Brazilian Multipurpose Reactor Project (RMB)

Project Status

Brazilian Nuclear Energy Commission (CNEN)

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December 2012

Topics

- Nuclear Research Reactors in Brazil
- RMB Project Scope
- RMB Project Status.

Research Reactors in Brazil

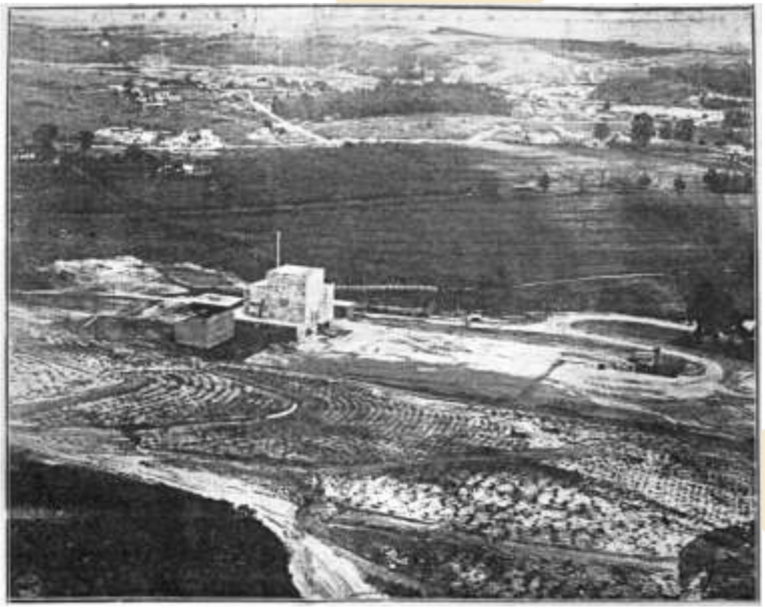
Name	Utilization	Power	Location	Startup	Type
IEA-R1	Research – Radioisotope Production	5 MW (2 MW)	IPEN/CNEN-SP São Paulo	1957	MTR Pool Type Reactor
IPR-R1	Research – Training	100 kW	CDTN/CNEN-MG Belo Horizonte	1960	TRIGA MARK-I
ARGONAUTA	Research – Training	500 W	IEN/CNEN-RJ Rio de Janeiro	1965	Argonaut
IPEN/MB-01	Critical Facility – PWR Core Analysis	100 W	IPEN/CNEN-SP São Paulo	1988	Pin Type Open Core

Research Reactors in Brazil

IEA-R1	IPR-R1	ARGONAUTA	IPEN/MB-01
•Specific radioisotope production for medical, industry, agriculture and engineering applications •Neutron activation analysis •Neutron Beam Utilization •Neutron radiography •Silicon Doping •Fuel irradiation and NDT analysis inside the pool •Teaching and training in reactor physics •Neutron Flux < 5×10^{13} n/cm^2.s (thermal)	Specific radioisotope production for medical, industry, agriculture and engineering applications •Neutron activation analysis. •Teaching and training in reactor physics. •Training the Brazilian nuclear power reactor operators.	•Teaching and training in reactor physics •Neutron radiography •Neutron activation analysis	•Validation of reactor physics methodology and nuclear data associated for PWR core analysis •Teaching and training in reactor physics

Research Reactors in Brazil

IEA-R1 Reactor (1958)



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Future Perspectives for RR Utilization

Brazilian Nuclear Program Review

- Electricity produced by nuclear power plants
  - Brazil will continue to use nuclear energy in its electrical power matrix.
- Nuclear Fuel
  - Brazil has a significant uranium ore reserve and domains the fuel cycle technology, including U enrichment.
  - Increase of industrial activities for supplying the nuclear power plants needs.
- Nuclear Techniques Utilization
  - Increase of nuclear techniques applications and radioisotope utilization in the benefit of the society.
  - Increase of autonomous technology development

Nuclear Medicine

ARAMAR - IPERÓ

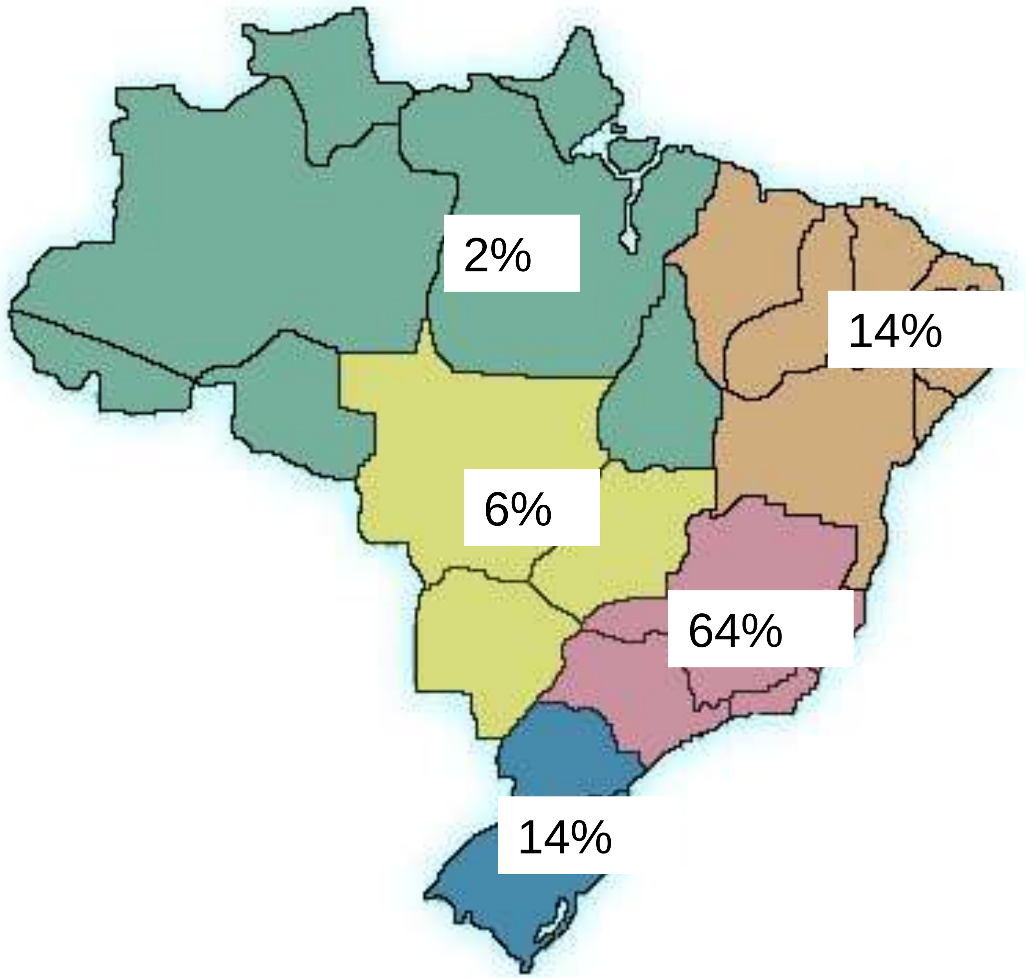
$^{99}Mo/^{99m}Tc$ Generator

- More than 330 generators per week
- 250,500,750,1000,1250,1500 and 2000 mCi

Produced by IPEN/CNEN-SP, with imported Mo99

Nuclear Medicine

Regional Distribution of Radiopharmacals produced by IPEN



More than 300 clinics

More than 1,5 million procedures per year

Fundamental in Nuclear Medicine

Future Perspectives for RR Utilization

Decision on the New Multipurpose Research Reactor!

