positive

The residual impact of the Cigéo overall project on leisure and tourism activities is low to very low.

3.14 Land-use planning and development (including urban planning) – compatibility with land-use planning documents and measures

3.14.1 The initial state of territorial planning and land use planning (including urban planning)

The immediate study area is located in the Grand Est region, straddling the departments of Meuse and Haute-Marne. The territory is primarily rural, consisting largely of agricultural, natural, and forested areas. The population and activities are mainly concentrated around the regional hubs of Bar-le-Duc and Saint-Dizier, supplemented locally by smaller hubs.

The area where the Cigéo overall project is located suffers from a lack of economic and residential appeal and has been severely impacted by the effects of deindustrialisation. This situation raises challenges in terms of land-use planning, with the aim of increasing the area's appeal to businesses and new residents. At the same time, the slowing rate of consumption of agricultural, natural, and forested land also poses a significant challenge: striking a balance between demographic and economic development and preserving the rural character of the region.

The main approved and current urban planning documents governing urbanisation and land use planning for the Cigéo overall project (excluding the 400 kV Houdreville-Méry transmission line) are:

- the Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) for the Grand Est region (103) ;
- the Territorial Coherence Plan (SCoT) of the Pays-Barrois region (117) ;
- the approved Intermunicipal Local Urban Planning Plans (PLUi) for Haute Saulx (118) and for Saulx et Perthois (137) ;
- the approved Local Urban Planning Plans (PLU) for Gondrecourt-le-Château, Tréveray, Givrauval, Ligny-en-Barrois, Tronville-en-Barrois, Velaines, Bar-le-Duc, Trémont-sur-Saulx (138–145) and municipal maps.

Among these documents, the SRADDET Grand Est, the SCoT of the Pays Barrois, as well as the PLUi Porte de Meuse – Haute-Saulx sector, the PLU of Gondrecourt-le-Château, and that of Velaines mention the Cigéo overall project. Aside from these documents, the other PLUs in the immediate study area do not mention the Cigéo overall project.

Some of the municipalities in the study area are subject to national urban planning regulations: the rule of limited buildability applies.

Other urban planning documents are currently being developed, notably the Nord Haute-Marne SCoT (146), the PLUi of the Joinville-en-Champagne Basin Community of Municipalities, and the PLUi Portes de Meuse (Val d'Ornois sector).

The immediate study area includes three reserved sites and several classified wooded areas, some of which are located in Bure. Several areas designated for development have been identified within the immediate study area.

Several utility easements cross the immediate study area, related to the presence of the Ornain River, a classified site in Ligny-en-Barrois, electrical and telecommunications networks, as well as the operation of a gas pipeline.

The immediate study area is included within the scope of the Lorraine State-Region Planning Contract (2021-2027) (135).

The 400 kV Houdreville-Méry transmission line falls within the territory of the Grand Est SRADDET and passes through the territories of the Nord Haute-Marne SCoT and the Pays Barrois ScoT (117, 146), as does the rest of the Cigéo overall project. It is also affected by the SCoTs of Meurthe-et-Moselle and of the Territoires de l'Aube. It is affected by several local urban planning (PLU) documents and municipal maps. The 400 kV Houdreville-Méry transmission line crosses the classified wooded area of the Saint-Amand state forest in Favières.

» OPERATION OF NATIONAL INTEREST (OIN)

Within the area where the Cigéo disposal facility is to be located, the government has recently established an OIN following consultation with the municipalities, departments, and regions whose territories are wholly or partially included within the scope of this OIN. Decree No. 2022-992 of July 7, 2022 (147) establishing it was published in the Official Journal of the French Republic on July 8, 2022. The OIN thus enables the State to address land-use planning challenges and ensure that the urban and strategic planning documents applicable within the OIN's boundaries do not impede the implementation of this operation of national interest.

3.14.2 The impacts and measures regarding territorial planning and land use planning (including urban planning) of the Cigéo project

The Cigéo disposal facility represents an opportunity for the economic and demographic revitalisation of the region. The potential impacts of the Cigéo overall project on land use planning are related to changes in land use, modifications to the transportation network and other utility networks, and the resulting urbanisation (indirect impact).

The impacts and measures related to various networks and transportation infrastructure are presented in the chapters 3.9 of this non-technical summary.

3.14.2.1 The direct effect on urbanisation

As part of a mitigation strategy, the footprints of the Cigéo disposal facility were selected so as not to impact classified wooded areas (EBC), particularly the Chaufour hill. The 027000 railway line does not impact any EBCs. The 400 kV Houdreville-Méry transmission line passes through a forested area classified under the Favières Local Urban Planning Scheme (PLU) (Forêt Domaniale de Saint Amand) (148). Should safety work on the 400 kV transmission line be carried out within this EBC, the regulations associated with the relevant local urban planning scheme would be complied with. Regarding other operations, the location of forested areas is taken into account as studies proceed, with priority given to avoidance.

Details of the measures implemented are presented in chapters 15.2 and 15.4 of Volume IV of this impact assessment.

The Cigéo disposal facility, the power supply project, the 027000 railway line, and the deviation of the D60/960 departmental road do not affect any reserved sites. If such sites were present in the drinking water supply project, priority would be given to avoidance.

Two reserved sites are created, respectively, for the inter-site link and the connected terminal (ITE).

The classification of the ramp and shaft zones has been adjusted to UYcq and 1AUyc zones (with the exception of a portion of the forested peripheral areas of the shaft zone, which remain classified as N zones), enabling a transition from prospective urban planning to operational urban planning tailored to the specific characteristics of the Cigéo disposal facility.

The direct land use for the construction of the Cigéo overall project facilities, and the associated measures, are presented in chapters 3.3, 3.6 and 3.8.2 of this non-technical summary.

The impacts related to public utility easements are detailed in the thematic chapters corresponding to Chapters 5 (Water), 9 (Utilities), and 14 (Landscape, Cultural Heritage, Tourism, and Recreation) of Volume IV of this impact assessment.

3.14.2.2 The indirect effect in terms of induced urbanisation

The potential impacts related to the induced urbanisation resulting from the Cigéo disposal facility are considered significant.

Local authorities, through their land-use planning documents, are incorporating the project to manage and leverage its impact on land-use planning. Land-use planning guidelines are designed to maximise the demographic and economic benefits associated with the Cigéo overall project. The regions are therefore being restructured to best accommodate the activity, employees, and residents, and to manage the associated impacts.

As part of the territorial development plan (PDT), the State and local authorities have planned actions to amplify the positive effects of the Cigéo overall project. RTE will implement, in collaboration with State agencies, a project support plan (PAP) for the electrical substation it is developing in the host region of the Cigéo overall project.

The Cigéo disposal facility constitutes a new hub of attraction that will result in a concentration of activities and people in a part of the region that is currently underdeveloped. It will influence the spatial organisation of the region by affecting the location of businesses supporting its operations, employees and their families, and commercial and service providers (medical, educational, food services, etc.). The project will also have an impact on the current transportation network, which may require adaptations (upgrading of roadways, development of public transportation, etc.).

The impact of the Cigéo overall project on induced urban development was studied by distinguishing between operations involving transportation infrastructure and other operations. The conclusion of the analysis is that the Cigéo overall project will have an impact on urbanisation through increased land use to accommodate businesses, new residents, and the facilities and services they require. This effect will be primarily linked to the Cigéo disposal facility, which will increase the area's attractiveness to businesses and lead to population growth. The other components of the Cigéo overall project are not expected to significantly alter urbanisation patterns.

The project's impact on urbanisation is expected to be felt primarily in the current major centres of activity: Bar-le-Duc, Saint-Dizier, Ligny-en-Barrois, and the Ornain and Saulx valleys. However, the expansion of urbanisation is governed by planning documents that establish the rules to be followed and limit the area of land to be developed in order to preserve the rural character of the region. Nevertheless, the Territorial Coherence Plan (SCoT) for the Pays Barrois (117) specifies that the areas dedicated to economic development driven by the Cigéo overall project (130 ha) are not factored into the objectives for reducing land consumption. The effects of the Cigéo overall project on urbanisation are twofold: a densification of existing urban areas and controlled urban expansion guided by urban planning documents.

Thus, the indirect impacts on land use planning following mitigation measures for the Cigéo overall project are diverse:

- densification of existing business zones near the Cigéo disposal facility, creation of new zones, and, on a larger scale, densification and expansion of more distant business zones;
- densification and expansion of residential areas, particularly in municipalities that are well-equipped and located near the Cigéo disposal facility or well-served by transportation networks;
- development of businesses, commercial areas, facilities, and services (medical centers, schools, etc.) in municipalities welcoming new workers;
- a positive impact on existing tourism-related facilities;
- potential adaptation and upgrading of the transportation network to ensure good connectivity from major urban centers;
- upgrading of digital networks leveraging the infrastructure built as part of the Cigéo overall project.

The Cigéo master plan is therefore driving a reorganisation of the local territory at the level of the communities of municipalities.

Due to its characteristics, the Cigéo overall project also has a broader impact on several cross-border living areas. The expected developments are of the same nature as those mentioned above, although they are likely to be less intense. They are anticipated by local stakeholders within the framework of the SCoTs. Finally, given the unique nature of the project and the potential for regional specialisation, it is likely that the sphere of influence of the Cigéo project will extend to the Grand Est region.

The Cigéo project, through its direct effects on job creation and economic activity and its indirect effects on demographics, services, and infrastructure—including the strengthening of the road network—has a significant and lasting positive impact on regional planning, addressing the needs expressed in planning documents and guided by them. However, the resulting urban development, an indirect consequence of the Cigéo project, places pressure on agricultural, natural, and forested lands.

To limit the impact associated with the resulting urban development, discussions have been initiated between Andra and local authorities. These discussions help clarify housing, infrastructure, and business space needs in order to anticipate and manage urban development by promoting the densification of urban areas rather than urban sprawl.

After applying mitigation measures, the residual impact of the Cigéo overall project on land use planning is classified as low. No compensation measures are proposed.

The Cigéo overall project will have a low residual impact on land use planning

3.14.3 Compatibility of the Cigéo overall project with land-use plans, schemes, and programs

The Cigéo overall project has been designed to comply with the key principles of land conservation and sustainable urban planning. It is therefore compatible with the objectives of the Grand Est Regional Plan for Land Use, Sustainable Development, and Territorial Equality (SRADDET) on these topics (103).

The Cigéo overall project is compatible with the Grand Est State-Region Planning Contract (CPER) (134) as it aligns with the guidelines identified therein regarding the competitiveness and efficiency of the Lorraine region economy, sustainable development, regional attractiveness, and balanced territorial development.

The process of bringing urban planning documents into compliance involves adapting the provisions of the various components of the urban planning documents to enable the construction of the Cigéo disposal facility, for which a declaration of public interest has been requested (*Note*: For projects not under the project management of Andra, it is the responsibility of each project manager to ensure, if necessary, that the relevant urban planning documents are brought into compliance).

The alignment of urban planning documents carried out by Decree No. 2022-993 of July 7, 2022 (1) declaring the Cigéo disposal facility to be in the public interest has made it possible to adapt the provisions of the urban planning documents relevant to the Cigéo disposal facility to allow for its construction, namely the Territorial Coherence Plan for the Pays Barrois (117), the Portes de Meuse - de la Haute Saulx Intermunicipal Local Urban Planning Plan (118), and the Gondrecourt-le-Château Local Urban Planning Plan (138).

3.15 Interactions and cumulative impacts

3.15.1 Interactions between different environmental media – initial state

» ECOSYSTEM SERVICES

Ecosystem services refer to “human use of the functions of certain ecosystems, through practices and regulations that govern this use.” Ecosystem services can be defined as the benefits humans derive from their environment.

Ecosystems, particularly the natural environment, are exploited by human activities to extract raw materials, including plant and animal products, wood, and water (provisioning services). These ecosystems are subjected to pressure in order to optimise production yields. The natural environment is also used for recreational activities (sociocultural services), including hunting, fishing, and gathering, which are widely practiced in the remote study area.

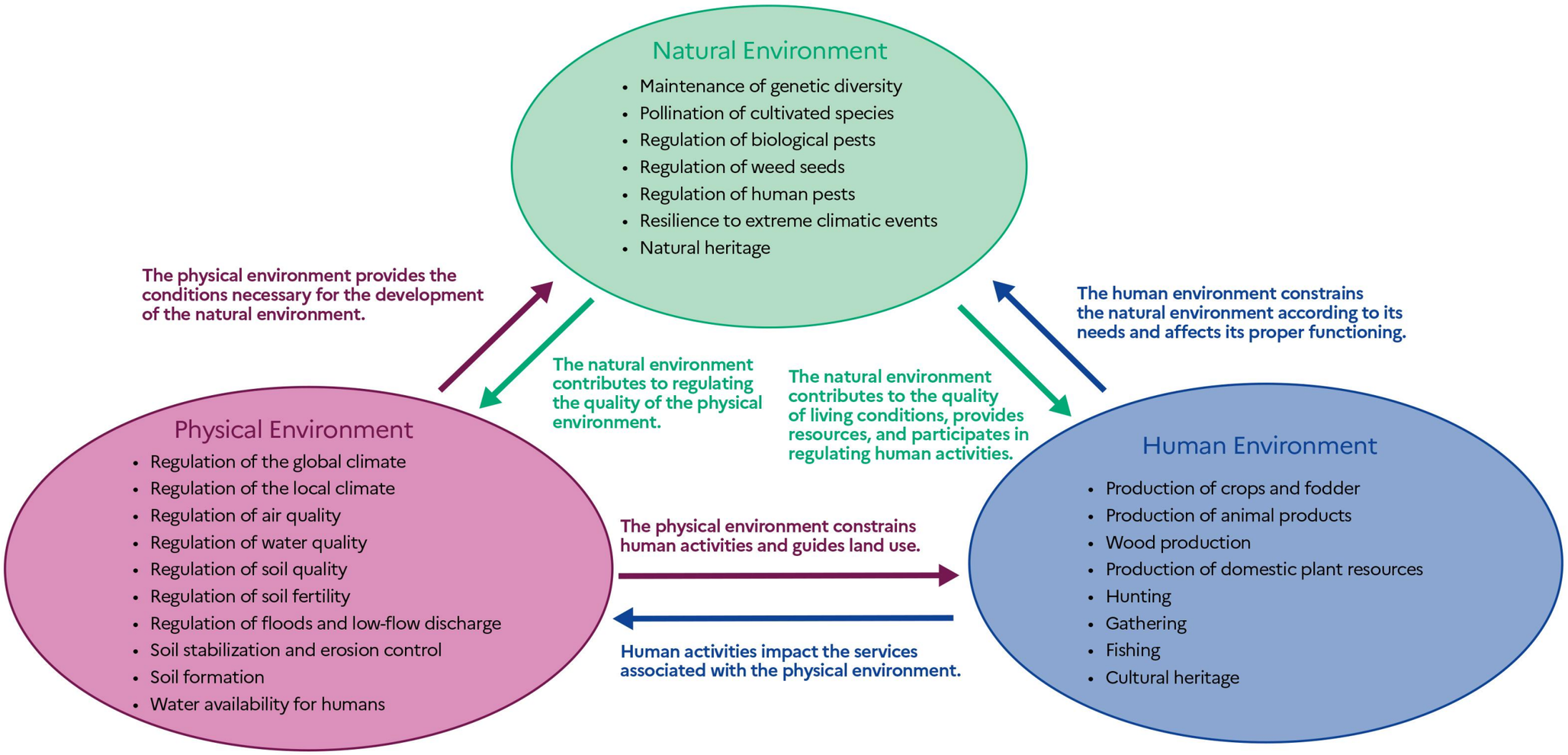
Through these uses, human activities have a significant impact on the functioning of ecosystems and, consequently, on the services they provide.

The levels of production and quality of these provisioning and socio-cultural services depend both on the intrinsic regulatory services of natural environments (supported by biodiversity) and physical services (supported by the state of the atmosphere, water, and soil), as well as on broader external factors (climate variations, atmospheric deposition, pollution, population pressure, societal changes, regulatory changes, etc.).

The regulatory services governing the state of the physical environment (climate, air, water, soil) are intimately linked to the major geochemical cycles of water, energy, and matter that define the conditions necessary for the development of the natural environment (biodiversity). In turn, the natural environment also actively participates in the processes underlying these major cycles and thus in the regulation of the quality of the physical environment. Finally, these regulatory services are also affected by the broader-scale external factors mentioned above.

By preserving the quality of the environments and biodiversity around the Cigéo disposal facility, the functioning of ecosystems should be minimally impacted. However, services related to soil properties, the maintenance of conditions conducive to biodiversity, and recreational activities such as hunting and fishing will be the subject of particular attention due to their direct link to the nature of the project’s work (land-use change, land development, habitat destruction, wastewater discharge, etc.).