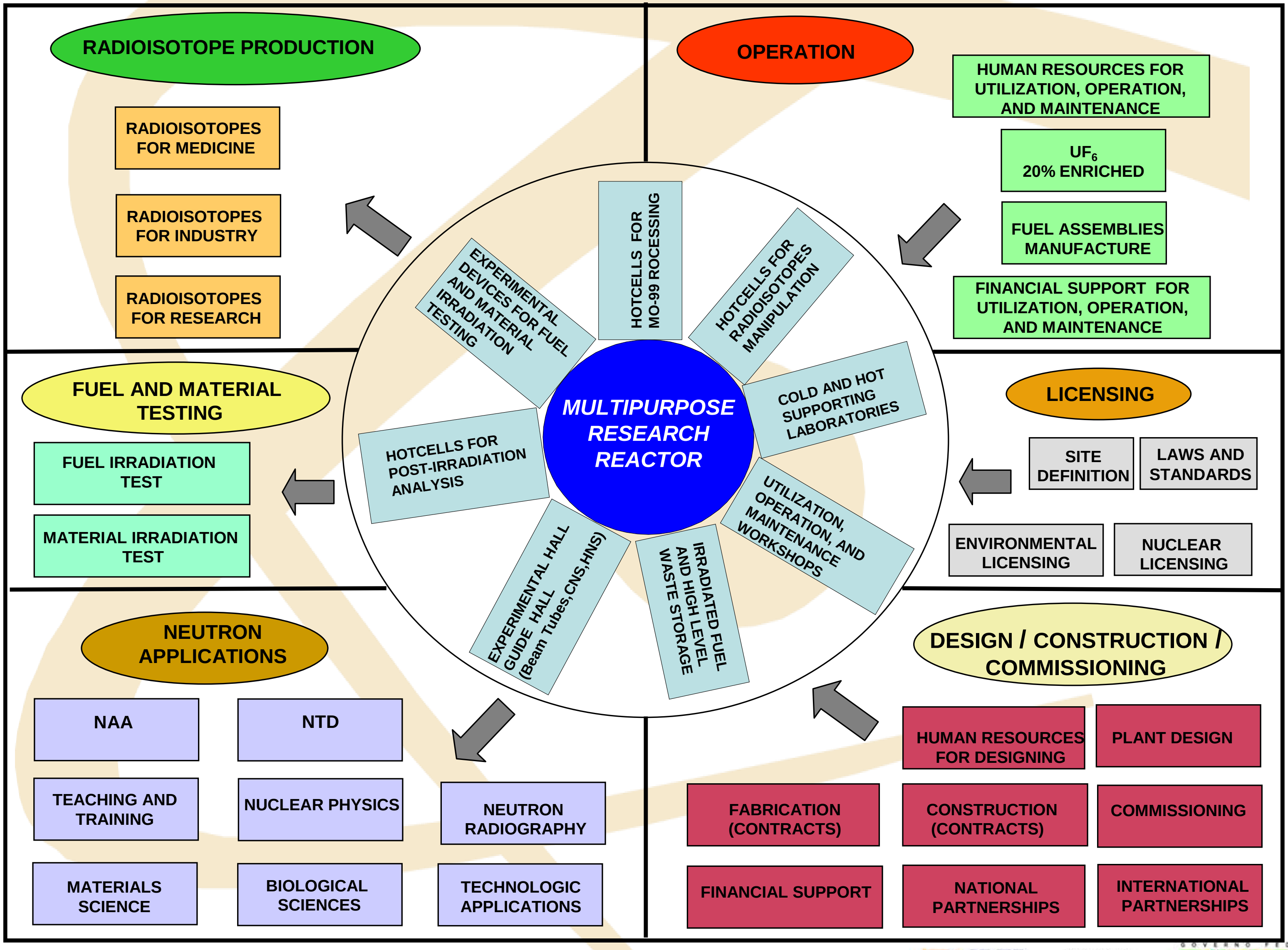
- ✓ The Science Technology and Innovation Ministry has decided to support the new research reactor construction in accordance to the Brazilian Nuclear Program
- ✓ The Brazilian Nuclear Energy Commission (CNEN) is in charge of implementing the new research reactor.
- ✓ The State of São Paulo is giving support to the project.
- ✓ This new research reactor shall have neutron fluxes compatible to the multipurpose uses and application needs.

Brazilian Multipurpose Research Reactor (RMB)

Main Functions

- Radioisotope Production for Medical and Industrial Applications
- Fuel and Materials Irradiation Testing
- Neutron Beam Scientific and Technological Research
- Education and Training

RMB Scope



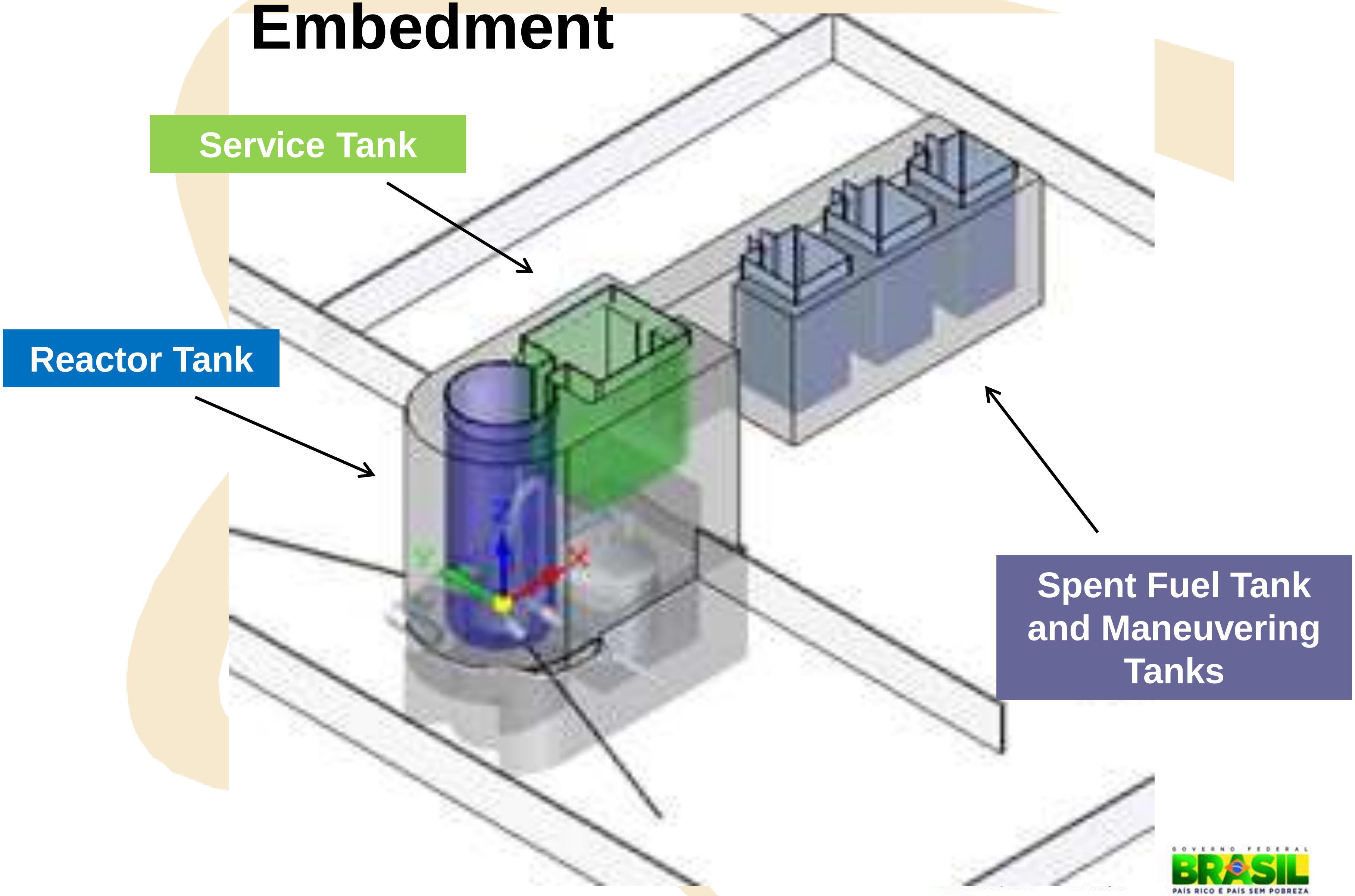
RADIOISOTOPE PRODUCTION
RADIOISOTOPES FOR MEDICINE
RADIOISOTOPES FOR INDUSTRY
RADIOISOTOPES FOR RESEARCH
OPERATION
HUMAN RESOURCES FOR UTILIZATION, OPERATION, AND MAINTENANCE
UF6 20% ENRICHED
FUEL ASSEMBLIES MANUFACTURE
FINANCIAL SUPPORT FOR UTILIZATION, OPERATION, AND MAINTENANCE
FUEL AND MATERIAL TESTING
FUEL IRRADIATION TEST
MATERIAL IRRADIATION TEST
LICENSING
SITE DEFINITION
LAWS AND STANDARDS
ENVIRONMENTAL LICENSING
NUCLEAR LICENSING
MULTIPURPOSE RESEARCH REACTOR
HOTCELLS FOR MO-99 ROCESSING
HOTCELLS FOR RADIOISOTOPES MANIPULATION
COLD AND HOT SUPPORTING LABORATORIES
UTILIZATION, OPERATION, AND MAINTENANCE WORKSHOPS
IRRADIATED FUEL AND HIGH LEVEL WASTE STORAGE
EXPERIMENTAL HALL GUIDE HALL (Beam Tubes,CNS,HNS)
HOTCELLS FOR POST-IRRADIATION ANALYSIS
EXPERIMENTAL DEVICES FOR FUEL AND MATERIAL IRRADIATION TESTING
NEUTRON APPLICATIONS
NAA
NTD
TEACHING AND TRAINING
NUCLEAR PHYSICS
NEUTRON RADIOGRAPHY
MATERIALS SCIENCE
BIOLOGICAL SCIENCES
TECHNOLOGIC APPLICATIONS
DESIGN / CONSTRUCTION / COMMISSIONING
HUMAN RESOURCES FOR DESIGNING
PLANT DESIGN
FABRICATION (CONTRACTS)
CONSTRUCTION (CONTRACTS)
COMMISSIONING
FINANCIAL SUPPORT
NATIONAL PARTNERSHIPS
INTERNATIONAL PARTNERSHIPS

Reactor Characteristics

- Open pool multipurpose research reactor with a primary cooling system through the core – OPAL RR as a reference model for conceptual design.
- The reactor core will be compact, using MTR fuel assembly type, with planar plates, U_3Si_2-Al dispersion fuel with maximum 4,8 gU/cm^3 density and 20 % U-235 enrichment.
- The reactor core will be cooled and moderated by light water, using heavy water as reflector and light water and/or beryllium in one side of the core .
- Neutron flux (thermal and fast) higher than $2x10^{14}$ $n/cm^2.s$.
- Maximum Thermal Power - 30 MW