The figure 3-72 summarises the main ecosystem services associated with the physical, natural, and human environments, as well as the interactions between them.



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Figure 3-72 *Interactions and ecosystem services among different environments*

3.15.2 Interactions within the Cigéo project and ecosystem services

CONCEPTS OF INTERACTIONS AND ECOSYSTEM SERVICES RELATED TO THE CIGÉO OVERALL PROJECT

Interactions arise from the complex relationships that exist within each environment (physical, natural, or human) and between environments. These complex relationships are essential for maintaining ecosystem functionality and ecological balances. Thus, a disturbance in one environment can, through a cascade effect, have consequences for other environments. For example, any significant impact on a factor of the physical environment (atmosphere, water, soil, or subsoil) can, through these interactions, affect another factor of the physical environment and/or factors of the natural environment (habitats, flora, and fauna) and/or the human environment (socioeconomics, land use, sociocultural activities, health, etc.). These multiple possible combinations of interactions make it complex to assess the overall impacts of a regional project such as the Cigéo project.

The concept of ecosystem services thus provides a simplified, holistic approach to the interactions between the physical environment, the natural environment, and their use by human societies. It highlights the fact that if interactions within and between these environments are disrupted, this can have consequences for the services that ecosystems provide to humans (e.g., production of goods, regulation of environmental quality). Ecosystem services thus encompass the complexity of these interactions and can enable a qualitative or quantitative assessment of the impacts of the Cigéo overall project.

The assessment of the 24 ecosystem services identified in the extended study area remains, however, complex and subject to numerous approximations. Based on the premise that significant direct impacts are most likely to trigger multiple interactions and thus disrupt ecosystem services, the simplified analysis presented here focuses on the consequences of residual direct impacts (after reduction and avoidance but before offsetting) classified as significant (moderate to very high). This approach also takes into account low or very low direct impacts that could, through cumulative effects, contribute to significant interactions. The approach is to present these interactions and, where relevant, to detail only the ecosystem service(s) significantly impacted by the Cigéo overall project.

3.15.2.1 Interactions due to disturbances of the physical environment

Interactions result from the complex relationships existing within each environment (physical, natural, or human) and between environments.

The interactions of the Cigéo overall project resulting from disturbance of the physical environment are primarily linked to land conversion. This land conversion also has consequences for ecosystem services provided by natural and human environments that depend on the land. Thus, land conversion primarily impacts agricultural and forestry activities. This is why Andra is implementing offsetting measures designed to maintain the balance of the local economy.

No significant impact is expected on drinking water use or water quality.

3.15.2.2 Interactions resulting from disturbances to the natural environment

The impact of the Cigéo overall project, even after the implementation of avoidance and reduction measures, remains significant on habitats and on species within certain biological groups, such as birds and bats. The Cigéo overall project therefore has a direct impact on natural environments. However, this direct impact has no effect on interactions between the natural environment and the other two environments (human and physical) or on relationships among factors within the natural environment.

Indeed, the destruction of habitats or individuals associated with the Cigéo project works is not of sufficient magnitude to harm the conservation status of species or groups of species with essential and unique ecological functions. No significant impact is expected on the biodiversity-related services of species and habitats within the natural environment.

The disturbances to the natural environment caused by the Cigéo overall project are too minor—particularly in terms of the areas and types of habitats affected—to result in significant interactions with the physical environment. Indeed, ecological functions are only slightly impacted by the Cigéo overall project, and consequently, the impacts on the ecosystem services provided (in this case, regulatory services) are also minor.

The expected changes to the natural environment will not have a significant impact on human activities carried out within these environments, such as foraging, hunting, fishing, or nature walks.

3.15.2.3 Interactions resulting from disturbances to the human environment

The main interactions of the Cigéo overall project related to the human environment primarily concern the effects of potential population growth.

In terms of ecosystem services, the interactions affect the production of agricultural and forestry goods as well as natural heritage. Regarding the production of goods, the implementation of the Cigéo project alters the dominant local economic activity—which is primarily rural and centred on agriculture and forestry—by introducing all aspects of industrial activity and landscape. These residual impacts, after avoidance and reduction measures, on economic, agricultural, and forestry activities range from moderate to significant. This impact is reduced by the implementation of agricultural and forestry compensation measures.

With regard to the natural environment, the implementation of the Cigéo project introduces a more industrial aspect to a rural landscape, which may alter residents' perception of it. The implementation of avoidance and reduction measures results in significant impacts on this service from certain perspectives during the preliminary construction phase, but minor impacts during the operational phase, once the landscape plantings have matured.

3.15.2.4 Altered ecosystem services

Before offsetting, the most significant residual direct impacts of the Cigéo overall project relate to soils—which are partially impervious or altered—water, certain species and their natural habitats, economic activities, local infrastructure, demographics (population), the living environment, and the landscape.

Thanks to avoidance and reduction measures, the other potential direct impacts are only minor or very minor. Through the interactions between environments and between the factors within these environments, all direct impacts may then have—sometimes cumulatively—effects on the state of the environments and the ecosystem services they provide.

Analysis of these interactions leads to the conclusion that the ecosystem services altered by the Cigéo overall project are:

- the service regulating soil quality and fertility;
- the agricultural production service;
- the timber production service;
- the water supply service for agricultural water use;
- the natural heritage service.

3.15.3 Cumulative impacts of the project with other existing or approved projects

CUMULATIVE IMPACTS

The concept of cumulative impacts refers to the possibility that the temporary or permanent impacts caused by the Cigéo overall project may add up to those of other existing or approved projects.

SOURCES AND METHODOLOGY

To analyse the potential cumulative impacts of the project with any other surrounding projects (in accordance with Article R. 122-5, II, 5° e) of the French Environment Code), a survey of existing or approved projects was conducted (as of August 2023).

To this end, discussions were held with the Departmental Directorates for Territories, the prefects of Meuse and Haute-Marne, and the websites of relevant administrative bodies (Regional Directorates for the Environment, Planning, and Housing; Prefectures; General Council for the Environment and Sustainable Development; Ministry of Ecological and Solidarity Transition) were consulted.

Projects likely to have cumulative impacts were identified by cross-referencing the criteria of project type, distance, and timeframe. The cumulative impacts of the identified projects were then analysed in relation to the key factors highlighted by the Environmental Authority in its opinions, as well as those likely to interact with the Cigéo overall project, given the project's potential impacts.

Several projects were excluded after cross-referencing the project type and distance criteria:

- water management projects (maintenance/restoration of watercourses, water abstraction, stormwater management, dams, ports, etc.) do not affect the water bassins or water bodies impacted by the Cigéo overall project;
- agricultural projects do not interact with the dominant agricultural activities in the close agricultural study area;
- land and agricultural development projects are too far away to interact with farms in the immediate agricultural study area;
- urban developments around Nancy, Reims, Metz, Mulhouse, and Strasbourg that do not interact with the agricultural area where the Cigéo overall project is located, and those that are too far from the Cigéo overall project to interact with it;
- projects related to waste treatment, notably the waste storage facility in Toul—the closest one, intended for household waste—which have no interaction with the Cigéo overall project;
- land-clearing projects located far from the immediate study area of the Cigéo overall project, with no particular environmental sensitivity, and covering only moderate areas;
- industrial projects are distant from the Cigéo overall project, and their main issues (health impacts, waste generation, road traffic) remain localised; they are therefore unlikely to have a cumulative negative impact when combined with the Cigéo overall project.

The quarry projects will be able to meet the significant needs of the Cigéo overall project for construction materials. These projects therefore contribute, in a complementary manner, to the economic development of the Grand Est region. Furthermore, the increase in materials available in the region of the Cigéo overall project helps reduce transport distances and thus the carbon footprint. All these quarry projects are therefore likely to have a positive cumulative impact when combined with the Cigéo overall project. This positive aspect is not analysed in detail. Depending on their location and nature, the quarry projects are analysed in the same way as other projects.

Thirty-seven projects are likely to have cumulative impacts with the Cigéo overall project: eleven wind farms, two industrial sites, nine photovoltaic power plants, the restart of an underground natural gas storage site, four urban development projects, six hydraulic engineering projects, one land clearing project, one road development project, one quarry project, and one agricultural and forestry land-use project. All of these projects will be operational when work on the Cigéo overall project begins; therefore, only the permanent impacts during the construction phase and the impacts during the operational phase are analysed.

The wind farm projects at Les Limodores, La Combe Rougeux, Le Piroy, the Ajoux Plateau, La Côte des Moulins, La Pavelotte, La Haie du Moulin, Petite Montagne, and La Côte are located between approximately 10 km and 30 km from the Cigéo overall project. The wind farm projects at Les Lavières, Les Muids, and Nouvellois are located approximately 1 km to 5 km from the Cigéo overall project. The main potential cumulative impacts associated with these projects concern the landscape and biodiversity (birdlife and bats). However, given their distant locations, the lack of ecological connectivity between the wind farm projects and the Cigéo overall project, and the avoidance, reduction, and offsetting measures implemented by each project, no significant cumulative impact on biodiversity is expected. This distance also contributes to the absence of cumulative landscape impacts between the wind projects and the Cigéo overall project.

The industrial laundry project is intended for the cleaning of lightly or non-contaminated linens from nuclear facilities. The project involves the construction and operation of two buildings designed to clean linens, equipment, and tools for various clients in the French and European nuclear industry. These buildings are equipped with nuclear ventilation systems (with a retention capacity of over 99% for radioactive aerosols). Treatment of the liquid effluents generated by the washing process allows for discharge into the Marne River while complying with the limit values imposed by regulations. The cumulative impacts with the Cigéo disposal facility are negligible due to the 15 km separating them, a distance sufficient to prevent the accumulation of their low levels of chemical and radioactive discharges and to rule out any risk of co-visibility. This laundry facility has the advantage of reducing transport distances for the processing of cleanroom suits for the French nuclear sector—the nearest equivalent of which is currently located in Denmark—and it also has positive cumulative impacts on the regional socio-economic context when considered alongside the Cigéo overall project.

The project to build a charcoal production site is located in the municipality of Saudron, at a place called Le Clair Chêne. At this same location is the platform associated with two planned drillings as part of the initial operations prior to environmental characterisation and monitoring (DR0 operations). The charcoal production site project covers an area of approximately 30 hectares. Construction is scheduled to take approximately 18 months and is expected to begin in 2025. Work related to Andra's drilling operations is planned for around 2026. Minor cumulative impacts may be expected regarding traffic, noise, and vibration; the latter will be negligible.

The photovoltaic power plant projects are located less than 20 km from the Cigéo overall project, notably the Bure photovoltaic power plant, situated on land adjacent to the Cigéo disposal facility. Their commissioning is expected before the start of preliminary works period for the Cigéo overall project; thus, the expected cumulative impacts relate only to their operational phase. The main potential cumulative impacts associated with these projects relate to the use of natural areas, biodiversity, and the landscape. The impacts on the natural environment (use of natural areas and biodiversity) are limited to the immediate vicinity of the photovoltaic power plants. Finally, given the distance between the various projects (no co-visibility) and their landscape integration measures, no cumulative impacts on the landscape are expected; this also applies to the Bure photovoltaic plant, located near the Cigéo disposal facility.

The restart of the Trois-Fontaines-l'Abbaye underground natural gas storage facility is located 17 km from the Cigéo overall project. The independent expert assessment by the French Geological Survey (BRGM), conducted as part of the environmental impact assessment for the Trois-Fontaines-l'Abbaye site, concludes that the Cigéo disposal facility project will have no impact on risks related to the subsurface. There will be no cumulative impact on the topics of the subsurface, biodiversity, groundwater and surface water, and hazards due to the distance between the two projects.

Urban development and hydraulic engineering projects do not result in cumulative impacts with the Cigéo overall project given their nature (construction/demolition of buildings, bridge restoration), their timing (already completed or work starting before 2025), and their location (near the 027000 railway line and up to 30 km from the ramp zone).

The installation of Andra's piezometers involves the placement of 23 PVC pipes (Rhoméo pipes). The project consists of monitoring groundwater levels in the Orge and Bureau valleys to determine the water supply to the two wetlands. At the end of the data collection period (fall 2023), the equipment will be dismantled and the site restored to its original condition. Therefore, the work for this project is not concurrent with that of the Cigéo overall project. Consequently, no cumulative impact is expected for these projects during the construction and operation phases.

Since the project to restore ecological continuity on the Ornain was completed in 2022, no cumulative impact with the Cigéo overall project is expected on bats.

The land clearing project at the site known as "Les Combes" is located within the Type I ZNIEFF (Site of Natural Interest for Fauna and Flora) designated for bat roosts in Chassey-Beaupré, which is also covered by the Environmental Impact Assessment (EIA). Given the small areas affected, the confirmed absence of bat roosts, and the ecological and forestry mitigation measures implemented, there will be no cumulative impacts with the Cigéo overall project.

The N135 national highway development project, which was submitted for public review in 2019, involves the construction of a new 3.3-kilometre section of the N135 national highway between Ligny-en-Barrois and Tronville-en-Barrois. This will allow traffic to bypass the village of Velaines. Work on the bypass is underway as of the date of this report and is expected to continue through 2027. The National Route N135 bypass includes an underpass crossing of the 027000 railway line, coordinated with SNCF Réseau in alignment with the Cigéo overall project.

It also includes large-scale hydraulic structures (bridge, viaduct), notably for crossing the Ornain River. The current railway crossing of the Ornain River serves as a baseline for the design of the future crossing of this same watercourse by the proposed National Route N135 bypass. The latter also includes plans for the restoration of watercourses. The proposed National Route N135 bypass does not increase the risk of flooding.

As part of the National Route N135 development project, agricultural and forest land readjustment is planned in the municipalities of Velaines, Nançois-sur-Ornain, and Ligny-en-Barrois. These are separate municipalities located more than 8 km away from those affected by the AFAF (Agricultural and Forest Land Readjustment) component of the Cigéo overall project. Thus, no cumulative impacts are expected in terms of land acquisition and agricultural parceling between the AFAFs of the Cigéo overall project and those related to the N135 national highway bypass.

The potential cumulative impacts of the projects therefore do not result in significant impacts, whether on infrastructure, watercourses, or their hydrological regime.

The project to continue operating a limestone quarry in the municipalities of Burey-en-Vaux and Maxey-sur-Vaise includes, among other things, a 1.5-hectare stripping operation. No ecological connectivity has been identified between this quarry and the Cigéo overall project. The project related to the Maxey-sur-Vaise quarry and the Cigéo overall project are located in two different valleys. Therefore, these projects have no significant cumulative impact on the natural environment, biodiversity, or the landscape.

The agricultural and forestry land-use planning (AFAF) project in the municipalities of Sommelonne and Saudrupt aims to improve agricultural operating conditions in the municipalities. Given the distance from the Cigéo overall project (approximately 18 km), the nature of the project (land consolidation), and the respective impacts and mitigation measures of these two projects, no cumulative impact is expected between them.

The cumulative impacts of the Cigéo overall project with other existing or approved projects are very low.

3.16 Best available Technologies

METHODOLOGY

The environmental impact assessment for the Cigéo overall project must include a comparison with the Best Available Techniques (BAT), as listed in the reference documents adopted by the European Commission pursuant to Directive 2010/75/EU of the European Parliament and of the Council of November 24, 2010 on industrial emissions (149).

At this stage of the studies and procedures associated with the implementation of the Cigéo overall project, the comparison with Best Available Techniques is conducted for the Cigéo basic nuclear installations (BNI). For the project's other operations, comparisons will be made, if required, within the framework of the procedures applicable to them; they will then be presented in an updated version of the impact assessment.

Article R. 593-93 of the French Environment Code specifies that for basic nuclear installations, this comparison with the best available techniques applies to the "IED facility," defined as comprising:

- the BNI, at least one of whose activities is listed in Annex I of the IED Directive;
- equipment, facilities, structures, works, or activities located or carried out within the boundaries of the BNI and under the responsibility of the same operator, which are necessary for the operation of said BNI;
- the facilities or equipment directly related thereto, operated on the same site, technically linked to the first two categories, and likely to have an impact on the emissions and pollution of the latter.

Once the "IED facility" has been defined, a comparison is made with the Best Available Techniques listed in the reference documents adopted by the European Commission.

The impact assessment must include details regarding the measures planned for the application of Best Available Techniques, pursuant to Articles R. 122-5, R. 593-17, and R. 593-94 of the French Environment Code:

- the content of the environmental impact assessment for proposed works, structures, and developments is established by Article R. 122-5 of the French Environment Code. It specifies that for a Basic Nuclear Installation, the impact assessment is supplemented in accordance with the provisions of Article R. 593-17 of the French Environment Code, and in particular that it must demonstrate the use of Best Available Techniques);
- when the BNI involves one or more activities listed in Annex I of Directive 2010/75/EU of the European Parliament and of the Council of November 24, 2010 on industrial emissions (referred to as the IED Directive and referred to as such throughout the remainder of this chapter) (149), the impact assessment includes the information required by Article R. 593-94 of the French Environment Code, in particular a comparison of the operation of such activity or activities with the BATs described in the reference documents adopted by the European Commission.

The IED aims to prevent and reduce emissions into the air, water, and soil from certain industrial activities listed in its Annex I. It specifies that BATs are defined as the most effective and advanced stage of development of activities and their operating methods, demonstrating the practical suitability of specific techniques to serve, in principle, as the basis for emission limit values aimed at preventing and, where this proves impossible, generally reducing emissions and the impact on the environment as a whole:

- "technologies" refers both to the technologies used and to the way in which the facility is designed, constructed, maintained, operated, and decommissioned;
- "available" refers to techniques developed on a scale that allows them to be applied in the context of the relevant industrial or agricultural sector, under economically and technically viable conditions, taking into account costs and benefits, whether or not these techniques are used or produced domestically, provided that the operator concerned can have access to them under reasonable conditions;
- "best" refers to the techniques most effective in achieving a high overall level of protection for the environment as a whole.

Based on these elements of the regulatory context, and at this stage of progress in the studies and procedures associated with the implementation of the Cigéo overall project, the comparison with the Best Available Techniques is made for:

- the Cigéo BNI and the equipment, facilities, structures, works, or activities necessary for its operation, namely:
  - ✓ in the area where the underground structures are located:
    - the disposal areas for radioactive waste packages in the Callovian-Oxfordian layer;
    - the associated logistics support areas (operation and construction).
  - ✓ in the ramp zone:
    - the BNI's surface nuclear facilities and structures (nuclear rail terminal, surface nuclear buildings, horizontal transport package unloading facility (ETH), and package ramp head);
    - the service shaft head, a facility supporting BNI operations.
  - ✓ in the shaft area:
    - facilities supporting underground structure excavation activities (construction shaft);
    - facilities supporting the disposal of Callovian-Oxfordian excavation excavated materials deposit in the construction shaft and storage areas (facilities for the transfer, storage, and, where applicable, treatment of excavated materials);
    - facilities supporting the operation of the BNI (production shafts).
- facilities or equipment directly related to the BNI, operated on the same site (namely the Cigéo disposal facility, including the BNI), technically linked to the BNI and to the equipment, facilities, structures, works, or activities necessary for its operation, and likely to have an impact on the emissions and pollution associated with the latter, namely:
  - ✓ facilities for the management of associated waste;
  - ✓ facilities for managing aqueous effluents;
  - ✓ facilities for the production and transfer of "hot water" used to heat the fresh air introduced into the underground zones;
  - ✓ facilities for the production and transfer of "chilled water" used to cool the stale air extracted from underground areas.

Two categories of activities listed in Annex I of the IED are selected and covered by the application for a permit to establish the Cigéo BNI :

- *"5.6. Underground disposal of hazardous waste, with a total capacity exceeding 50 tons,"* corresponding to the activity carried out at the deep geological repository for radioactive waste (the ZIOS of the Cigéo disposal facility)⇨ this is the primary activity identified under the IED;
- *"5.5. Temporary storage of hazardous waste not covered by point 5.4, pending one of the activities listed in points 5.1, 5.2, 5.4, and 5.6, with a total capacity exceeding 50 tons, excluding temporary storage at the site where the waste is generated, pending collection,"* corresponding to the activity carried out in the EP1 and EP2 nuclear buildings.

The selected BAT reference documents are as follows:

- *"Conclusions on best available Technologies for waste treatment"* under Directive 2010/75/EU of the European Parliament and of the Council(149), adopted by Commission Implementing Decision (EU) 2018/1147 of August 10, 2018 (150) ;
- *Best Available Techniques Reference Documents* (BREFs)*: "EFS – Emissions from Storage" (151), "ENE – Energy Efficiency" (152), "ICS - Industrial Cooling Systems" (153)* and *"BREF ROM - General Principles for Monitoring Emissions to Air and Water from Installations Covered by the Industrial Emissions Directive" (154).*

The BATs mentioned in the above documents are applicable to the activities of receiving waste packages shipped by producers, inspecting and preparing them for disposal, and transferring them to the underground facility where they are placed in disposal cells according to their nature and activity, as well as waste disposal.

In addition, the BREF titled "MWEI – Management of Waste from the Extractive Industries," adopted pursuant to Directive 2006/21/EC of March 15, 2006 (155) concerning the management of waste from the extractive industries and amending Directive 2004/35/EC, is also applied to the potential recovery of tailings.

3.16.1 Analysis in light of conclusions on Best Available Techniques and sector-specific *Best Available Techniques Reference Documents (BREFs)*

The comparison with BAT is applied, on the one hand, during design choices and, on the other hand, during the selection of measures to avoid and reduce potential impacts. This chapter of the environmental impact assessment aims to justify the use of BAT, based on these choices, for the IED facility as defined.

To this end, a presentation of the reference documents and a comparison of the selected design choices/measures with the BATs listed in these documents are provided. For each reference document analysed, the measures planned within the project to meet the selected BATs are highlighted. The main ones are specified below; for further details, the reader is invited to refer to Chapter 17 of Volume IV of this impact assessment.

Generally speaking, during the design studies, the decision was made to locate the Cigéo repository away from urbanised areas and to situate it, as far as possible, outside of sensitive areas, particularly those with exceptional underground resources.

An integrated environmental management system known as SMI (ISO 9001:2015 (156), ISO 14001:2015 (157), ISO 45001 (158), ASN Guide No. 30 (159)) is implemented and enables continuous improvement in addressing environmental preservation. Within the framework of this SMI:

- procedures for the characterisation and acceptance of waste received and processed at the BNI, a system for tracking and inventorying this waste, and procedures for the handling and transfer of waste are established and implemented;
- the frequency of monitoring water and energy consumption is defined in accordance with applicable regulations, administrative requirements, and relevant decrees;
- an inventory of generated aqueous and gaseous effluent streams and an environmental monitoring plan are established and regularly updated, in accordance with applicable regulations, the administration, and the permits obtained (for facilities within the BNI scope, these comply with the requirements of the regulations applicable to BNIs).

To reduce the environmental impact and risk associated with the receipt, handling, transfer, and disposal of radioactive waste:

- the transport of radioactive waste packages is carried out in packaging that meets the protection criteria set by hazardous materials transport regulations, and the packages are prepared according to acceptance specifications established by Andra;
- within the perimeter of the Cigéo disposal facility, the layout of the BNI has been optimised to minimise unnecessary handling of waste packages. In particular, the facilities required to perform all operations necessary for handling the packages—from their receipt through to their transfer to the underground disposal infrastructure—are grouped together in the operational area of the ramp zone;
- within the BNI, waste packages are transported through the nuclear facility, which consists of a closed, climate-controlled building (thus protected from the elements and significant temperature spikes), where the floors of areas presenting a risk of contamination are sealed. The dwell time of the waste in the buffer zone of the nuclear facility (before descent into the underground zone) is limited. The descent of the packages to the underground disposal facilities and the handling operations for disposal are automated. The nuclear facility is also equipped with dedicated ventilation systems, featuring very high-efficiency filters and discharge vents channeled high above ground level. Continuous monitoring of the filtration systems for nuclear ventilation is performed via leak detection at the discharge vents;
- and the stored inventory is continuously monitored. The design of the underground facility ensures that the subsurface characteristics favourable to the containment of radioactivity are maintained, and a protection perimeter is defined.

Regarding the rational use of natural resources:

- the design of the Cigéo disposal facility aims to preserve local resources used for drinking water supply. It prioritises the recycling and reuse of water generated by its operations. To this end, each surface facility (shaft zone, ramp zone) is equipped with a wastewater and industrial water treatment plant and a seepage water treatment system. Water consumption is monitored *via* meters distributed throughout the Cigéo disposal facility. In addition, the networks and equipment undergo regular maintenance. To detect leaks, the networks (chilled water, hot water, fire protection water, drinking water) are monitored by tracking pressure and/or flow rates. Finally, the networks are designed to be isolated in sections if necessary, allowing for the quantification of a leak, if applicable;
- Energy efficiency is periodically assessed in the environmental evaluations conducted as part of ISO certification, and improvement objectives may be defined in the SMI's environmental management plan. Energy consumption is monitored *via* meters distributed throughout the Cigéo disposal facility, and optimisation measures may be implemented throughout the facility's operational life, taking technological advancements into account. An energy audit is conducted periodically.

Regarding the management of stormwater and conventional and unconventional liquid effluents:

- For the management of aqueous effluents, the principle of separate sewer systems is applied. No non-conventional liquid effluents are discharged into the local environment. Management and treatment systems are in place to ensure that discharges of stormwater and conventional liquid effluents comply with applicable standards for discharge into the local environment; these discharges are monitored;
- The stormwater and conventional liquid effluent management structures are designed and sized to collect pollution in the event of runoff onto the disposal facility, particularly from roadways or firefighting water in the event of an incident. Additionally, stormwater from the nuclear rail terminal is collected and directed to two containment basins for radiological monitoring;
- non-conventional liquid effluents are stored in dedicated tanks (placed on retention basins and equipped with safety levels) or directly in the affected areas in the event of a fire or pollution (premises in areas where nuclear waste may be produced are retained *via* thresholds and an impermeable floor).

Regarding air emissions:

- measures to limit dust emissions are planned:
  - ✓ depositing spoil in a dedicated area away from urbanised zones (in the shaft zone);
  - ✓ to the extent possible, adapting equipment and machinery to limit emissions;
  - ✓ depending on weather conditions, misting of spoil awaiting covering;
  - ✓ internal transport of Callovo-Oxfordian spoil via a semi-underground, enclosed conveyor belt;
  - ✓ processing of Callovo-Oxfordian spoil, when the spoil is reclaimed in preparation for the closure of the facilities, inside a closed building.
- Measures to limit noise and vibration emissions are planned:
  - ✓ For construction sites:
    - suspension of work likely to cause a nuisance to the neighbourhood between 10 p.m. and 7 a.m. (in the event that night work is necessary, exemptions will be requested in accordance with local regulations);
    - selection of the least noisy machinery and equipment;
    - delivery of materials by train followed by internal transport via a semi-underground conveyor belt.
  - ✓ For the actual operation of the Cigéo disposal facility:
    - handling of received waste inside a closed building or in an underground area;
    - selection of the quietest equipment and silent extraction systems for the ventilation plants;
    - internal transport of Callovian-Oxfordian overburden via a semi-underground, enclosed conveyor belt;
    - processing of Callovo-Oxfordian overburden, during the removal of backfill in preparation for facility closure, inside a closed building;
    - Noise barriers and walls installed or constructed to mitigate emissions towards sensitive areas.

Finally, an internal emergency plan, specifying the organisation as well as the material and human resources for managing accident situations, is established prior to the facility's commissioning. Procedures are implemented to detect incidents and accidents, respond to them, and learn from them; these are included in the SMI. Procedures are implemented to detect incidents and accidents, respond to them, and learn from them.

3.16.2 Proposals for BATs specific to the activity of underground disposal of radioactive waste at the Cigéo disposal facility

In accordance with Article R. 593-94 of the French Environment Code, the analysis is supplemented by a proposal for Best Available Techniques for the activity of underground disposal of radioactive waste.

The proposed BATs aim to design the Cigéo disposal facility so that people and the environment are protected, in the long term, from the radionuclides and toxic chemical substances contained in radioactive waste, without the need for intervention (passive safety).

The BAT proposals for the underground disposal of radioactive waste at the Cigéo disposal facility are:

- Long-term protection of people and the environment relies on the selection of the Callovian-Oxfordian formation, which plays a central role in this protection. It possesses favourable characteristics (low permeability, high retention, thickness, etc.) for limiting the transfer of radionuclides and toxic chemical substances from the disposal facility to the geological formations above or below the Callovo-Oxfordian layer, and subsequently to the biosphere;
- the design of the repository is based on the acquisition and consolidation of knowledge regarding, in particular, the geological environment and the assessment of the behaviour of engineered components and their interactions with the Callovo-Oxfordian layer; it also incorporates provisions (architectures, engineered components, etc.) that further help limit the migration of radionuclides and toxic chemical substances into the biosphere;
- the disposal facilities are located deep underground (approximately 500 metres) within the Callovo-Oxfordian layer, in an area lacking exceptional or specific underground resources, away from surface phenomena (particularly erosion) and unintended human activities (road construction, building construction extending to a depth of several tens of metres);
- as soon as the Cigéo disposal facility is constructed, a process to preserve records for as long as possible (*at least* 500 years) is implemented;
- The processes and techniques used are either proven or implemented following testing either in an underground laboratory (in particular the Meuse/Haute-Marne Underground Research Laboratory) or in an above-ground technology facility;
- the performance, robustness, and acceptability of the long-term health impact are subject to an iterative long-term impact assessment process recognised by national authorities and international bodies (IAEA). This process verifies that the long-term health impacts associated with the few radionuclides that might reach human water intake points (discharge points), assessed to represent the expected operation of the disposal facility, remain below the reference value of 0.25 mSv/year provided by the safety guide and below the regulatory value of 1 mSv/year provided in the French Public Health Code. The robustness of the disposal system is verified by quantifying scenarios deviating from normal operation, such as those involving the assumed malfunction of a major component (verification of the lines of defense in place);
- Andra participates in exchanges, R&D programs, and scientific and technological innovation initiatives focused on scientific and technological knowledge, and on safety, particularly at the international level;
- To enable future generations to either continue the construction and subsequent operation of successive phases of a disposal facility or to reassess previously defined choices and adapt management solutions, the various components of "reversibility" are implemented.

Conclusion

All measures taken meet the requirements of the BAT reference documents adopted by the European Commission and selected for the analysis.

The analysis is further supplemented by a proposal for best available techniques for the underground disposal of radioactive waste at the Cigéo disposal facility.

3.17 The impacts of decommissioning, closure, and post-closure operations

The protection of people and the environment is the fundamental safety objective of deep geological disposal. Thus, the Cigéo repository is designed to ensure safety from its construction through to several hundred thousand years after its closure. In the long term, after the repository is closed, safety is ensured passively (without human intervention).

3.17.1 The Impacts of Decommissioning and Closure Operations

At the end of the operational phase, all surface facilities at the Cigéo disposal facility will be permanently shut down and decommissioned. The underground facility will also be gradually closed. Decommissioning must be authorized by a decree, and only a law can authorize the permanent closure of the Cigéo disposal facility.

The main impacts will be related to the nuisances associated with these operations, such as noise and vibrations, as well as the quantities of waste generated, primarily conventional waste and dust resulting from demolition work and earthmoving.

Given technological advancements, the measures currently planned will be refined to reduce impacts on people and the environment.

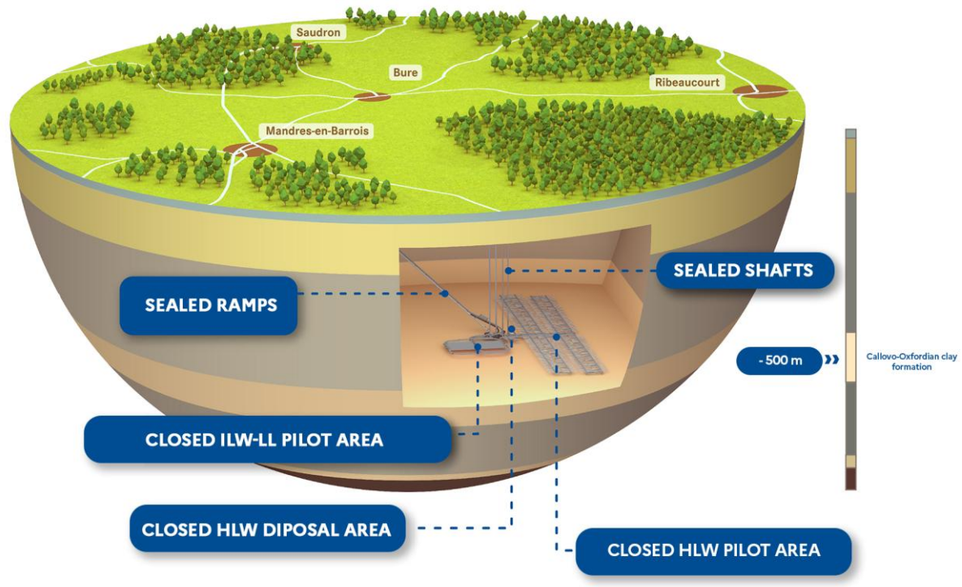
The so-called “vive” excavated materials deposit (for backfilling), accounting for approximately 40% of the total volume of excavated Callovian-Oxfordian rock, will be used, after processing, as backfill material for the sealing and permanent closure of the disposal cells, the galleries of the underground facility, logistics support areas, disposal quarters, and surface-underground connections, once the Cigéo disposal facility has ceased operations. The topography in the area where the excavated materials deposits area is located will be altered following its reuse for the closure of the underground facility, as well as the shafts and ramps. The buildings, particularly the surface structures, will be removed. However, given the measures taken to integrate the facility into the landscape from the construction phase onward, the landscape will be minimally impacted by these operations. The landscaping following the decommissioning and closure operations will provide an opportunity to seek a positive impact on the landscape, the living environment, and biodiversity in consultation with the needs that will then be expressed by the local community.