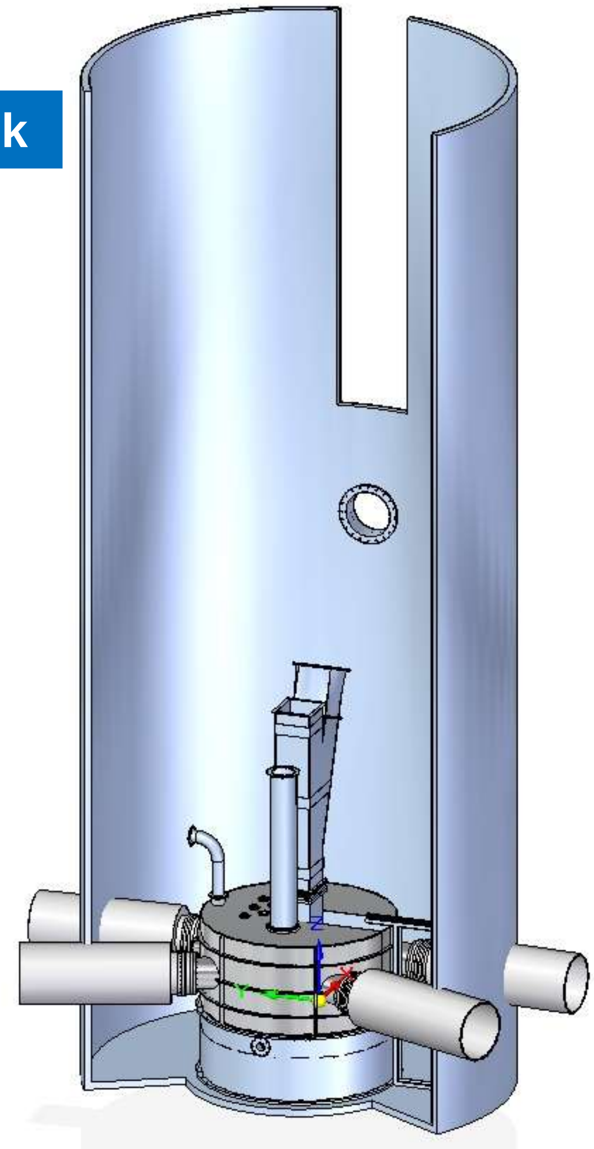
Reactor Characteristics

Embedment

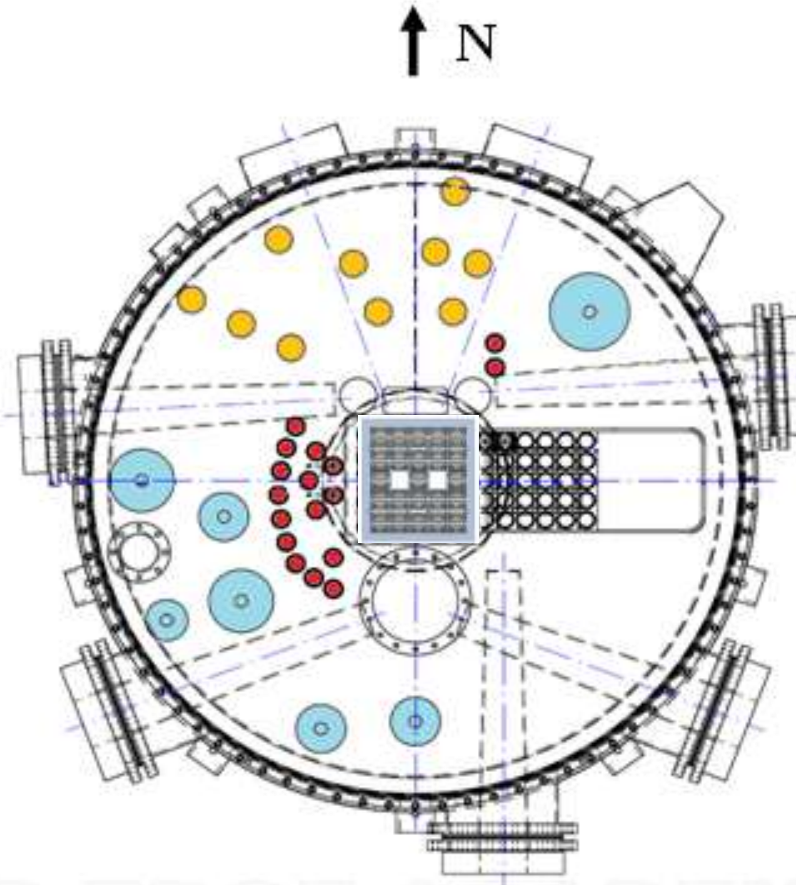


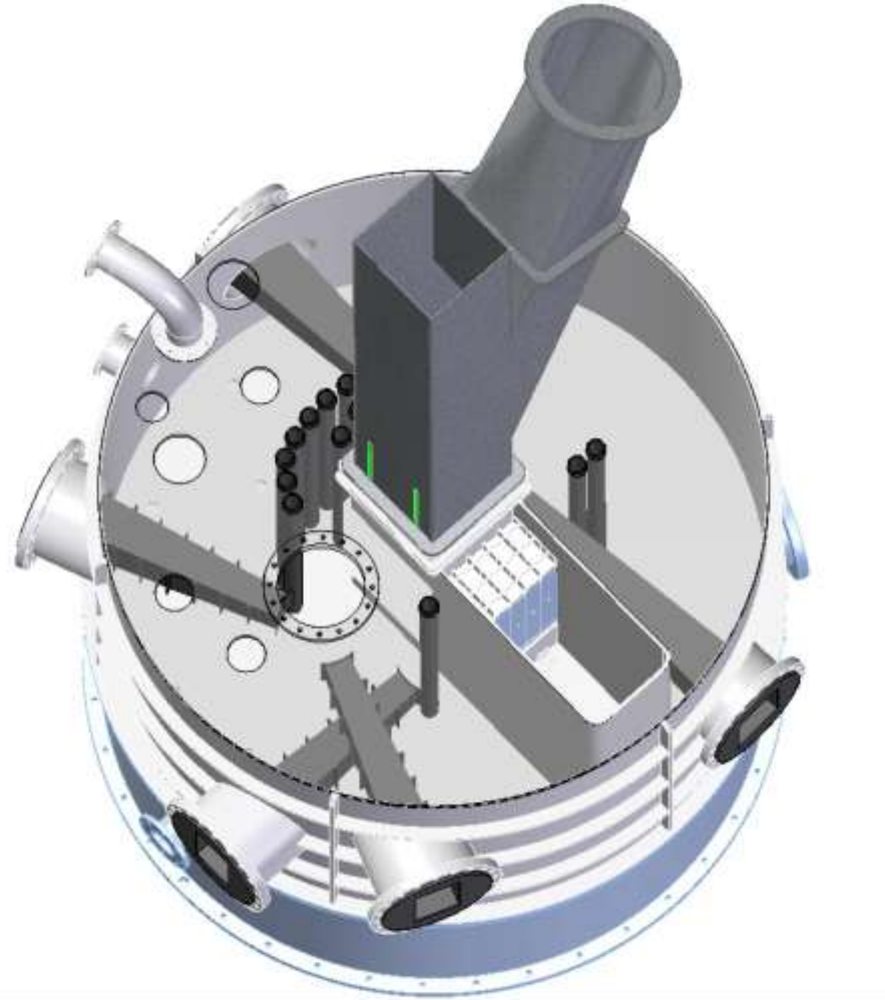
Reactor Characteristics

Reactor Tank

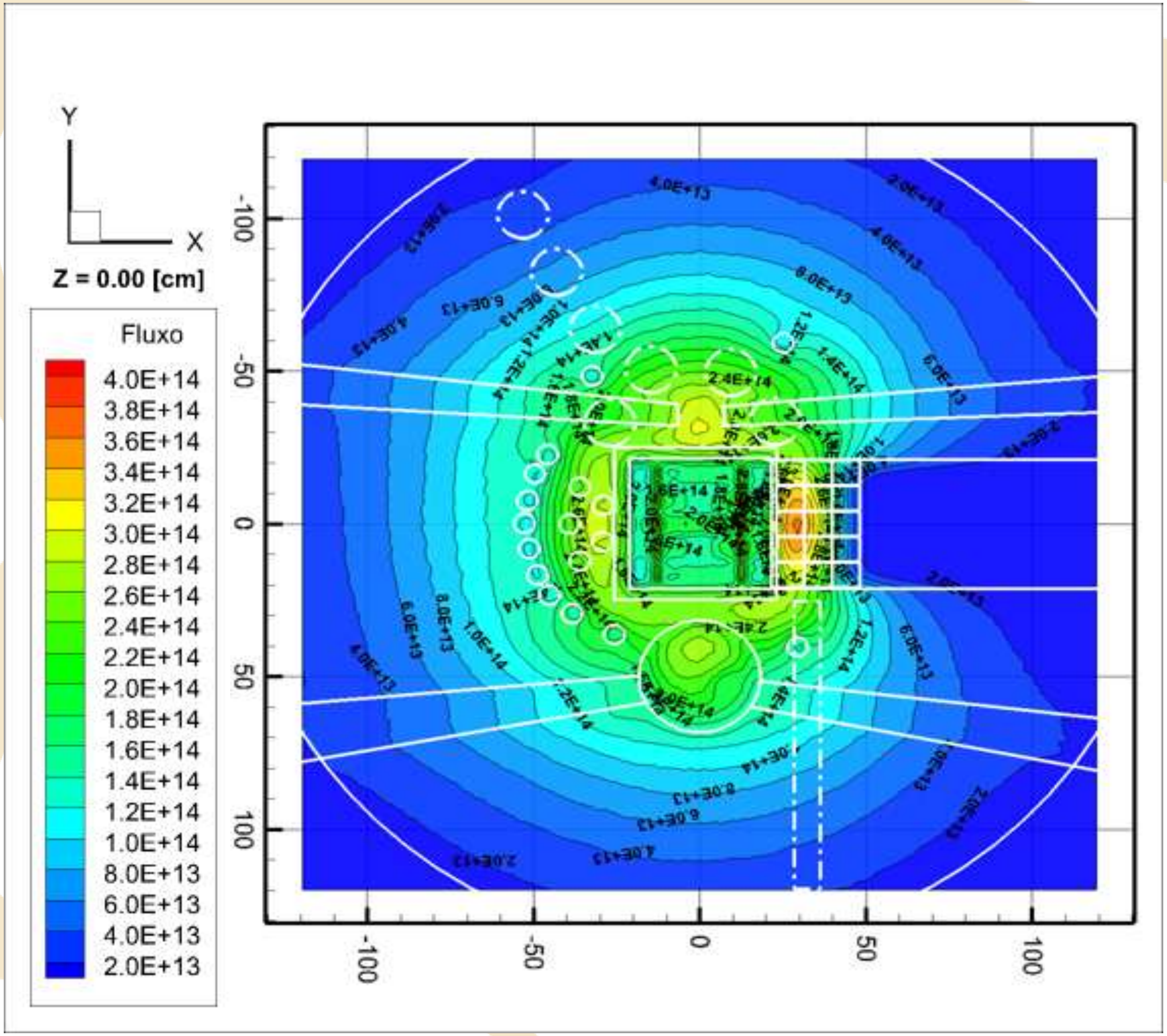


RMB Reactor



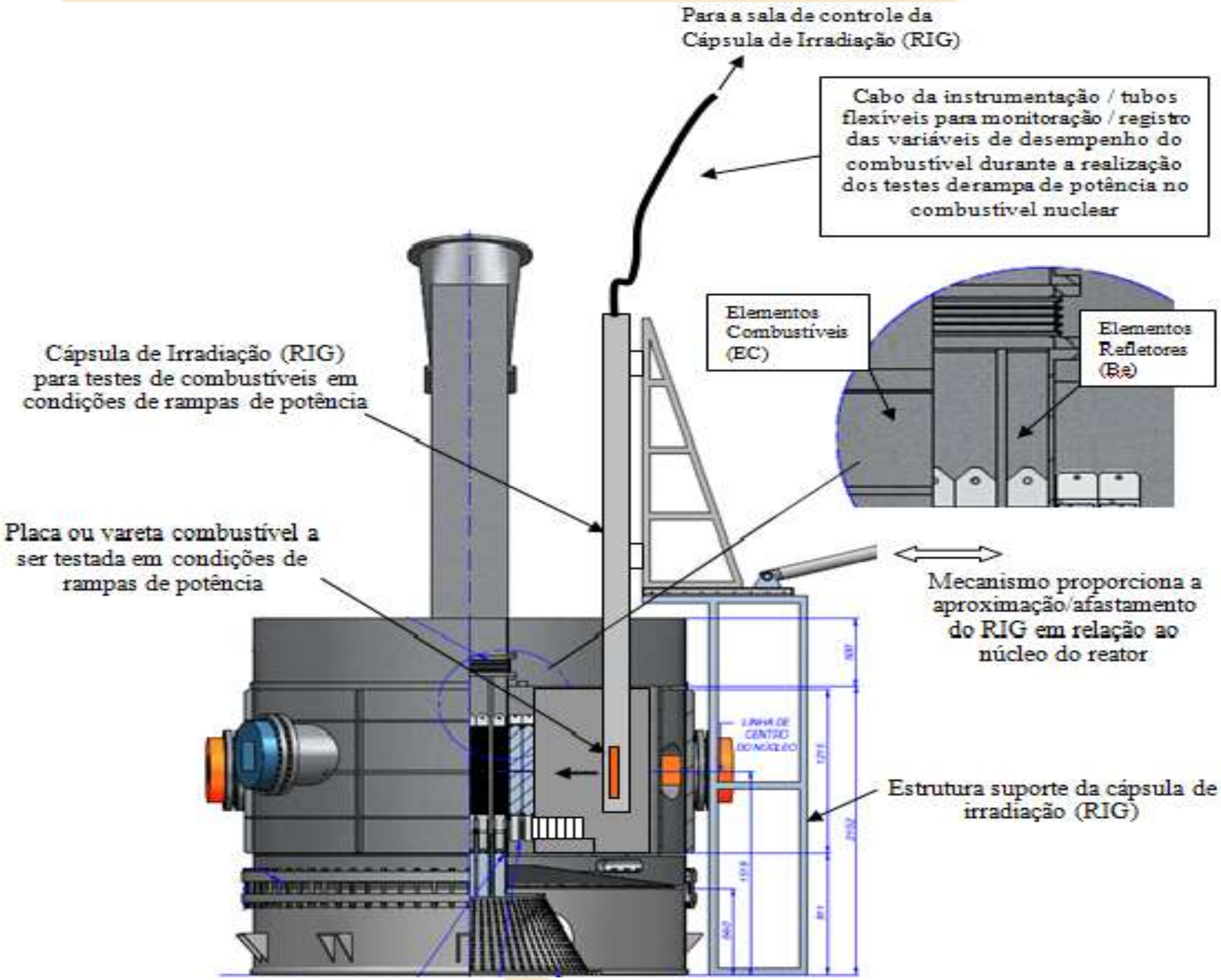


RMB Reactor



Y
X
Z = 0.00 [cm]
Fluxo
4.0E+14
3.8E+14
3.6E+14
3.4E+14
3.2E+14
3.0E+14
2.8E+14
2.6E+14
2.4E+14
2.2E+14
2.0E+14
1.8E+14
1.6E+14
1.4E+14
1.2E+14
1.0E+14
8.0E+13
6.0E+13
4.0E+13
2.0E+13
-100
-50
0
50
100

RMB Reactor


Para a sala de controle da
Cápsula de Irradiação (RIG)
Cabo da instrumentação / tubos flexíveis para monitoração / registro das variáveis de desempenho do combustível durante a realização dos testes derampa de potência no combustível nuclear
Elementos Combustíveis (EC)
Elementos Refletores (Be)
Cápsula de Irradiação (RIG) para testes de combustíveis em condições de rampas de potência
Placa ou vareta combustível a ser testada em condições de rampas de potência
Mecanismo proporciona a aproximação/afastamento do RIG em relação ao núcleo do reator
Estrutura suporte da cápsula de irradiação (RIG)