The residual impacts during decommissioning and closure operations are at the same level as during construction operations, except for the significant generation of waste during this phase.

3.17.2 Impacts following the final closure of the repository

The Cigéo disposal facility is designed to be closed at the end of its operational phase to provide long-term protection for people and the environment without requiring further human intervention. Safety is ensured passively, meaning that people and the environment are protected from the radioactive elements and toxic chemicals contained in the radioactive waste without the need for intervention. Long-term protection of people and the environment relies on the Callovian-Oxfordian formation, which plays a central role in this protection, supplemented in particular by engineered measures such as surface-underground connections seals that block access to the underground structures.

The underground facility and the Callovo-Oxfordian host rock constitute the post-closure disposal system.



CG-TE-D-MGE-AMOA-SR0-0000-22-0031-A-EN

Figure 3-73 Illustration of the Cigéo disposal facility after closure

Following the decision to authorize closure, the Cigéo BNI enters the monitoring phase. Environmental monitoring during the monitoring phase consists of verifying the absence of contamination, relying in particular on monitoring of surface water quality and air quality. Its duration has not yet been determined but could span several centuries, similar to what is planned for surface disposal facilities.

Following the decision to decommission the Cigéo BNI, the “post-monitoring” phase begins, marking the end of monitoring activities. Only systems designed to preserve disposal records will remain in place for as long as possible. By definition, this phase has no end. It corresponds to the time horizon targeted by the objective of permanently securing radioactive waste, as established by the French Environment Code. This concept is used in particular in safety assessments. It allows for the characterization of very long-term radiological and chemical impacts following the decommissioning of the facility. The safety assessment assumes the end of all institutional oversight and the loss of awareness of the disposal facility’s existence. The Cigéo disposal facility is designed so that safety can be guaranteed in a completely passive manner during this phase.

Once the underground facility is permanently closed—that is, once the underground structures, shafts, and ramps have been backfilled and sealed—the HLW and ILW-LL waste packages will slowly degrade over time. The radionuclides contained in these waste packages will gradually be released into the disposal cells. Water is the primary factor in the degradation of waste packages and the main vector for the migration of radionuclides and toxic chemical substances contained in the waste into the biosphere. The assessment of residual impacts on human health involves quantitatively evaluating the level of protection provided by the disposal system against the few radionuclides and toxic chemical substances that might eventually reach a discharge point (water extraction point) accessible to humans and used by them for their activities (drinking water, irrigation, animal watering, etc.).

The post-closure safety assessment aims to robustly ensure that the disposal system (natural environment, particularly the Callovian-Oxfordian host clay layer; engineered components of the disposal facility, particularly waste packages and seals; and the facility’s design) guarantees the protection of people and the environment over time.

The results of the post-closure safety assessment confirm the ability of the repository and the geological environment, particularly the Callovian-Oxfordian host clay rock, to ensure long-term safety. They highlight:

- the central role of the clay host rock due to its characteristics (low permeability, high radionuclide retention capacity, low migration of highly soluble radionuclides not retained due to low diffusion, great thickness, etc.);
- the complementary nature of the repository and its design. The latter aims to ensure that the favourable characteristics of the host rock are maintained (for example, by limiting the maximum temperature in the host rock to below 100 °C around exothermic waste compartments, such as high-level vitrified waste) and to take advantage of these favourable characteristics.

It is evident from all the post-closure safety assessment studies that, in the long term:

- the vast majority of radionuclides remain within the repository or in the Callovian-Oxfordian layer in its immediate vicinity;
- only a few radionuclides—those with long half-lives and high mobility—reach the edges of the host rock and then the discharge points, but in small quantities and diluted over time and space.

In terms of dose to humans, for the reference design-basis evolution scenario—representative of the expected behaviour of the repository—the maximum dose is on the order of 0.0015 mSv/year, thus well below the reference value of 0.25 mSv/year.

The conservative situation of the design-basis evolution, which constitutes a conservative estimate of impacts under normal disposal conditions, confirms the robustness of the disposal system in the face of residual uncertainties in knowledge. The health impacts on people remain well below the reference value (0.25 mSv/year) in the majority of the discharge pathways and biospheres studied, even when conservative assumptions are combined to increase the transfer of solutes to the biosphere. They are on the order of magnitude of this value for one of the “Pumping into the Oxfordian” pathways (for a single age class in the case of a warm biosphere).

The demonstration of the disposal system’s robustness is reinforced by the results of scenarios deviating from the normal evolution of the disposal system and its environment, particularly since these scenarios addressed both situations, notably the conservative situation of the design-basis evolution scenario, which is based on the conservative characteristics of the Callovian-Oxfordian layer.

The results of the assessments of these scenarios further highlight the central role of the Callovian-Oxfordian layer, even with conservative characteristics, reinforced by the aforementioned disposal design (in particular the modularity of the disposal or the lengths of the tunnels from the cells to the surface-underground connections structures). These results are essentially similar to those of the design-basis evolution scenario in terms of containment performance. The maximum human health impact in terms of annual dose remains of the same order of magnitude as that of the design-basis evolution scenario.

In all cases for the *non design-basis evolution*, *What-if*, and *Inadvertent human intrusion* scenarios, the maximum dose levels remain below the levels likely to induce deterministic effects and, in most cases, below the reference value adopted for the SEN (0.25 mSv/year).

All results thus confirm the robustness of the disposal system in the face of residual uncertainties in knowledge.

All results thus confirm the robustness of the disposal system in the face of residual uncertainties in knowledge. Environmental monitoring during the monitoring phase therefore consists of verifying the absence of contamination, relying in particular on the monitoring of surface water quality and air quality.

The assessment of the radiological and chemical impact on wildlife during the long-term post-closure period applies only to the design-basis evolution scenario (SEN). The radiological or chemical risk to wildlife in the Ornain River (the only natural outlet) can be ruled out (the hazard quotient indicators remain well below the value of 1).

3.18 Impacts on human health

3.18.1 Impacts of physical emissions on human health

The Cigéo overall project generates physical emissions, namely noise, vibration, light, odours, and electromagnetic fields.

Physical emissions have significant potential impacts and are subject to avoidance and mitigation measures. However, since these emissions propagate through the air and/or soil, they decrease significantly with distance.

The health impacts of these emissions have been the subject of scientific studies conducted at the national and even international levels. The results and analyses have led to the formulation of recommendations by national and international experts and to the establishment of nuisance thresholds and/or regulatory thresholds aimed at protecting public health. These data serve as a reference for assessing the potential health impacts of the Cigéo overall project on nearby residents.

3.18.1.1 Noise emissions

The most significant noise impacts of the Cigéo overall project are associated with site preparation works and initial construction work in the shaft and ramp zones over an extended period (approximately twenty years). Noise sources are varied, including earthwork operations using construction equipment such as jackhammers, material loading/unloading operations, road and rail freight traffic, and construction activities such as blasting for earthworks and shaft excavation, as well as the operation of concrete plants.

During the operational phase, noise emissions are primarily associated with the operation of facilities such as ventilation plants, the 400/90 kV electrical substation, the concrete plant supporting the construction of disposal cells continuing in the underground facility, and road and rail traffic for the movement of personnel and the transport of waste and material shipments.

Avoidance and reduction measures, along with their expected effects and monitoring procedures, are described in the “3.12.2.1” chapter of this non-technical summary.

The shaft zone and the inter-site link (LIS) are located more than 500 metres from residential areas. Trains operate only during the day (between 6 a.m. and 10 p.m.), with very rare exceptions on the terminal spur line and on rail line 027000. A semi-underground conveyor belt is installed to transport materials between the ramp zone and the shaft zone. Work likely to cause a disturbance to the neighbourhood is suspended between 10:00 p.m. and 7:00 a.m. In the event that night work is necessary, exemptions will be requested in accordance with local regulations. An earthen embankment and noise barriers are installed to protect residential areas. Other operations related to the overall project are located as far away from residential areas as possible.

During the preliminary works phase, future noise levels generated by the Cigéo overall project are below 60 dBA, corresponding to a typical background noise level. Only the noise level at the Hôtel du Bindeuil increases by more than 10 dBA, while remaining within a typical background noise level (<50 dBA).

During the initial construction phase, during daytime hours, the noise levels generated by the Cigéo overall project are below 60 dBA, corresponding to a typical background noise level. The noise level at the Hôtel du Bindeuil increases by more than 10 dBA while remaining within a typical background noise level (<60 dBA). For all other residences, the increase in noise level is less than 10 dBA.

During the initial construction phase, at night, the noise levels generated by the Cigéo overall project are below 55 dBA, corresponding to a typical background noise level. The noise level at the Hôtel du Bindeuil increases by more than 10 dBA while remaining within a typical background noise level (<55 dBA). The town of Bure has a few homes (located to the south) where the noise level increases by more than 10 dBA, while remaining within a fairly quiet background noise level (<45 dBA). For all other homes, the increase in noise level is less than 10 dBA.

During operation, in the daytime, the noise levels generated by the Cigéo overall project are below 60 dBA, corresponding to a typical background noise level. Furthermore, the increase in noise level is less than 10 dBA for all residences in the study area, which represents an improvement in the acoustic environment compared to the initial construction phase during daytime hours.

During the operational phase, at night, the noise levels generated by the Cigéo overall project are below 55 dBA, corresponding to a typical background noise level. Furthermore, the increase in noise levels is less than 10 dBA for all residences in the study area, representing an improvement in the acoustic environment compared to the initial construction phase during daytime hours.

Furthermore, the noise levels of all operations within the Cigéo overall project are below the applicable regulatory thresholds during both daytime and nighttime hours.

For the connected terminal (ITE), noise levels related to rail traffic (during the initial construction phase and the operational phase) remain below the WHO recommendation of 54 dBA on the Lden index (no rail traffic at night). For the inter-site link (LIS), noise levels associated with road traffic (during the initial construction phase and the operational phase) remain below the WHO recommendation of 53 dBA on the Lden index and 45 dBA on the Lnight index. Specific acoustic studies for 027000 railway line and for the D60/960 departmental road deviation will be incorporated into subsequent updated versions of this impact assessment.

The residual acoustic impacts on human health from the Cigéo overall project are low.

3.18.1.2 Vibration emissions

The vibrations generated by the Cigéo overall project are primarily related to the movement of machinery, heavy trucks, and trains, as well as those generated by the use of machinery and equipment during construction work across all potential project areas. They are barely perceptible outside the potential project areas. In addition, blasting operations are also carried out for earthworks and the excavation of shafts at the Cigéo disposal facility during the initial construction phase.

Avoidance and reduction measures, along with their expected effects and monitoring procedures, are described in the “3.12.2.2” chapter of this non-technical summary. These measures include limiting train traffic to daytime hours (between 6 a.m. and 10 p.m.) on the connected terminal (ITE) and on the 027000 railway line, suspending work likely to cause disturbance to the neighbourhood between 10 p.m. and 7 a.m., and keeping operations as far away as possible from residential areas.

The vibrations caused by blasting for earthworks and excavation of shafts may be felt very occasionally in the buildings closest to the ramp zone (residences in Saudron, the Hôtel du Bindeuil, the EDF archives, the Ferme du Cité, and Andra buildings). However, there are no residences within 1 kilometre, and vibrations will not be felt at those locations.

Since the activities causing vibrations take place during the day, they are unlikely to disturb residents’ sleep at night.

The residual impacts of vibrations from the Cigéo overall project on human health are low

3.18.1.3 Light emissions

The main sources of light emissions from the Cigéo overall project are related to the lighting of construction site operations during the preliminary development and initial construction phases, industrial buildings, and safety lighting (at the guard posts of the Cigéo disposal facility) during the operational phase to ensure the safety of people and facilities

Avoidance and reduction measures, along with their expected effects and monitoring procedures, are presented in Chapter 3.12.2.3 of this non-technical summary. In particular, the number of lighting points is very limited (primarily associated with the security of the disposal facility) and the lighting design is optimised.

The disturbance caused by this light pollution is low in residential areas, given the mitigation measures implemented and the distance from the shaft and ramp zones of the Cigéo disposal facility.

The residual impacts of light emissions from the Cigéo overall project on human health are low.

3.18.1.4 Odour emissions

Odours emitted by the Cigéo overall project are primarily linked to atmospheric emissions from construction equipment, occasional construction operations, the potential presence of waste from catering areas, and water management. The potential impacts on human health are significant.

Measures to prevent and reduce odours, along with their expected effects and monitoring procedures, are presented in the “3.12.2.4 ” chapter of this non-technical summary. These include the storage of hazardous materials, the disposal of conventional waste, and the ventilation of facilities.

Odours associated with exhaust gases from internal combustion engines and the laying of asphalt pavement are mild and highly localised. They disperse rapidly into the atmosphere and are barely perceptible to nearby residents.

The residual impacts of odour emissions from the Cigéo overall project on human health are very low.

3.18.1.5 Electric and magnetic fields

Sources of electric and magnetic field emissions are associated with the power supply infrastructure of the Cigéo overall project, namely, two very short sections of 400 kV overhead lines, two 90 kV underground cables, the potential location of the 400/90 kV substation, the 90 kV delivery substation and the 90/20 kV transformer substation located in the shaft and ramp zones. The electromagnetic field of the 400 kV overhead line remains unchanged.

Avoidance and reduction measures, along with their expected effects and monitoring procedures, are presented in the “3.12.2.5” chapter of this non-technical summary; in particular, electrical facilities are positioned as far as possible from residential areas. Furthermore, they are designed and operated in accordance with regulatory requirements aimed, among other things, at limiting the exposure of third parties to electric and magnetic fields.

The electric and magnetic fields generated by the electrical equipment of the Cigéo overall project are well below regulatory limits.

The residual impacts of the electric and magnetic fields from the Cigéo overall project on human health are very low.

3.18.2 Health impacts related to chemical emissions

The Cigéo project generates atmospheric chemical emissions (dust, volatile organic compounds, etc.) and liquid emissions (runoff water, industrial water, wastewater, etc.) during its preliminary works, initial construction, and subsequent operation phases.

The assessment of impacts on human health related to chemical emissions focuses on substances likely to affect the health of surrounding populations due to their exposure and potential toxicity. This assessment is based on a health risk study in accordance with the recommendations of the French National Institute for Industrial Environment and Risks (Ineris (160)).

Chemical emissions have significant potential impacts on human health and are subject to prevention and reduction measures.

3.18.2.1 Liquid chemical emissions

The sources of liquid chemical emissions from the Cigéo overall project are the waters generated and/or managed at the various project sites and throughout all phases of the project's lifecycle (rainwater, runoff water on the excavated material deposits, wastewater, and groundwater).

Given the avoidance and reduction measures implemented, the good chemical, ecological, and bacteriological quality of the discharged water (with monitored parameters below the reference values set, among others, by the Water Framework Directive) and the transfer mechanisms to the receiving environment (dilution, filtration) ensure that there is no potential degradation of the current water quality necessary for its use and its carrying capacity.

The assessment of human exposure is conducted using a conservative approach, with conservative assumptions chosen to account for as much of the associated uncertainty as possible. The populations likely to be most exposed to liquid chemical emissions from the Cigéo overall project are, given the nature and quantity of the emissions, the residents of the municipality of Bure, as it is located near the discharge points of the Cigéo disposal facility. It is assumed that the population consumes products from cattle (meat, milk/dairy products) and game animal. These animals drink from the Orge, Ormançon, and Bureau streams, which are the receiving environments for Cigéo's liquid discharges.

The quantitative chemical risk assessment shows that the hazard quotients and individual excess risk calculated using the INERIS methodology are below the reference values. According to this methodology, the health risk is classified as not of concern to human health.

Thus, liquid emissions (discharged water) are not considered a source of emissions hazardous to human health, regardless of the life cycle phase considered (during its preliminary works, initial construction, and subsequent operation phases).

The residual impact of liquid chemical emissions from the Cigéo overall project on human health is very low.

3.18.2.2 Atmospheric chemical emissions

The main atmospheric chemical emissions from the Cigéo overall project during the preliminary construction phase are typical of a large construction site, consisting of dust, nitrogen oxides, sulphur oxides, carbon monoxide, and combustion gases (primarily volatile organic compounds).

During the initial construction and operational phases, chemical emissions are primarily linked to the movement of machinery and vehicles during work at the Cigéo disposal facility, followed by the operation of facilities such as boilers, concrete plants, and ventilation systems; and to particulate emissions associated with the placement of waste and material storage areas. The chemical compounds emitted are primarily dust, carbon oxides, sulphur oxides, carbon monoxide, and combustion gases.

These atmospheric chemical emissions can be diffuse or channelled. They are localised within and around the Cigéo disposal facility and in connection with the operations of other project owners.

Prevention and reduction measures are implemented, particularly to reduce dust emissions and minimise transportation (a source of combustion gas emissions). All of these measures, along with their expected effects and monitoring procedures, are outlined in Chapter 2.4 of Volume IV of this environmental impact assessment. These include the location of excavated materials deposits area directly above the underground facility in the shaft zone and their transfer from the ramp zone to the shaft zone via a semi-buried conveyor, as well as the misting of uncovered tailings. To limit dust emissions from vehicle traffic, vehicle speeds are restricted, and asphalt paving is carried out as soon as possible on the roads used by vehicles.

The methodology recommended by the French National Institute for Industrial Environment and Risks (Ineris) (160) consists of evaluating, using toxicological reference values for the substances under study, either hazard quotients (HQ) in the case of substances with a threshold effect (non-carcinogenic substances), or individual excess risk (ERI) in the case of substances without a threshold effect (carcinogenic substances). This methodology is applicable only to certain chemicals based on current scientific knowledge. For other chemicals, the associated impact on human health is assessed by comparing the results of the human exposure assessment with available regulatory or reference values for population protection.

The human exposure assessment is conducted using a conservative approach, with conservative assumptions chosen to account for as much of the associated uncertainty as possible. The populations most exposed to atmospheric chemical emissions from the Cigéo overall project are, given the nature and quantity of the emissions, those located closest to the Cigéo disposal facility, namely the residents of: Bonnet, Gillaumé, Saudron, Mandres en Barrois, Ribeaucourt, and Bure, as well as people frequenting the Hôtel du Bindeuil and the school in Échenay.

The primary route of human exposure to atmospheric chemical emissions from the overall project is the inhalation of potentially toxic substances. Human health exposure assessments related to atmospheric chemical emissions are conducted by ARIA Technologies using the AirAdvanced® Map Standard version software, a benchmark tool for many Installations Classified for the Protection of the Environment (ICPE). These assessments are performed using assumptions that overestimate the results (for example, populations are considered exposed 365 days a year for 70 years).

The results of these assessments confirm that no residences, public facilities, or sensitive populations identified within the close study area of the Cigéo project's physical environment are exposed to combined concentrations of toxic chemicals exceeding regulatory reference values (limit values for the protection of human health) or management values (quality objectives).

For other so-called substances of interest with toxicological reference values (benzene, representative of volatile organic compounds; carbon monoxide; and benzo(a)pyrene), which are representative of emitted substances and risk indicators, the hazard quotients and individual excess risk calculated according to the INERIS methodology are below the recommended reference values. According to this methodology, the health risk is classified as not of concern to human health.

In any case, the combined concentrations of toxic atmospheric chemicals emitted by the Cigéo overall project remain well below the regulatory thresholds for human health protection at residential levels.

The residual impacts of atmospheric chemical emissions from the Cigéo overall project on human health are very low.

3.18.3 Health impacts related to radioactive emissions

The Cigéo project will receive packages of High-Level and Long-Lived Intermediate-Level (HLW and ILW-LL) waste throughout its operation phase. These waste packages are transported to the Cigéo disposal facility and then transferred within the facility to the disposal cells in the Callovian-Oxfordian layer. During their transport on public or private roads and their transfer within the Cigéo disposal facility, they undergo no transformation and are handled only remotely for underground disposal.

The identified sources of radioactive emissions from the overall project are related to gaseous releases of certain radionuclides (tritium, carbon-14, and krypton-85) from certain ILW-LL packages, the potential presence of radionuclides on the external surfaces of waste packages that are received, and the possible recovery of unconventional liquid effluents from areas within the Cigéo disposal facility where nuclear waste may be generated, subject to the Basic Nuclear Installation (BNI) regulations (161).

Radionuclides emit radiation, the danger of which depends on the nature and level of radioactivity. The assessment of effects on humans is conducted over the course of a lifetime, through the calculation of an "effective dose," expressed in Sieverts (Sv) or millisieverts (mSv, i.e., 0.001 Sv), taking into account locally observed lifestyle habits.

The various radioactive emissions from the Cigéo overall project have significant potential impacts; they are subject to avoidance and reduction measures as part of the design of the Cigéo overall project.

3.18.3.1 Emissions related to the transport of waste packages

To be transported on public roads, radioactive waste is conditioned (solidified and, where applicable, immobilised in a non-dispersible form) and placed in a container, then packed in transport containers appropriate to its hazard level and transport conditions.

The shielding of transport containers provides protection against ionizing radiation on the one hand and resistance to the consequences of an accident (such as a fall or a fire) on the other. For example, high-level (HL) radioactive waste is transported in forged steel containers weighing around 100 tons.

To ensure the public's radiation protection, regulations governing the transport of hazardous materials impose limits on dose rates: 2 mSv/h at the vehicle walls, 0.1 mSv/h at a distance of 2 metres from the vehicle walls. Packaging and means of transport on public roads are designed to meet protection criteria against ionizing radiation; in particular, contamination of accessible surfaces of the transport containers and the means of transport must not exceed 4 Bq/cm² for beta and gamma-emitting radioactive elements and 0.4 Bq/cm² for alpha-emitting radioactive elements.

This packaging design ensures that there is no impact on human health even in the event of prolonged exposure lasting several days.

Thus, an individual standing two metres away from the path of all trains would receive an annual effective dose of on the order of a few tenths of microsieverts.

Given these factors, exposure to transport convoys is extremely low and limited in duration.

3.18.3.2 Non-conventional liquid effluents from areas where nuclear waste may be generated

The nuclear process for storing radioactive waste packages at the Cigéo disposal facility (primarily handling and transfer operations) does not generate radioactive liquid effluents.

During the operation of the Cigéo disposal facility, certain liquid effluents, depending on their source or use, may contain very low levels of radioactive substances. This is the case when they originate from:

- from underground, from the mine drainage collection system of the high-level waste cells that have been in contact with waste packages;
- on the surface, from areas where nuclear waste may be produced, such as condensates from the internal energy recovery units of the EP1 surface nuclear building.

These effluents are referred to as "non-conventional liquid effluents". They are collected and sent to an external facility dedicated to their treatment. Measures are in place. "Non-conventional" liquid effluents are isolated and packaged. Once the collection tanks in the surface nuclear building are full, the effluents undergo radiological characterisation to enable their transport. These effluents are then transferred to an external facility. They are transported in accordance with transport regulations for treatment and disposal at a suitable facility. All of these measures, along with their expected effects and monitoring procedures, are described in Chapter 10 of Volume IV of this impact assessment.

The estimated annual quantities of non-conventional liquid effluents, calculated on a conservative basis, during the first decades of the BNI's operation up to the year 2080, are on the order of 90 m³/year (i.e., on the order of 90 t/year).

The maximum activity of these unconventional liquid effluents, calculated as a rough estimate, is on the order of 10 Bq/L for total alpha and 100 Bq/L for total beta.

These quantities and radioactivity levels were estimated using very conservative assumptions, well above the effluents actually expected.

The Cigéo disposal facility therefore does not discharge any unconventional liquid effluents into the local environment.

The impact of liquid radioactive emissions on human health is therefore extremely low.

3.18.3.3 Atmospheric radioactive emissions

The gaseous radionuclides originating from certain ILW-LL packages are tritium (^{3}H), carbon-14 (^{14}C), and krypton-85 (^{85}Kr). These three radionuclides are highly volatile and remain in a gaseous state or as water vapor, without forming aerosols. They are also low in radiotoxicity. Radioactive particles (alpha and beta emitters) that may be present on the outer surface of radioactive waste packages (also known as labile surface contamination) can be suspended by the ventilation of the structures.

The avoidance and reduction measures implemented in the Cigéo overall project aim both to prevent and reduce the effects associated with the presence of these radionuclides and, consequently, public exposure.

The assessment of health risks and impacts on human health associated with these radioactive emissions is conducted using a conservative approach, with stringent (conservative) assumptions at each stage:

- the assessment of radioactive discharges (including releases of gaseous elements without considering the container's retention capacity, transient surface contamination of transport vehicles, packaging, and packages at the maximum authorised thresholds, the presence of radioactive waste packages in the surface nuclear facility at maximum capacity…);
- the assessment of the dispersion of these radioactive releases and their subsequent transfer into the environment and the food chain (assuming 100% presence of individuals at the exposure site, and air inside habitations considered identical to outdoor air…);
- the assessment of human exposure through the calculation of an effective dose committed (using the most harmful chemical form of tritium, with alpha and beta emitters treated as harmful radionuclides, and considering several population age groups…).

The populations likely to be most exposed to radioactive atmospheric releases from the Cigéo overall project are, given the nature and quantity of the emissions, those located closest to the Cigéo disposal facility, downwind of it, and in particular near the nuclear ventilation stack in the shaft zone.

The assessments are conducted using the Code for Rapid Environmental and Health Assessments (CERES) calculation platform, a reference tool of the French Alternative Energies and Atomic Energy Commission (CEA). These tools have already been analysed by the French Nuclear Safety Authority (ASN) and its technical support body, the Institute for Radiation Protection and Nuclear Safety (IRSN).

The maximum human exposure associated with atmospheric radioactive emissions is extremely low in the village of Bure, on the order of one microsievert per year (µSv/year), which is more than a thousand times lower than one millisievert (mSv). Human exposure for other surrounding villages within a radius of approximately 8 km is even lower: between 20% and 40% below the potential exposure in the municipality of Bure. Furthermore, exposure from transport convoys—which will carry only a very limited number of radioactive waste packages and whose passages are infrequent and time-limited—is even much lower than that associated with the Cigéo disposal facility.

3.18.3.4 Health risk associated with radioactive emissions

During the operational phase, human exposure from emissions associated with the Cigéo overall project is thus well below the regulatory limit of 1 mSv/year for human activities excluding natural radioactivity and medical radiation doses, as well as the 0.25 mSv/year limit adopted by Andra. It is negligible compared to the annual exposure due to natural radioactivity for the French population, even the least exposed (average of 2.9 mSv/year, and the lower range, corresponding to the Meuse/Haute-Marne area, at 1.6 mSv/year). Given the rapid decrease in concentrations of radioactive gases and aerosols from atmospheric radioactive releases with distance and the small quantities involved, the effects of the project overall do not accumulate with those of other nuclear projects and facilities in the region.

The residual impacts of liquid and atmospheric radioactive emissions from the Cigéo overall project on human health during the operational phase are very low.

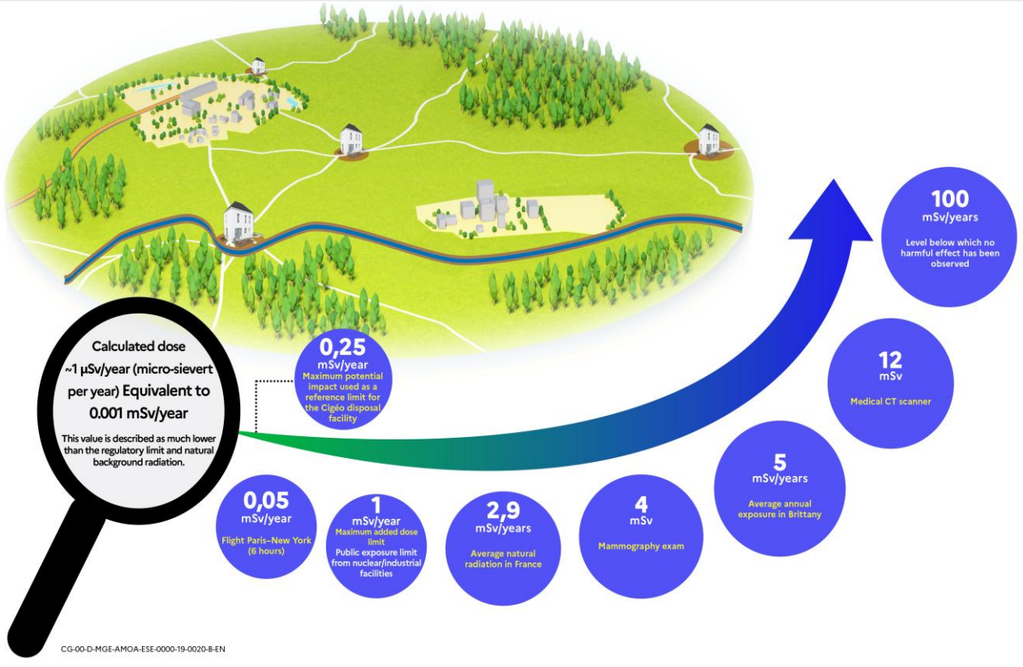


Figure 3-74 *Reference values for human exposure to radioactive emissions*

3.18.4 Post-closure impacts on human health

Once the underground facility is permanently closed—that is, once the underground structures, shafts and ramps have been backfilled and sealed—the HLW and ILW-LL waste packages will slowly degrade over time. The radionuclides contained in these waste packages will gradually be released into the disposal cells. Water is the primary factor in the degradation of the waste packages and the main vector for the migration of radionuclides and toxic chemical substances contained in the waste into the biosphere.

Safety is thus ensured in a completely passive manner, meaning that people and the environment are protected from the radioactive elements and toxic chemical substances contained in the radioactive waste without the need for human intervention. Indeed, the long-term protection of people and the environment relies on the Callovian-Oxfordian formation, which plays a central role in this protection, supplemented in particular by engineered features such as the sealing structures for surface-underground connections (shafts and ramps).

The assessment of residual impacts on human health consists of quantitatively evaluating the level of protection provided by the disposal system against the few radionuclides and toxic chemical substances that might eventually reach a discharge point (water extraction point) accessible to humans and used by them for their activities (drinking water, irrigation, animal watering, etc.).

The post-closure safety assessment aims to robustly ensure that the disposal system (the natural environment, particularly the Callovian-Oxfordian host clay layer; the engineered components of the disposal facility, particularly the waste packages and seals; and the disposal facility's design) guarantees the protection of people and the environment over time.

To conduct the post-closure safety assessment, Andra implements a rigorous and prudent approach, consistent with the requirements of the French Nuclear Safety Authority (ASN) and international practices. This approach has been tested and refined over more than 30 years through the numerous dossiers submitted by Andra and evaluated by the ASN, as well as through international expert reviews and expert reviews commissioned by stakeholders. The main features of this approach are as follows:

- on the one hand, it is both qualitative and quantitative. It thus relies on cross-referenced arguments and the quantification of relevant indicators:
  - ✓ the fundamentals of deep geological disposal, such as the quantity of radionuclides that has remained confined within the repository, or in its immediate vicinity within the host clay layer, over a million years, or the concentration of radionuclides in water at a discharge point (pumping into a groundwater aquifer or river);
  - ✓ the impact on human health, such as the total annual radiation dose to which a human being might be exposed. This dose is assessed against the benchmark value of 0.25 mSv adopted by the Nuclear Safety Authority as an indicator for radioactive waste disposal after closure, which is itself below the annual dose limit for the general public of 1 mSv.
- on the other hand, it considers various situations and scenarios that allow for both:
  - ✓ assess the performance of the disposal facility for the most likely evolution scenarios, in accordance with the objectives set by the ASN for these situations;
  - ✓ to conservatively account for (*i.e.,* provide a safety margin against) residual uncertainties in knowledge regarding the behaviour of the disposal facility and the natural environment over time (for example, by using conservative parameter values for the release and migration of radionuclides);
  - ✓ to demonstrate the robustness of the repository even in the event of conventionally ("arbitrarily") and severely "postulated" events relating to the repository components or the geological environment (for example, the failure of all seals or the existence of a fracture in the host rock that was not detected).

Post-closure safety scenarios are defined to represent how radionuclides and toxic chemicals contained in the waste are likely to reach humans.

The approach is based on contrasting scenarios that allow for the evaluation of the expected performance of the repository as well as its robustness in the face of uncertainties.

The "reference" design-basis evolution scenario makes it possible to assess the expected safety performance of the repository based on the current state of scientific and technological knowledge—which is accepted and derived in particular from academic research in the field of disposal as well as in other fields—and on the design-basis requirements of the facility. As a precaution, this scenario also incorporates a number of conservative assumptions regarding the repository and its environment (for example, assuming the repository is saturated with water upon closure, even though this saturation will not be reached until well beyond several tens of thousands of years, due in particular to the low permeability of the host rock, resulting in very low water flow rates, or the fact that pumping outlets are modelled as capturing all radionuclides arriving in a zone rather than the local quantity and concentration around the pumping point).