Radioisotope Production

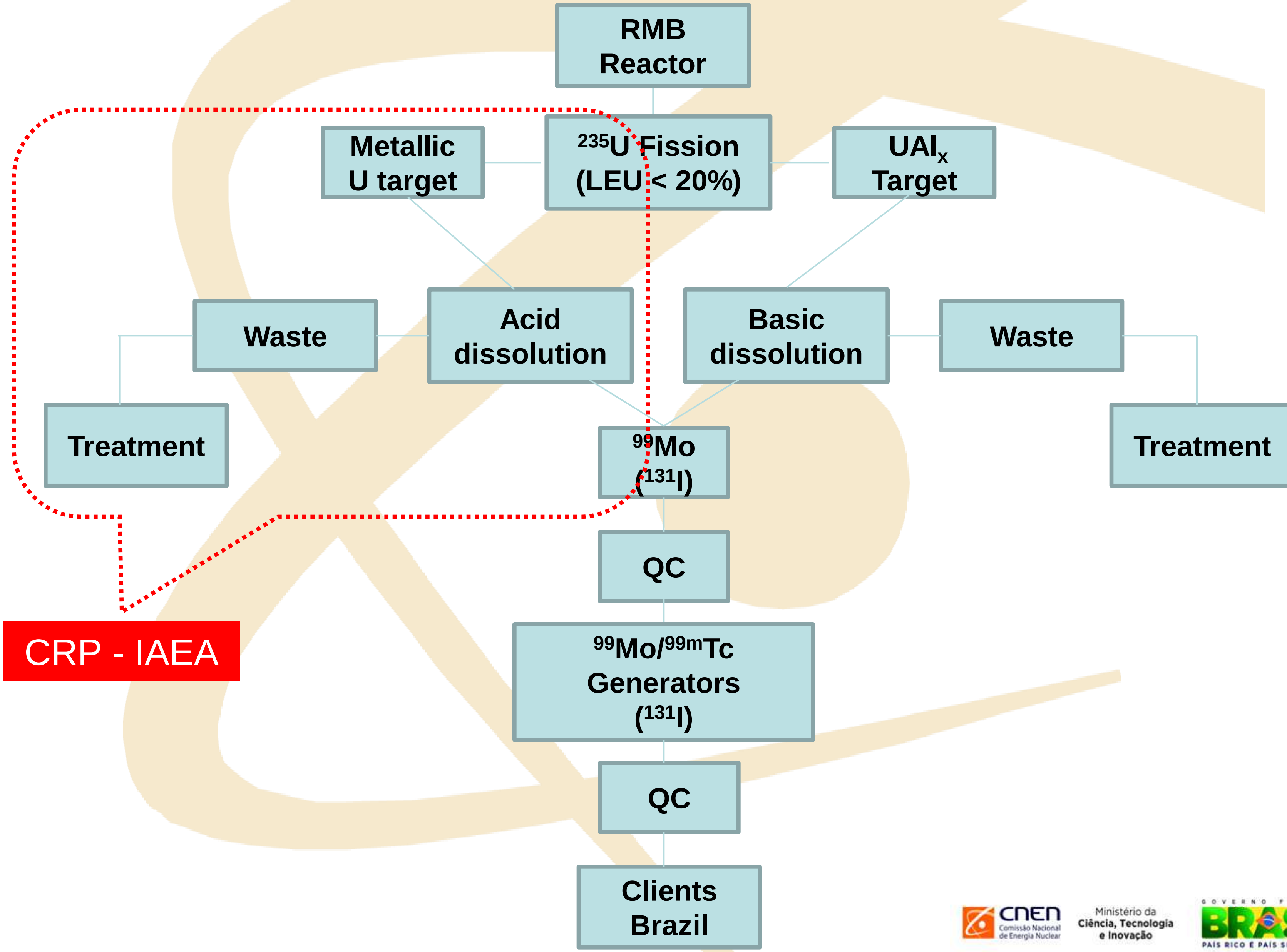
- **Radioisotope for Injectable Radiopharmaceuticals**
  - ^{99}Mo , ^{131}I, ^{51}Cr, ^{153}Sm, ^{177}Lu, ^{166}Ho, ^{90}Y, ^{188}W, ^{32}P
    - ✓ ^{99}Mo obtained by LEU target irradiation and processing
    - ✓ 1000 Ci/week (Today 350 Ci/week imported by IPEN and 450 Ci/week before the international crisis)
- **Radioisotope for Brachtherapy**
  - ^{125}I, ^{192}Ir
- **Radioisotope for Industry**
  - ^{192}Ir, ^{60}Co
- **Tracers**
  - ^{203}Hg , ^{131}I, ^{82}Br

Radioisotope Production

Infrastructure

- Processing hot cells for irradiated U targets (LEU) to produce ^{99}Mo and ^{131}I;
- Hot cells for handling and transport preparation of produced radioisotopes;
- Special hot cells for radioactive sources processing and sealing;
- Hot cell and special devices for ^{125}I production;
- Shielded casks for radioisotope transportation;
- Irradiation devices for in core and in reflector radioisotope production;

^{99}Mo Production (R&D)



Nuclear Fuel and Materials Irradiation Test

Materials	Test Objective
Nuclear Fuels	Fuel Performance Characterization and Specification Optimization
Structural Materials	Life Extension of Nuclear Power Plants Characterization of Materials and Performance under Irradiation
All	Safety Analysis

Nuclear Fuels and Materials Irradiation Test

Irradiation Systems

- Pressurized irradiation loops for fuel testing with pressure and cooling temperature control
- Irradiation capsules for fuel specimens testing
- Horizontal displacement devices for simulating power ramps and loading following
- Irradiation capsules with temperature control for structural materials testing
- Irradiation experiments control room and data collection systems
- Experimental devices for underwater nondestructive analysis (visual inspection, gamma scanning, sipping, etc)

Post-irradiation Examination

- One hot cell laboratory for irradiated fuel and one hot cell laboratory for irradiated materials examination
- The hot cells laboratory shall allow:
  - Nondestructive physical characterization analysis of irradiated specimens
  - Puncturing and fission gas collection
  - Sample preparation for metallographic analysis
  - Optical microscopy
  - Physical and mechanical properties characterization equipment