To demonstrate the robustness of the post-closure safety case with respect to the disposal design and residual knowledge uncertainties, other scenarios are studied:

- a "conservative" scenario representing design-basis evolution that aggregates conservative values and assumptions. This representation increases the transfer of radionuclides and toxic chemical substances from the stored packages to the biosphere and then to humans. It constitutes an upper bound on the cumulative impact of residual knowledge uncertainties. Through this choice of conservative assumptions and data, it defines the boundary of the normal operating range of the disposal system and its environment;
- scenarios of deviation from normal evolution, referred to as non design-basis evolution scenarios, *"what-if"* scenarios, or scenarios of inadvertent human intrusion.

These scenarios aim to test the robustness of the disposal system against the loss or degradation of one of its fundamental safety functions, even if such a loss or degradation is considered unlikely or very unlikely. Examples include the failure of all seals or inadvertent human intrusion into the repository via drilling should its existence be forgotten over the long term.

The safety assessment presented in the application dossier for authorisation to establish the Cigéo deep geological repository addresses all of the scenarios listed above, including requests from the ASN and its technical support organisation, the Institute for Radiation Protection and Nuclear Safety (IRSN), made during the review of the safety options dossier. It allows for further testing of the robustness of post-closure safety, particularly through the combination of conservative assumptions, for example regarding the migration parameter values of radionuclides, or the postulated choice of situation/scenario, such as a collapse in an ILW-LL cell that would lead to a reduction in the host rock cover at the location of that cell.

The quantitative assessment is conducted using numerical tools capable of simulating and quantifying the release of radionuclides and toxic chemical substances from the packages, their migration through the underground structures, into the Callovian-Oxfordian layer, and then through the overlying formations from the Callovian-Oxfordian layer to the discharge points. These tools are subject to a qualification process to ensure their appropriate use, particularly in terms of result analysis, especially in the numerical domain, for example through intercomparison exercises of computational codes.

The results of the post-closure safety assessment confirm the ability of the repository and the geological environment—specifically the Callovian-Oxfordian clay host rock—to ensure long-term safety. They highlight:

- the central role of the host rock due to its characteristics (low permeability, high radionuclide retention capacity, low migration of highly soluble radionuclides not retained due to low diffusion, great thickness, etc.);
- the complementary nature of the repository and its design. The latter aims to ensure that the favourable characteristics of the host rock are maintained (for example, by limiting the maximum temperature in the host rock to below 100 °C around exothermic waste compartments, such as high-level vitrified waste) and to take advantage of these characteristics.

It is evident from all the post-closure safety assessment studies that

- the vast majority of radionuclides remain within the repository or in its immediate vicinity;
- only a few radionuclides—those that are long-lived and mobile—reach the edges of the host rock and then the discharge points, but in small quantities and diluted over time and space.

This is the case for the design-basis evolution scenario, but also for the other scenarios, which mobilise few radionuclides due to the characteristics of the Callovian-Oxfordian host rock—even when accounting for degraded properties—and the design of the repository. For example, a borehole or fracture in the host rock that intersects a disposal cell mobilises only a fraction of the amount of radionuclides contained in that cell.

In terms of the human dose indicator, for the reference design-basis evolution scenario—which represents the expected behaviour of the repository—the maximum dose is on the order of 0.0015 mSv/year, and thus well below the reference value of 0.25 mSv/year. The “conservative” situation of the design-basis evolution scenario leads to impacts that are, at most, on the order of magnitude of this reference value.

The demonstration of the disposal system’s robustness is reinforced by the results of scenarios deviating from the normal evolution of the disposal system and its environment, particularly since these scenarios addressed both situations, notably the “envelope” (conservative) situation of the normal evolution scenario, which is based on the “conservative” characteristics of the Callovian-Oxfordian layer.

The results of the assessments of these scenarios further highlight the central role of the Callovo-Oxfordian layer, even with conservative characteristics, reinforced by the aforementioned disposal design (in particular the modularity of the underground disposal volume or the lengths of the tunnels from the cells to the surface-underground connections structures). These results are essentially similar to those of the design-basis evolution scenario in terms of containment performance. The maximum human health impact in terms of annual dose remains of the same order of magnitude as that of the design-basis evolution scenario.

In all cases for the non design-basis evolution, What-if, and inadvertent human intrusion scenarios, the maximum dose levels remain below the levels likely to induce deterministic effects and, in most cases, below the reference value adopted for the SEN (0.25 mSv/year).

All results thus confirm the robustness of the disposal system in the face of residual uncertainties in knowledge.

3.18.5 Accident scenarios at the Cigéo BNI

Risk management in Basic Nuclear Installations (BNI) is a priority, based on the principle of defence in depth, which involves establishing multiple independent layers of defence, each capable of taking over after the failure of the previous one, in order to prevent the occurrence of an incident or accident and to limit its consequences on the population and the environment.

Thus, the creation of the BNI requires the completion of “Document 8 – Risk Management Study” (31), which is attached to this Creation Licence Application (DAC).

This study presents an inventory of the risks posed by the proposed facility, as well as an analysis of the measures taken to prevent these risks and the specific measures designed to limit the probability of accidents and their effects. Its content is commensurate with the significance of the hazards posed by the facility and their foreseeable effects, in the event of an incident, on public safety, health and healthiness or the protection of nature and the environment.

The methodology and design criteria are based primarily on the regulations applicable to all BNIs, the fundamental safety rules, and the guidelines for BNIs.

The safety analysis is based on a risk analysis and an operational scenario analysis, which identify the various situations the facility may face, group them according to their likelihood, and verify that the technical and organisational measures ensuring their control enable the protection of interests—that is, the protection of safety, public health and healthiness, as well as the protection of nature and the environment.

These situations cover normal operation and degraded operation, design-basis incidents and accidents, as well as more complex accident scenarios (extended design-basis scenarios) that may result from multiple cumulative events or extreme weather events (particularly based on lessons learnt from the Fukushima accident).

They primarily concern situations involving the dropping of radioactive waste packages during handling, fires near waste packages, or situations related to external hazards (e.g., earthquakes).

A summary of the results for several accident scenarios is presented in the risk management study:

- accident scenarios deemed plausible but which do not pose significant radiological impacts on people and the environment;
  - ✓ the fall of a primary package following a handling crane failure;
  - ✓ a fire involving a package transfer trolley in the above-ground nuclear building.
- accident scenarios that are less plausible but would be the most severe in terms of maximum dose to people and the environment (severe accident scenarios):
  - ✓ fall of an open ILW-LL transport package during unloading in the above-ground nuclear building;
  - ✓ ignition of a package of bituminous waste within a disposal package.

An estimate of the doses received by people and the environment is performed at various distances from the BNI’s ramp and shaft zones, under the most unfavourable meteorological conditions and taking into account conservative assumptions. To demonstrate the robustness of the safety approach, the estimate of doses received by the public and the environment is compared to the protection objectives set by Andra, which are based on the recommendations issued by the International Commission on Radiological Protection (ICRP) (see Document 8 “Risk Management Study” in this license application file (31)).

In the event of an accident at the Cigéo BNI, analysis of accident scenarios, even the most severe ones, shows that the protection objectives are not exceeded and that they do not lead to the need for public protection measures over time and space, such as sheltering.

3.18.5.1 Accident scenarios for other risks associated with the Cigéo overall project

3.18.5.2 Risks associated with the transport of packages

Radioactive waste packages shipped to the Cigéo disposal facility are transported in shipping containers whose robustness and operational transport conditions (labelling, marking, number of packages per railcar/truck, etc.) are adapted to the risks associated with the radioactive substances they contain, in accordance with current regulations governing the transport of hazardous materials.

In the event of a transport accident, regardless of the type of accident (road or rail), the transport packaging for radioactive waste packages is designed and tested to withstand severe accident conditions (such as a drop from a height of nine metres onto a non-deformable surface).

A transport plan for radioactive waste packages is drawn up by the shipper (the producers) and specifies the route to be taken and the details of the journey (parking, accommodation, special conditions). Prefectures and gendarmerie units are notified of the convoys' movements. Convoys are tracked in real time via geolocation, and any deviation from the transport plan triggers an alert.

Carriers have a Transport Emergency and Response Plan that enables them to respond to a transport incident or accident. To this end, a crisis management system is in place 24 hours a day, 7 days a week, which includes, among other things, alerting public authorities (fire department, emergency medical services, French Nuclear Safety and Radiation Protection Authority, etc.) and providing them with the information necessary for their response. This crisis management system aims to limit the consequences and implement any measures necessary to protect the public.

In addition, public authorities define response plans in the event of an accident at the national and local levels. The French Nuclear Safety Authority (ASN) assists the authorities responsible for rescue operations.

3.18.5.3 Risks associated with the transport, receipt, and distribution of fuels

The construction and operation of the Cigéo disposal facility require the use of fuels for vehicles, machinery, and combustion facilities.

The most feared accident involving the transport of hazardous materials is a leak from the fuel delivery truck, which has a capacity of about 15 m³, leading to fuel spilling onto the ground and the dispersion of fuel vapours into the air. In the presence of an ignition source, this leak could cause a fire (thermal effects) or an explosion (overpressure effects).

In the event of a spill, accidental pollution would be collected in the stormwater system and directed to a containment basin. Thus, accidental pollution on the site would not reach the environment or waterways.

In the event of a fuel fire, the thermal effects associated with flame radiation would be limited and would not be felt in buildings outside the site. The plume of toxic smoke would rise rapidly due to the temperature and disperse quickly at high altitude.

An explosion of fuel vapours would generate a blast that would propagate as an air pressure wave. This could cause projectiles (e.g., broken glass).

The thresholds for thermal and overpressure effects remain confined within the boundaries of the Cigéo disposal facility.

3.18.5.4 Risks associated with boiler rooms

The primary function of the boiler rooms is to treat the air (temperature and humidity) in the Cigéo disposal facility. They also provide domestic hot water.

There are two boiler rooms at the Cigéo disposal facility, one located in the ramp zone and the other in the shaft zone. Each of these boiler rooms includes a main biomass boiler fuelled by wood chips and three auxiliary boilers fuelled by liquid petroleum gas (LPG) during the coldest periods.

The feared accident scenario during the transport and receipt of LPG is a leak from the delivery tank or a rupture of the unloading hose. In the presence of an ignition source, this leak could cause a flaming jet or the ignition in open air of a "cloud" of gas, producing thermal effects and overpressure effects. Furthermore, in the event of a sudden rupture of the tank, a violent, explosive vaporisation of the LPG contained in the tank may occur, also producing thermal effects, overpressure effects, and projectiles. Inside the boiler room, a leak in an LPG pipe or a failure in a boiler's LPG supply system can lead to the dispersion of flammable gas within the room. In the presence of an ignition source, this leak can cause a fire or an explosion in the room.

Thermal and overpressure effects diminish with distance. The comprehensive risk management measures in place ensure that the potential consequences of these accident scenarios are controlled. No impact would be felt outside the Cigéo disposal facility.

The wood chips used to fuel the biomass boilers are combustible materials that, in the event of a fire, are likely to ignite and thus provide a fuel source. They are stored in an underground silo located inside the boiler rooms and equipped with firewalls. If, despite these preventive measures, a fire was to occur, the thermal effects would be very limited.

The thresholds for thermal effects and overpressure remain contained within the boundaries of the Cigéo disposal facility.

3.18.5.5 Risks associated with non-radioactive hazardous substances

Non-radioactive hazardous substances may be used at the Cigéo disposal facility. They will be delivered and stored in small or very small containers.

A feared accident scenario involves a leak from a container leading to the spillage of these substances onto the ground. In areas where flammable substances are stored or handled, in the presence of an ignition source, such a spill could cause a fire or even an explosion. Furthermore, in the event of simultaneous spills of incompatible substances, dangerous chemical reactions may occur (release of heat and/or harmful, even toxic, substances).

A set of risk control measures has been implemented, including the storage of hazardous substances in containment tanks, taking into account incompatibility rules and in suitable facilities.

The thresholds for thermal effects and overpressure remain within the confines of the Cigéo disposal facility.

3.18.5.6 Risks associated with electrical installations/premises

The feared accident scenarios related to the presence of these electrical installations are potential oil leaks at electrical substations, fires and the explosion of hydrogen released during the charging of batteries for material-handling equipment and electric vehicles.

Adherence to best practices in the design and operation of these installations helps control risks and limit the potential consequences of such accidents.

Oil leaks, thermal effects, and overpressure thresholds remain contained within the boundaries of the Cigéo disposal facility.

3.18.5.7 Risks associated with explosives that may be used for earthworks

Explosives may be used during the preliminary works phase for earthwork operations. The impacts in terms of overpressure depend on the quantities of explosives involved in accident scenarios. Compliance with regulations governing the use of explosives helps control risks and limit the potential consequences of an accident.

The thresholds for overpressure effects remain within the boundaries of the Cigéo disposal facility.

3.18.6 Conclusion

At all phases of the Cigéo overall project (preliminary works, initial construction, operation, post-closure, as well as during an accident), the impacts of physical, chemical, or radioactive emissions on human health are low to very low.

Emissions from the Cigéo overall project have a low impact on human health.

3.19 Nature and monitoring of follow-up environmental measures

Monitoring is based on a set of principles, the long-term tracking of which should make it possible to:

- verify compliance with regulatory requirements regarding environmental protection, particularly those defined in the various permits issued;
- detect any abnormal situation or development in order to locate and identify its causes;
- to define, where necessary, new measures designed to prevent the recurrence of abnormal situations or developments.

The proposed environmental monitoring plan includes an organisational structure established to ensure environmental monitoring of the Cigéo disposal facility. It is based in particular on:

- a competent department responsible for environmental functions (implementation of the monitoring system, collection and interpretation of data, drafting and submission of reports to various government agencies, etc.) under the authority of a site manager;
- the establishment by government agencies of a Local Information Commission (CLI), whose general mission is to monitor, provide information, and facilitate consultation regarding nuclear safety, radiation protection, and the impact of nuclear activities on people and the environment as they pertain to the site's facilities. The CLI receives the information necessary for its mission from the operator, the French Nuclear Safety Authority (ASN), and other government agencies. It may commission expert assessments or have measurements taken regarding the facility's releases into the environment;
- Andra's contribution, within the limits of its authority, to public health initiatives that may be undertaken, particularly in connection with the implementation of the health observatory for residents near the Cigéo disposal facility;
- the conduct of scheduled and unannounced inspections by the French Nuclear Safety and Radiation Protection Authority (ASNR).

The environmental monitoring plan, approved in particular by the French Nuclear Safety and Radiation Protection Authority (ASNR), enables the monitoring of:

- the consumption and emissions of the Cigéo disposal facility's facilities: each type of effluent and atmospheric emission is subject to measurements and sampling at one or more points, at a frequency adapted to the types of effluents, the intended nature of the monitoring, and the phasing;
- the facilities at the Cigéo disposal facility: several environmental compartments (noise and vibration, atmosphere, water, terrestrial ecosystems) are subject to measurements and sampling at one or more points, at a frequency adapted to the types of effluents, the nature of the planned monitoring, and the project's phasing.

This plan also allows for the monitoring of:

- the various environmental compartments of the Cigéo disposal facility;
- the post-construction environments in terms of biodiversity at the Cigéo disposal facility.

Also planned are:

- procedures for monitoring environmental measures, including the establishment of a construction site organisation tailored to environmental challenges. These procedures make it possible, in particular, to verify the proper implementation of ecological compensation sites and to monitor their effectiveness over time;
- emergency response and management resources in the event of an accident;
- an environmental monitoring plan for the other operations of the Cigéo overall project.

3.20 Estimated costs of environmental measures

Environmental protection measures represent a budget of approximately 296 Million €uros (M€) for the entire Cigéo project, based on economic conditions as of January 2018, broken down as follows:

- 112 M€ corresponds to strategic design choices made in favour of the environment;
- 176 M€ corresponds to measures to avoid and reduce impacts, including 2.4 M€ for the power supply operation;
- 8 M€ corresponds to ecological, forestry, and collective agricultural offsetting measures.

Additional costs for environmental monitoring and oversight throughout the project's life cycle (construction, followed by operation, maintenance, and monitoring of compensation sites) will be incurred over the lifespan of the Cigéo overall project. These represent a budget of approximately 1 M€ per year.