Post-Irradiation Laboratories

CTMSP

↓

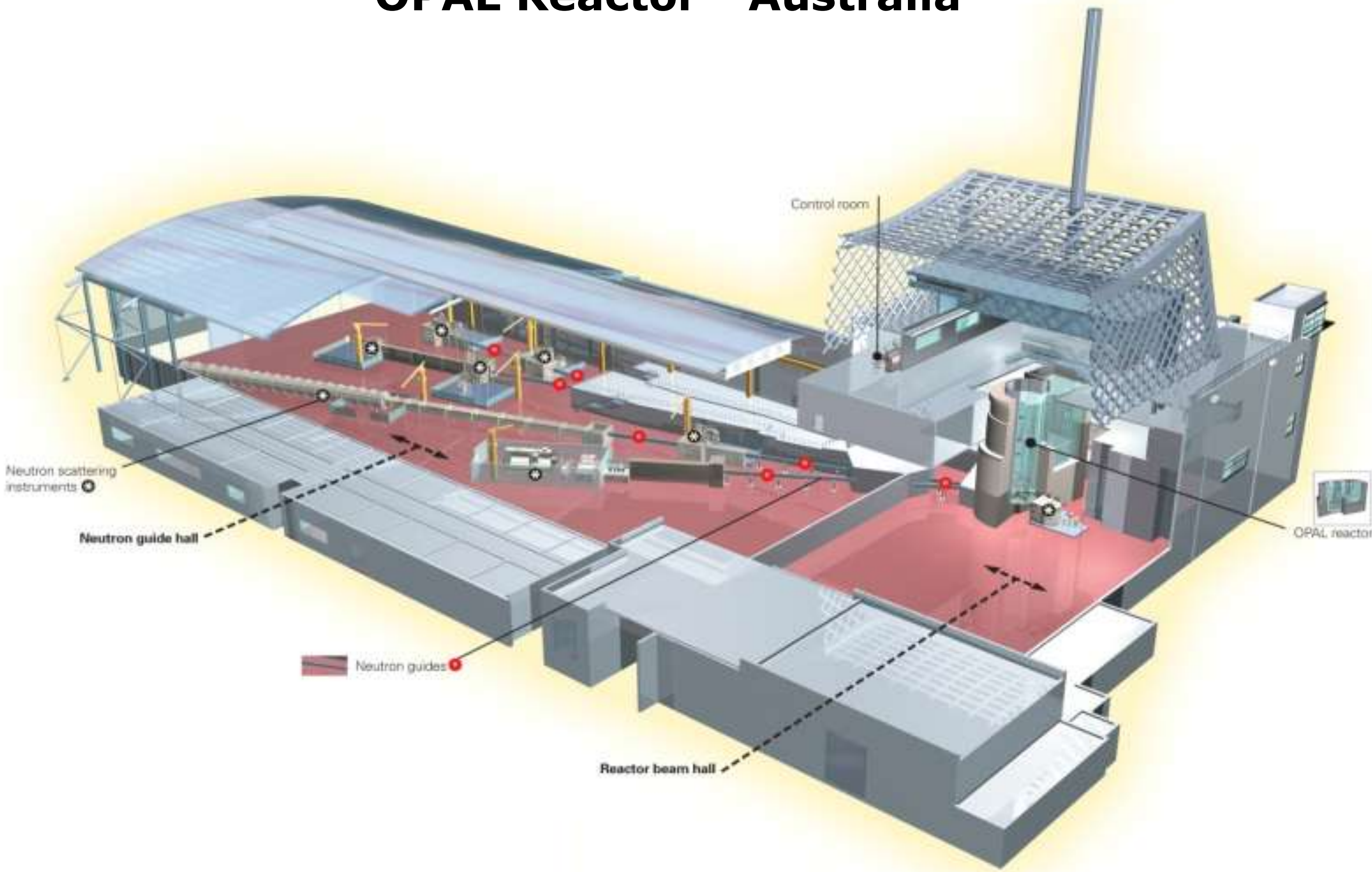
CNEN

Neutron Beam Utilization

- To allow the possibility of at least three beam holes (today proposed 5)
- To project two beam holes with neutron guides: one for thermal and one for cold neutrons. Each beam hole shall have capacity for at least 2 neutron guides (today with 3 guides)
- The technical characteristics of each beam hole (dimensions and position) will be established during the preliminary design of the reactor.
- Each beam hole shall have a flux higher than:
  - $1x10^9$ n/cm^2.s outside the reactor shielding; or
  - $1x10^{14}$ n/cm^2.s at the point of tangency near the core.

Neutron Beam Utilization Model

OPAL Reactor - Australia



Neutron Beam Utilization

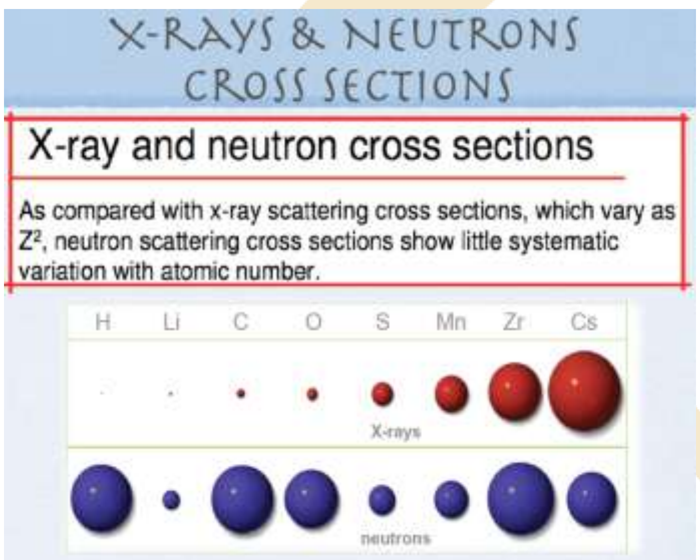
Initial Equipment Proposal

Thermal Neutrons Beam	
Guide Hall	**Experimental Hall**
High Resolution Diffractometer	Three Axis Spectrometer
High Intensity Diffractometer	Neutron radiography
Laue Diffractometer	
Residual Stress Diffractometer	
Cold Neutrons Beam	
Small Angle Neutron Scattering	
Prompt Gamma Analysis	

CNEN and LNLS/CNPEM Cooperation

The neutron beam will be used for fundamental and technological research managed by LNLS / CNPEM, which has extensive experience in acting as infrastructure multiuser

RMB



Multiuser research infrastructure

Neutron beams

Managed by

LNLS

CNPEM

Neutron Activation Analysis

- Neutron Activation Analysis at irradiation positions with thermal neutron flux in the range of 10^{11} to 10^{13} n/cm^2.s.
- One irradiation position with cadmium filter for epithermal neutrons activation.
- Pneumatic stations with transit time of 10 seconds, and one very fast station with transit time less than 10 seconds for analysis of radioisotopes with very high decay constant.
- Pneumatic stations for transportation of samples (long irradiation) from core to the radiochemical laboratory.
- Fission delayed neutron measurement system for samples containing U and Th.