These budgets should be viewed in the context of the projected investment required to bring the Cigéo disposal facility online, estimated at approximately 8.26 billion €uros (under January 2018 economic conditions). The additional cost for continuing construction of the Cigéo disposal facility is estimated at approximately 6.54 billion €uros (economic conditions as of January 2018). More specifically, the costs of operations for the Cigéo overall project excluding the Cigéo disposal facility, which will be financed in whole or in part by Andra (power supply, water supply, railway line revamping, and road deviation), are estimated at approximately 191 million €uros (economic conditions as of January 2018).

3.21 Evolution of the environment with and without project

The time scales considered for studying environmental changes with and without the project are 2030 and 2050. These dates span the initial construction phase and the operational phase of the Cigéo overall project.

Climate change, linked to human activities, may cause changes in the various environmental components of the study area.

The scenarios associated with climate change include extreme flooding and droughts. Changes in human activities will also have a significant impact on environmental changes. Land use and soil pollution, in particular, depend heavily on changes in agricultural practices within the region. It is anticipated that current trends regarding population and employment will continue and remain on a downward trajectory. The region lags behind the rest of France in terms of various networks and transportation infrastructure, although regional planning documents foresee improvements in these areas.

With the implementation of the Cigéo overall project, some of these environmental factors will evolve differently. Land use will be significantly altered, with 783 ha of land undergoing a change in use. This change in land use will have consequences for agriculture and biodiversity due to the loss of agricultural land or the destruction of habitats. The facilities will disrupt the landscape during the operation phase, but will soon become less noticeable thanks to the planned landscaping. Throughout its lifespan, the Cigéo project will create a significant number of jobs, leading to a positive demographic shift. Finally, the infrastructure and networks established for the project will be a significant asset for regional development.

The Cigéo overall project will have a positive indirect impact on the organisation of the local territory, as well as on the scale of the Grand Est region (densification, expansion, and/or creation of business and residential zones, development of retail, facilities, and services, and adaptation of the transportation network).

By 2100, climate change linked to human activities will intensify, as will its consequences on the evolution of various environmental systems.

In the long term, scientists estimate that there will be no change in the region's tectonic characteristics for several million years.

3.22 Summary of the environmental impacts of the Cigéo overall project

The assessment of the impact depends (see Chapter 1.1 of Volume IV of this environmental impact assessment) on the phenomena involved (emissions, land use, etc.) as well as their magnitude, duration, and the sensitivity of the various environmental factors.

Various factors for assessing impact levels are summarised in table 3-15 and are used as a “guiding principle” for assessing the level of impacts.

Table 3-15 Factors for assessing the level of impact (indicative guidance grid)

Impact level	Assessment criteria
Positive	Direct or indirect improvement of the factor through project implementation
Very low **Zero net loss of biodiversity**	No effect No or marginal alteration of an environmental compartment
Low	Slight alteration of an environmental factor that does not affect its functions A barely perceptible effect over a small geographic area and for a limited or one-time duration
Moderate	Perceptible change to an environmental factor that is localised or limited in time Significant disruption or degradation of factors of low importance
High	Significant change in an environmental factor over a long period or permanently Significant disturbance or degradation of factors of moderate to high importance
Very high	Very significant change in an environmental factor over a long period or permanently Destruction of an environmental factor of high significance or degradation of an environmental factor of very high significance

The French Environment Code does not define what constitutes a significant impact. Therefore, on a five-level scale of negative impacts, this impact assessment has chosen to consider the three highest negative levels (moderate, high, and very high) as corresponding to significant negative impacts.

The table 3-16 lists all the topics likely to be affected by the Cigéo overall project and the prioritisation of impacts. Note that this table presents the highest levels of significance and impact for the Cigéo overall project.

Table 3-16 Ranking of impacts of the main environmental factors

Environment	Factor	Sub-Factors	Prioritisation of the issue	Avoidance Measures	Reduction measures	Offsetting measures	Impact level after A, R, and O measures
Physical environment	**Atmosphere**	Local weather conditions	Light		X		Very low
		Climate change			X		Very low
		Energy and greenhouse gases	Moderate	X	X		Low
		Air Quality: conventional substances	High	X	X		Low
		Air quality: radioactive substances		X	X		Very low
	Soil	Land use	Moderate	X	X	X	Moderate The Cigéo overall project alters the land use of nearly 783 ha, of which approximately 586.9 ha of forest and agricultural land is developed, including 158.7 ha that is made impervious
		Topography			X		Low
		Soil pollution			X		Very low

Environment	Factor	Sub-Factors	Prioritisation of the issue	Avoidance Measures	Reduction measures	Offsetting measures	Impact level after A, R, and O measures
Natural environment	Subsoil	Accidental physicochemical contamination	Low		X		Very low
		Potential radiological and chemical contamination of the subsoil by waste packages			X		Very low
		Natural hazards		X	X		Very low
		Subsurface resources		X	X		Low
	Water	Groundwater and surface water: Quantitative	High	X	X		Low
		Groundwater and surface water: Qualitative	High	X	X		Low
		Groundwater and surface water: Uses	High	X	X	As needed	Low
	Biodiversity	Environmental zoning	Moderate	X	X	X	No net loss of biodiversity
		Wetlands	High	X	X	As needed	No net loss of biodiversity
		Ecological connectivity	Moderate, potentially high locally	X	X		No net loss of biodiversity
		Habitats, fauna, flora	High	X	X	X	No net loss of biodiversity
Human environment	Population and economic activities	Population, employment, and economic activities	Strong	X			Positive
	Agricultural and forestry activities	Agricultural activities	Strong	X	X	X	Low to very low
		Forestry activities	Moderate	X	X	X	Low to very low
	Networks	Networks	Moderate	X	X		Very low to Positive
	Radioactive and conventional waste	Radioactive waste	High	X	X		Low to positive
		Conventional waste	Moderate	X	X		Low
	Transport infrastructure	Transport infrastructure	Moderate	X	X		Low to very low
	Living environment	Noise environment	Moderate	X	X		• Moderate during the preliminary planning and initial construction phases; • Low during the operational phase.
		Vibration environment		X	X		Low
		Lighting environment		X	X		• Low during the preliminary development phase; • Moderate during the initial construction and operational phases: the project requires nighttime lighting in an environment with little lighting other than streetlights in the villages and lighting in the Meuse/Haute-Marne center.
		Olfactory environment		X	X		Very low

Environment	Factor	Sub-Factors	Prioritisation of the issue	Avoidance Measures	Reduction measures	Offsetting measures	Impact level after A, R, and O measures
		Electric and magnetic fields		X	X		Very low
	Landscape, cultural heritage, tourism, and recreational activities	Landscape	High	X	X		Low to high during the preliminary works and initial construction phases, then low during the operation phase once the landscape plantings have matured
		Archaeological heritage	High (western section)		X		Moderate
		Historical and architectural heritage and listed sites, classified sites	Moderate (027000 railway line)	X	X		Low
		Tourism and recreational activities	Low	X	X		Very low to positive
	Human health	/	/	X	X		At all stages of the Cigéo overall project (preliminary works, initial construction, operation, post-closure, as well as in the event of a major accident or disaster), the impact of physical, chemical, or radioactive emissions on human health is low to very low.

TRACEABILITY TABLE OF THE MAIN SUBSTANTIVE CHANGES

The following table provides a summary of the main changes in the impact assessment, with the following columns:

- details on technical characteristics: the details provided by the project owners regarding the specific characteristics of the operations comprising the overall project, related to clarifications or design changes, particularly in connection with public participation procedures;
- changes from the initial state: changes to the initial state of the environment as of the date the environmental impact assessment was submitted;
- regulatory changes: regulatory changes;
- clarification requested during the review of the application: clarifications provided by the project owners regarding the detailed characteristics of the operations comprising the overall project, related to responses to comments made by the reviewing authorities during the review of the previous environmental impact assessment.

The “Relevant Update” column specifies whether the changes made are related to the first update of the environmental impact assessment (EI-DAC) as part of the application to establish the BNI Cigéo and/or are related to the second update of the environmental impact assessment (EI2) as part of the first environmental characterisation and monitoring operations.

Chapter EI DAC		Details on technical characteristics	Changes from the initial status	Regulatory changes	Clarification requested during the review of the application	Relevant updates	Details on changes made to the content of the non-technical summary of the EI-DAC application submitted EI-DAC1 = impact assessment of the application to establish the Cigéo National Repository, submitted in 2023 EI-DR0 = Impact assessment of the DR0 construction phase files EI-DAC2 = impact assessment associated with the regulatory consultations for the DAC, submitted in 2025 EI-DAC3 = impact assessment associated with the DAC public inquiry, submitted in 2026
	Preamble	X				**EI-DAC1/EI-DR0/EI-DAC2/EI-DAC3**	Update of the impact assessment volume table. Clarifications provided in the text of the section “Impact assessment and Cigéo Overall Project”
1.1	**The Cigéo overall project, subject of the environmental impact assessment**	X				**EI-DAC1/EI-DR0**	Clarifications regarding the scope of the Cigéo overall project. Update consistent with the scope of the EI (DAC) and the progress of the Cigéo overall project.
1.2.3	**The project owners of the environmental characterisation and monitoring operations**	X				**EI-DR0**	Addition of a paragraph to present the project owners of the DR0 operations.
1.3.1	**The environmental assessment process**	X				**EI-DAC1**	Clarifications provided to facilitate a better understanding of the environmental assessment process.
1.3.3	**What information is included in the environmental impact assessment and its non-technical summary?**	X				**EI-DR0**	Update of regulatory references in the table “Breakdown of the regulatory content of the environmental impact assessment related to Articles L. 122-1 and R. 122-5a of the French Environment Code.”
1.4.1	**The impact assessment in the administrative procedures for the Cigéo overall project**				X	**EI-DAC1**	Clarifications regarding the successive updates to the impact assessment of the Cigéo overall project.
1.4.2	**Reasons for the updates to the environmental impact assessment in the context of its successive submissions**				X	**EI-DAC1**	

Chapter EI DAC		Details on technical characteristics	Changes from the initial status	Regulatory changes	Clarification requested during the review of the application	Relevant updates	Details on changes made to the content of the non-technical summary of the EI-DAC application submitted EI-DAC1 = impact assessment of the application to establish the Cigéo National Repository, submitted in 2023 EI-DR0 = Impact assessment of the DR0 construction phase files EI-DAC2 = impact assessment associated with the regulatory consultations for the DAC, submitted in 2025 EI-DAC3 = impact assessment associated with the DAC public inquiry, submitted in 2026
1.4.3	The impact assessment that is the subject of this file				X	EI-DAC1/ EI-DR0/ EI-DAC2/ EI-DAC3	Details regarding the management of changes to the impact assessment: what will change and how these changes will be tracked. Details regarding updates to the impact assessment.
1.4.4	Traceability of impact assessment updates within the framework of successive environmental assessment processes	X				EI-DR0/ EI-DAC2/EI-DAC3	Clarification regarding the specific case of managing the traceability of the DR0/DAC2/DAC3 impact assessment in relation to that associated with the application for a creation permit (DAC1) and the application for public utility (DUP).
1.5	Experts involved in the preparation and conduct of the impact assessment	X				EI-DAC1/EI-DR0	Updating of information: new contributors; removal of references to consulting firms whose studies have been modified; updates to experts' experience.
2.1.1	Justification of the need for sustainable management of high-level (HLL) and long-lived intermediate-level (LLIL) radioactive waste	X				EI-DAC1/EI-DR0/EI-DAC3	Clarifications and justification provided regarding the need for radioactive waste management. Figure 2-1 updated based on data from the 2026 edition of the National Inventory Essentials
2.1.2	The choice of deep geological disposal in the Callovian-Oxfordian clay formation	X				EI-DAC1	Details and justifications provided for the solutions not selected.
2.1.3	The selection of the site for the Cigéo disposal facility and other associated operations	X				EI-DAC1/EI-DR0	Clarifications regarding the site selection for the Cigéo disposal facility and other related operations. Update on the elements of the alternatives in light of the progress of consultations (electrical substation and D60/960 departmental road alternative).
2.1.3.2.2	Water supply		X			EI-DAC2/EI-DAC3	Addendum reflecting project progress Update to reflect the publication of the report on the consultation conducted by the water authority
2.1.3.2.3	Upgrading of railway line 027000		X			EI-DAC2	Addendum reflecting the project's progress
2.1.3.2.4	The rerouting of the D60/960 departmental road		X			EI-DAC2	Supplement reflecting project progress
2.1.3.2.5	Environmental characterisation and monitoring activities	X	X			EI-DR0/ EI-DAC2	Addition of a chapter on environmental characterisation and monitoring operations. Link to the Andra website added
2.1.3.4 2.1.3.5	Design choices related to facility safety and the gradual acquisition of scientific and technological knowledge Environmental design choices	X			X	EI-DAC1	Addition of a summary of technical design choices, in connection with the updates made to Volume II and the Environmental Authority's recommendation on the EI-DUP for the Cigéo overall project.
2.1.4	The project developed in dialogue with society		X			EI-DAC2/EI-DAC3	Supplement reflecting project progress

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2.1.5	Why proceed with the construction of the Cigéo disposal facility now?	X				EI-DAC1	Clarifications and justifications regarding the construction of the Cigéo disposal facility and the industrial pilot phase.
2.1.5.1	A project that has reached maturity				X	EI-DAC2	Addition of the Expert Committee's progress report and the socio-economic assessment to the draft
2.2	Waste destined for the Cigéo disposal facility		X			EI-DAC3	Update of figures for HLW and ILW-LL already produced in line with data from the 2026 edition of the National Inventory Essentials
2.3.1	The Cigéo disposal facility, managed by Andra, in operation	X				EI-DAC1	Addition of an introduction to improve the organisation and clarity of the chapter presenting the Cigéo repository.
2.3.1.2	The ramp zone	X				EI-DAC2	Addition regarding the medical center
2.3.1.1.4	The Basic Nuclear Installation (BNI)	X				EI-DAC1	Addition of a chapter presenting the basic nuclear installation and its scope.
2.3.1.2	The ramp zone	X				EI-DAC1	Clarifications provided in the description and illustrations of operations at the Cigéo disposal facility, in line with the updates made to Volume II.
2.3.1.3	The shaft zone	X				EI-DAC1	
2.3.1.4	The area where underground structures are located	X				EI-DAC1	
2.3.2	Other operations of the Cigéo overall project related to its construction and operation	X				EI-DAC1/EI-DR0	Clarifications regarding the preliminary consultation conducted for the upgrade of railway line 027000, in connection with the updates made to Volume II. Update related to the consultation and selection of alternatives (power supply and departmental road D60/960). Details provided regarding environmental characterisation and monitoring operations.
2.3.2.6	Environmental characterisation and monitoring activities	X				EI-DAC2	Link added to the Andra website
2.4	The successive phases of deployment of the Cigéo overall project	X				EI-DAC1/EI-DR0	Clarifications provided regarding the description of the phases of the Cigéo overall project's implementation. Clarifications regarding environmental characterisation and monitoring operations. Clarifications regarding the timing of work and operations by other project owners. Clarifications regarding the first environmental characterisation and monitoring operations.
2.4.1.3	The operational phase	X				EI-DAC2	Alignment of the schedule
2.4.2	Description of the industrial pilot phase		X			EI-DAC2/ EI-DAC3	Clarification regarding the industrial pilot phase Update to reflect the publication of the summary of the consultation conducted by Andra on reversibility reviews
2.4.3.3	Integration of reversibility into the design of the disposal facility		X			EI-DAC2/ EI-DAC3	Clarification provided regarding the consultation Update to reflect the publication of the summary of the consultation conducted by Andra on reversibility reviews

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2.5	The main tasks and their implementation procedures	X				EI-DAC1/EI-DR0	Addition of a summary describing the main works and their implementation methods for the various phases of the Cigéo overall project, in line with the updates made to Volume II. Addition of a clarification regarding preventive archaeology work. Addition of a clarification regarding decommissioning work.
2.5.1.3	The first environmental characterisation and monitoring operations, known as “DR0 operations”			X		EI-DAC2	Clarification regarding the review of the application file containing requests for environmental permits and requests for planning permits for DR0 work
2.6	Estimation of resource consumption and expected emissions and residues	X				EI-DAC1	Addition of a summary of the estimated resource consumption and expected emissions and residues for the Cigéo overall project, in conjunction with the updates made to Volume II.
2.6.2.7	Waste	X				EI-DAC2	Clarification regarding unconventional liquid effluents.
3.1.1.2	Impacts and measures	X				EI-DAC1	Clarifications regarding the factors used to assess the level of impact.
3.1.2	Definition of study areas				X	EI-DAC1/EI-DR0	Update of the remote study area for the “Water” theme to reflect the Environmental Authority’s recommendation regarding the EI-DUP for the Cigéo overall project, and of the remote study area for other physical environmental factors. Update of the immediate study area and the nearby study areas. Update of the expanded and immediate study areas for biodiversity. Addition of a map for the study areas concerning the landscape. Addition of mapping for the study areas concerning interactions.
3.2.1.1	Initial status		X			EI-DAC1/EI-DAC2	Clarifications regarding the presentation of weather stations Updated with weather data from 2018 and 2019.
3.2.2.2	Impacts and associated measures	X				EI-DAC1	Clarifications and justifications provided regarding the analysis of the Cigéo overall project’s vulnerability to major meteorological risks. Clarifications provided regarding the design of the Cigéo overall project. Clarifications regarding the selection of drought-resistant tree species.
3.2.3	Energy and Greenhouse Gases		X			EI-DR0	Clarifications regarding the measures.
3.2.3.1.1	Energy profile		X			EI-DR0	Details regarding the energy profile.
3.2.3.1.2	Renewable energy potential		X			EI-DR0/EI-DAC2	Data update.
3.2.3.2	Impacts and associated measures	X				EI-DAC2	Duration precision
3.2.4.1	Conventional parameters	X				EI-DAC1	Details regarding the implementation of atmospheric dispersion modelling to assess impacts on air quality. Summary of modelling results and the absence of air quality degradation.
3.2.4.1.2	Impacts and associated measures	X				EI-DAC2	Update of the software used

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3.2.4.2	Radiological parameters	X	X			EI-DAC1/EI-DAC3	Clarifications regarding the initial radiological state Addition of a paragraph presenting the results of atmospheric dispersion modelling of radioactive releases into the air. Clarifications provided in connection with the IRSN report "Assessment of the Radiological Status of the French Environment from 2018 to 2020"
3.3.2	Land use	X				EI-DAC1	Consistency of the impacts of the Cigéo overall project on land-use change, in connection with the updates made to Chapter 3 of Volume IV.
3.3.3.1	Initial condition	X				EI-DAC2	Consistency with the clarification provided in Volume III of the EI
3.3.3.2.1	During preliminary development and initial construction phases	X				EI-DAC2	Alignment with details provided in Volume III of the EI
3.4.1.1	The initial state		X			EI-DAC1/EI-DR0	Clarifications provided on the method for characterising the initial radiological state of the subsurface. Update of the study areas on the map of the local tectonic context
3.4.1.2	Impacts and measures	X				EI-DAC1	Clarifications Regarding the Long-Term Safety of the Cigéo Disposal Facility
3.4.2	Major risks related to geology		X			EI-DAC1/EI-DR0	Addition of a box on the concept of major risks. Clarifications provided on the geodynamic and seismotectonic context.
3.4.2.2.1	Vulnerability to seismic risk of natural and anthropogenic origin	X			X	EI-DAC1/EI-DR0/EI-DAC2	Details regarding the vulnerability of the Cigéo overall project to seismic risk of natural and anthropogenic origin.
3.4.3	Subsurface resources	X				EI-DAC1	Details regarding the absence of exceptional or unique geological resources at the Cigéo disposal facility site.
3.4.3.1	Initial status	X				EI-DAC2	Alignment with the clarification provided in Volume III of the EI
3.4.4	The project's compatibility with the departmental quarry plans for Haute-Marne and Meuse	X				EI-DAC1/EI-DAC2	Clarifications provided regarding the demonstration of the project's compatibility with the Haute-Marne and Meuse Departmental Quarry Plans.
3.5.1.3	Groundwater		X			EI-DAC1	Update of the methodology section with the supplementary survey on water uses conducted by Andra in 2020. Clarifications provided in the summary regarding the levels of concern for quantitative, qualitative, and usage aspects.
3.5.1.3.1	Groundwater "bodies" and aquifers		X			EI-DAC1	Update of the Dogger Limestone water body code. Update following the adoption of the Seine-Normandy SDAGE 2022-2027.
3.5.13.2	Groundwater use		X			EI-DAC1	Update based on the supplementary survey on water uses conducted by Andra in 2020.

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3.5.1.2	Surface water		X			EI-DAC1	Details provided in the methodology section on surface water. Update following the adoption of the Seine-Normandy SDAGE 2022-2027. Clarifications provided in the summary of priority levels for quantitative and qualitative aspects, water uses, and flood risk. Update of data on surface water quality for the 2018–2019 period. Clarifications provided on flood risk.
3.5.1.2.1	Surface water bodies (watercourses and bodies of water)		X			EI-DAC1/EI-DR0	Details provided on bodies of water located near the ITE. Addition of the Ragère body of water
3.5.1.2.5	Surface water use		X			EI-DAC1	Updating data on surface water use.
3.5.2.2	The ERC approach to limiting quantitative impacts	X				EI-DAC1/EI-DR0	Reorganisation and clarifications provided to clarify the presentation of the ERC sequence regarding quantitative and qualitative aspects and uses. Addition of details regarding the impacts of constructing surface-to-subsea connections.
3.5.2.3	The ERC approach to limiting impacts on water quality	X				EI-DAC1	
3.5.2.4	The ERC approach to limiting impacts on water uses	X				EI-DAC1	
3.5.2.6	Compatibility of the Cigéo overall project with various planning tools		X			EI-DAC1/EI-DR0	Update following the adoption of the 2022–2027 Seine-Normandy and Rhine-Meuse Regional Water Management Plans (SDAGE). Clarifications provided on the objectives related to the “water” component of the Grand Est SRADDET (103), water distribution zones, as well as reservoirs and biodiversity corridors. Addition of the Grand Est policy
3.6.1	Initial status		X			EI-DAC1	Addition of a definition box regarding the names of the different species.
3.6.1.1	Biodiversity protection policy		X			EI-DAC1	Update following the adoption of the Seine-Normandy (97) and Rhine-Meuse 2022-2027 (98–102) SDAGEs.
3.6.1.2	General Characterisation of Biodiversity in the Remote Study Area		X			EI-DAC1/EI-DR0	Addition of the results of the literature review conducted at the scale of the immediate study area of the Cigéo disposal facility for the period 2010–2022. Updating of data consistent with the updated immediate study area.
3.6.1.3.3	Characterisation of wetlands in the Cigéo overall project		X			EI-DR0	Update of inventoried areas in conjunction with the supplementary studies conducted.
3.6.1.4.2	Biodiversity corridors and reservoirs identified in the SRADDET		X			EI-DAC1	Clarifications provided on the main elements constituting the green and blue infrastructure within the study area of the 400 kV transmission line.
3.6.1.4.3	Sub-networks representative of the study area distant from the Cigéo overall project		X			EI-DAC1/EI-DR0	Update regarding ecological connectivity at the national and regional levels, the corridors identified in the SRADDET, and the sub-grids representative of the immediate study area, in conjunction with the updates made to Volume IV. Clarifications provided on the modelled sub-grids of forested and open habitats. Clarifications provided for the remote study area.

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3.6.1.5	Biodiversity issues at the scale of the Cigéo overall project		X			EI-DAC1/EI-DR0	Addition of definition boxes. Reorganisation and updating of data based on the latest inventories, issue levels, the summary map of issues, and the summary table of issues, in line with the updates made to Volume III. Updating of data in the immediate biodiversity study area, incorporating the 2022 inventories. Addition of a chapter presenting the ecological issues (fauna and flora) from the first environmental characterisation and monitoring operations.
3.6.1.5.9	Radiological Status	X				EI-DAC3	Clarifications provided in connection with the IRSN report "Assessment of the Radiological Status of the French Environment from 2018 to 2020"
3.6.2	Impact and measures	X				EI-DAC1	Clarifications regarding the elements of the media-difference compensation method.
3.6.2.6.2	Chemical emissions	X				EI-DAC2	Addition of a paragraph on chemical emissions
3.6.2.2	Residual impacts on protected or outstanding natural areas	X				EI-DAC1	Clarifications regarding the mitigation of impacts on key species in ZNIEFF areas.
3.6.2.5.1	Residual impacts by group and species assemblage	X				EI-DAC1	Update on residual impacts by species group and assemblage. Details on compensation measures to achieve the goal of zero net loss of biodiversity.
3.6.2.7	The ecological debt of the Cigéo disposal facility project	X				EI-DAC1	Update with the new calculation of ecological debt presented in Volume IV.
3.6.2.8	Ecological compensation	X				EI-DAC1/EI-DR0	Update of information regarding ecological compensation sites. Addition of a specific paragraph on “Other specific compensation needs” addressing wetlands, ponds, and the Ciliated Melic.
3.6.4	Natura 2000 Impacts		X			EI-DR0	Update of the distance to the project, taking into account DR0 operations.
3.7.1 3.7.2 3.7.3	Population Employment and economic activities Housing		X			EI-DAC1/EI-DR0	Update of data regarding the characterisation of the initial state of the population, employment, and economic activities. Updating of data consistent with the updated immediate study area. Details provided on the age structure of the population, the socio-professional distribution of the population, and commuting patterns.
3.8.1.1	The initial state	X				EI-DAC3	Details provided in connection with the IRSN report "Assessment of the Radiological Status of the French Environment from 2018 to 2020"
3.8.1.2	Impacts and associated measures	X				EI-DAC1	Update of agricultural parcel areas for the Cigéo disposal facility, following parcel exchanges carried out in recent years. Clarifications provided on the elements of the method for estimating the need for compensation for agricultural activities.

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3.9.1	**The initial status**		X			**EI-DR0**	Clarifications regarding the networks identified in connection with changes to the study areas. Update of the refined study area on the network location map
3.9.2.1	**Existing networks**	X				**EI-DAC1**	Clarifications provided on avoidance and mitigation measures. Alignment of the residual impact level with the text of the EI-DUP.
3.9.2.2	**The creation and securing of networks**	X				**EI-DAC1**	Details on the positive impacts of the creation and securing of networks
3.10.1.1	**The Initial State**		X			**EI-DAC1**	Addition of a definition box for radioactive waste Update with the 2022-2026 National Plan for the Management of Radioactive Waste (PNGMDR) (162).
3.10.1.2	**Impact and associated measures**	X				**EI-DAC1/EI-DR0**	Update with the 2022-2026 PNGMDR. Clarifications provided on the nature, quantity, and management of radioactive waste generated by the operation of the BNI. Clarifications provided on “non-conventional effluents”
3.10.2.1	**Initial status**		X			**EI-DAC1/EI-DR0**	Addition of a definition box for conventional waste. Clarifications regarding the relationship between the PRGD and the SRADDET
3.10.2.2	**Impact and associated measures**	X				**EI-DAC1/EI-DR0**	Details regarding the nature, quantities, and management of conventional waste generated by the Cigéo overall project.
3.11.1	**Initial status**		X			**EI-DAC1/EI-DR0**	Update of major risks based on information from the latest editions of the Regional Disaster Management Plans (DDRM) for Haute-Marne and Meuse. Update of census data on facilities classified for environmental protection (ICPE). Clarifications provided using available data on Class C dams identified in the municipalities of the detailed study area. Clarifications provided in the section on issues concerning ICPEs, TMDs, and dams. Updating of risk data in line with changes to the study areas.
3.11.1.1	**Risks of Natural Origin**			X		**EI-DAC2**	Clarification regarding the DDRM currently being updated
3.11.2	**Vulnerability to major accidents and disasters, and assessment of the consequences of accidental situations on the environment and human health**					**EI-DAC1**	Chapter divided into three main subchapters: Vulnerability to major accident or disaster risks, risks associated with the Cigéo BNI, and other risks of the Cigéo overall project Risks associated with the Cigéo BNI, developed in line with the risk management study, Document 8 of the application for a construction permit (DAC). Other chapters updated in line with the initial status
3.12.1	**The initial status**		X			**EI-DAC1/EI-DR0**	Clarifications and justifications provided regarding the definition of the level of concern (without changing the level of concern compared to the EI-DUP).
3.13.1	**The initial state**		X			**EI-DR0/EI-DAC2**	Clarification provided regarding the territory’s issues (sites sensitive to nuisances). Update of study areas on maps

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3.13.2.1	**Acoustic impacts and measurements**	X				**EI-DAC1/EI-DR0**	Emphasis on mitigation measures related to site selection and train traffic between 6 a.m. and 10 p.m. Clarifications provided on noise avoidance and reduction measures. Addition of noise maps derived from modelling. Justifications provided for residual impacts. Revision of impacts during the pre-authorisation phase. Mention of the noise barrier along the western tracks of the ramp zone east of Saudron, with the addition of a map.
3.13.2.1.1	**The preliminary development phase**		X			**EI-DAC2**	Alignment with the new initial acoustic conditions
3.13.2.1.2	**The initial construction phase**		X			**EI-DAC2**	Alignment with new initial acoustic condition
3.13.2.2	**Vibration-related impacts and measures**	X				**EI-DR0**	Emphasis on mitigation measures related to site selection, train operations between 6 a.m. and 10 p.m., and the suspension of night work whenever possible.
3.13.2.3	**Lighting impacts and measures**	X				**EI-DAC1**	Details provided on measures to avoid and reduce light emissions.
3.13.2.4	**Odour impacts and associated measures**		X			**EI-DR0**	Details provided on avoidance and reduction measures
3.13.2.5	**Impacts related to electric and magnetic fields and associated measures**	X				**EI-DAC1**	Details and justifications regarding measures to avoid and reduce emissions of electric and magnetic fields.
3.14.1.1	**Initial condition**		X			**EI-DAC1**	Redefinition of the units and subunits of the landscape analysis to strengthen the link with existing landscape studies.
3.14.1.2	**Impacts and associated measures**	X				**EI-DAC1**	Updating the analysis by: a broad-brush approach followed by a detailed one; project life cycles.
3.14.2	**Cultural heritage**		X			**EI-DR0**	Clarification provided in the sources and methodology section regarding unprotected notable heritage.
3.14.2.1	**Archaeological Heritage**	X	X			**EI-DAC1**	Extension of the classification of significance levels to all study areas. Clarifications provided regarding unprotected remarkable heritage.
3.14.2.2	**Historical and architectural heritage and listed sites, classified sites**						
3.15.1	**The initial state of territorial planning and land use planning (including urban planning)**		X			**EI-DAC1/EI-DR0**	Update with the Grand Est Regional Development Plan (CPER) 2021-2027 (135). Updating of data consistent with the updated immediate study area, taking into account changes in urban planning documents.
3.15.2	**Impacts and measures on territorial planning and land use planning (including urban planning)**	X				**EI-DAC1**	Update of these chapters in line with the required harmonisation of urban planning documents, as formalised by the declaration of public interest for the Cigéo disposal facility.

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3.15.3	The compatibility of the Cigéo overall project with plans, schemes, and programs related to land use planning	X				EI-DAC1	
3.16.1	Interactions between different environmental media – the initial state		X			EI-DAC1	Addition of a definition box on ecosystem services. Clarifications provided on ecosystem services.
3.16.2	Interactions between the Cigéo overall project and ecosystem services	X				EI-DAC1	Clarifications regarding compensation measures and their impact on ecosystem services.
3.16.3	Cumulative impacts of the project in combination with other existing or approved projects	X		X		EI-DAC1/EI-DR0	Addition of a box defining the concept of cumulative impacts. Update of the applied methodology. Addition of projects related to the update of the methodology, the update of study areas, and changes in available information. Aligned with Volume IV. Removal of the “Éole de la Joux” wind farm project, whose operating permit was rejected.
3.17	Best Available Techniques	X				EI-DAC1	Creation of a new Chapter 17 in the EI-DAC justifying the use of best available techniques for the Cigéo basic nuclear installation (BNI) in accordance with the provisions of Article R. 593-17 of the French Environment Code.
3.18.1	The impacts of decommissioning and closure operations					EI-DAC1	Clarifications provided on the nature of the impacts in line with the decommissioning, closure, and monitoring plan (PDFS), Document 13 of the application for a construction permit (DAC).
3.18.2	Impacts following the permanent closure of the disposal facility					EI-DAC1/EI-DAC2	Update of the chapter in accordance with the risk management study, Document 8 of the application for a construction permit (DAC). Addition of a paragraph on the radiological and chemical impacts on wild flora and fauna
3.19	Impacts on human health	X				EI-DAC1/EI-DR0	Consistency of the human health impacts of the Cigéo overall project, in line with the updates made to Volume VI.
3.19.1.1	Noise emissions		X			EI-DAC2	Update with new baseline
3.19.2	The Effects of Chemical Emissions on Human Health		X		X	EI-DAC2	Alignment with the clarification provided in Volume VI of the EI
3.20	The nature and procedures for monitoring environmental measures and surveillance		X			EI-DAC1/EI-DR0	Rewording
3.21	Estimated expenditures related to environmental measures		X			EI-DAC2	Update with cost estimate
3.23	Summary of the environmental impacts of the Cigéo overall project	X				EI-DAC1/EI-DAC2	Update of the summary table of impacts in line with Volume IV.

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