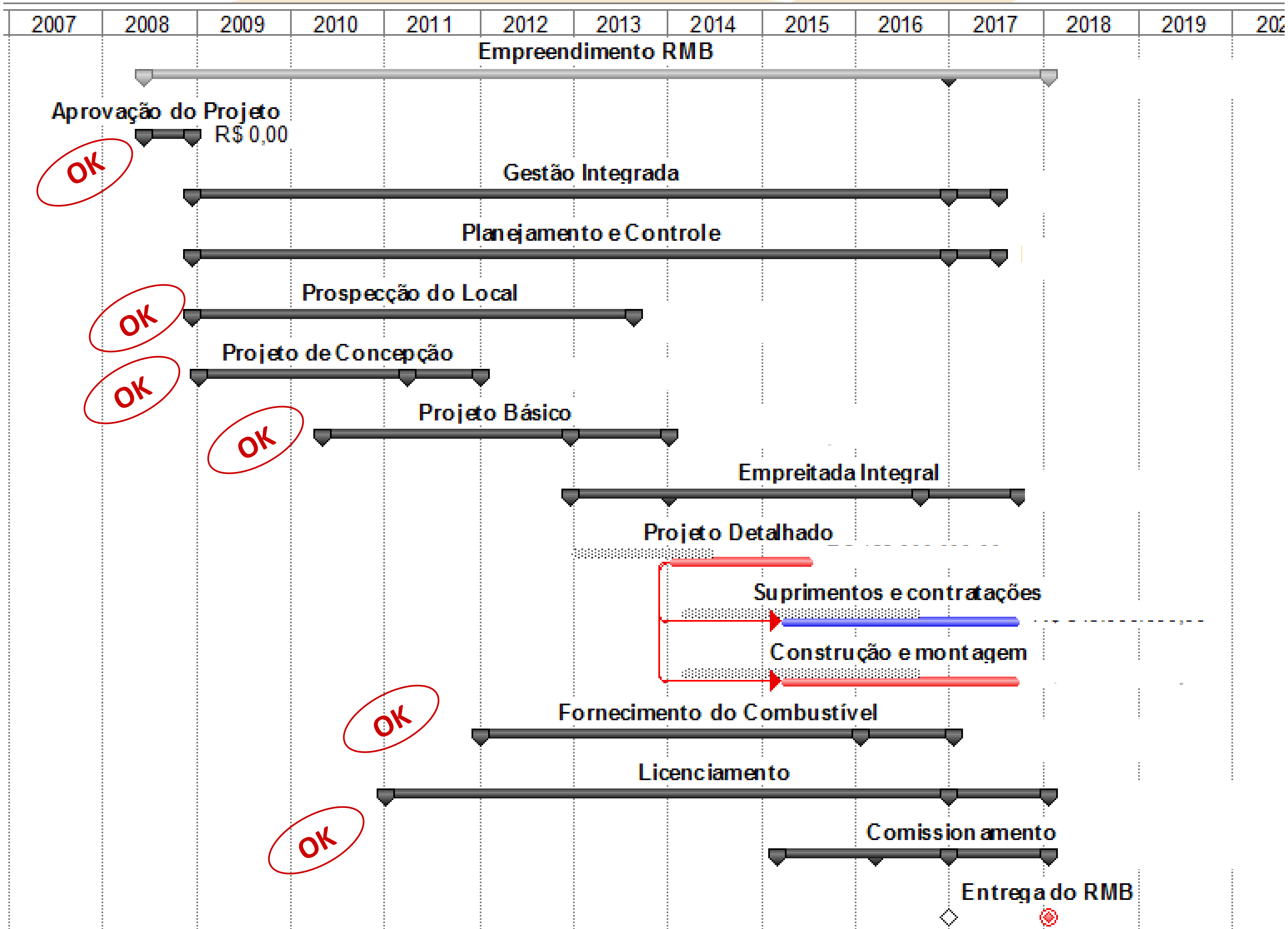
Project Management

- Project managed by the Research and Development Directorate of the Brazilian Nuclear Energy Commission (DPD-CNEN)
- Scope and preliminary design, licensing process managing and commissioning verification performed by the Research Institutes of CNEN: IPEN, CDTN, IEN, CRCN
- CNEN – CNEA (Argentina) Cooperation Agreement on Reactor Design of RMB and RA-10 based on INVAP / Opal design
- Basic and detailed design, manufacturing, construction, assembling and their management will be carried out by national and international companies.
- Project technically supported by Brazilian Academy
- Project Cost estimation of US$ 500 million (R$ 1000 million)
- Project time span of at least 6 years after the first contract signature and availability of funds. (2013)

Project Status

- CNEN Institutes technicians are developing the conceptual engineering design of the reactor systems and main facilities.
- R$ 30 million allocated by the MCTI (FNDCT- FINEP) to contract the basic engineering design of systems, buildings and infrastructure of the RMB (except basic engineering design of pure nuclear systems and components). Work contract under development. Brazilian company INTERTECHNE
- Brazil-Argentina Agreement (CNEN-CNEA) for common basic engineering design of the RMB and RA-10 (pure nuclear part). OPAL reactor in Australia as a reference. (project of the Argentine company INVAP). R$ 20 million allocated by the MCTI (FNDCT- FINEP) in addition to the first application.
- Environmental licensing process started. Term of Reference for EIA/RIMA approved by IBAMA. Work contract under development. Brazilian Company MRS.
- Nuclear licensing started. Term of Reference for Local Licensing (first License) is under analysis by DRS/CNEN.

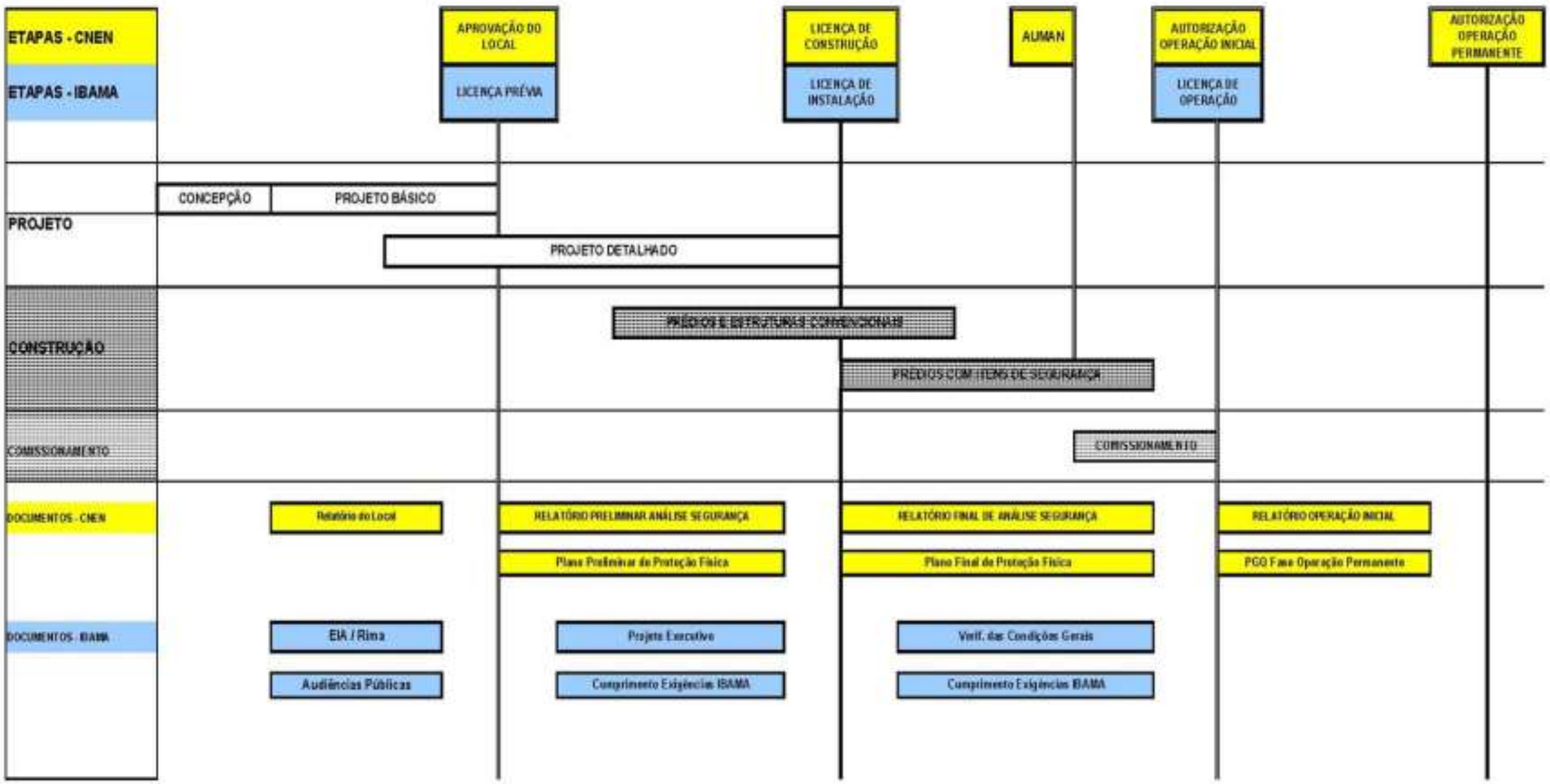
Chronogram



2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Empreendimento RMB
Aprovação do Projeto
R$ 0,00
OK
Gestão Integrada
Planejamento e Controle
Prospecção do Local
OK
Projeto de Concepção
OK
Projeto Básico
OK
Empreitada Integral
Projeto Detalhado
Suprimentos e contratações
Construção e montagem
Fornecimento do Combustível
OK
Licenciamento
OK
Comissionamento
Entrega do RMB

Licensing Steps

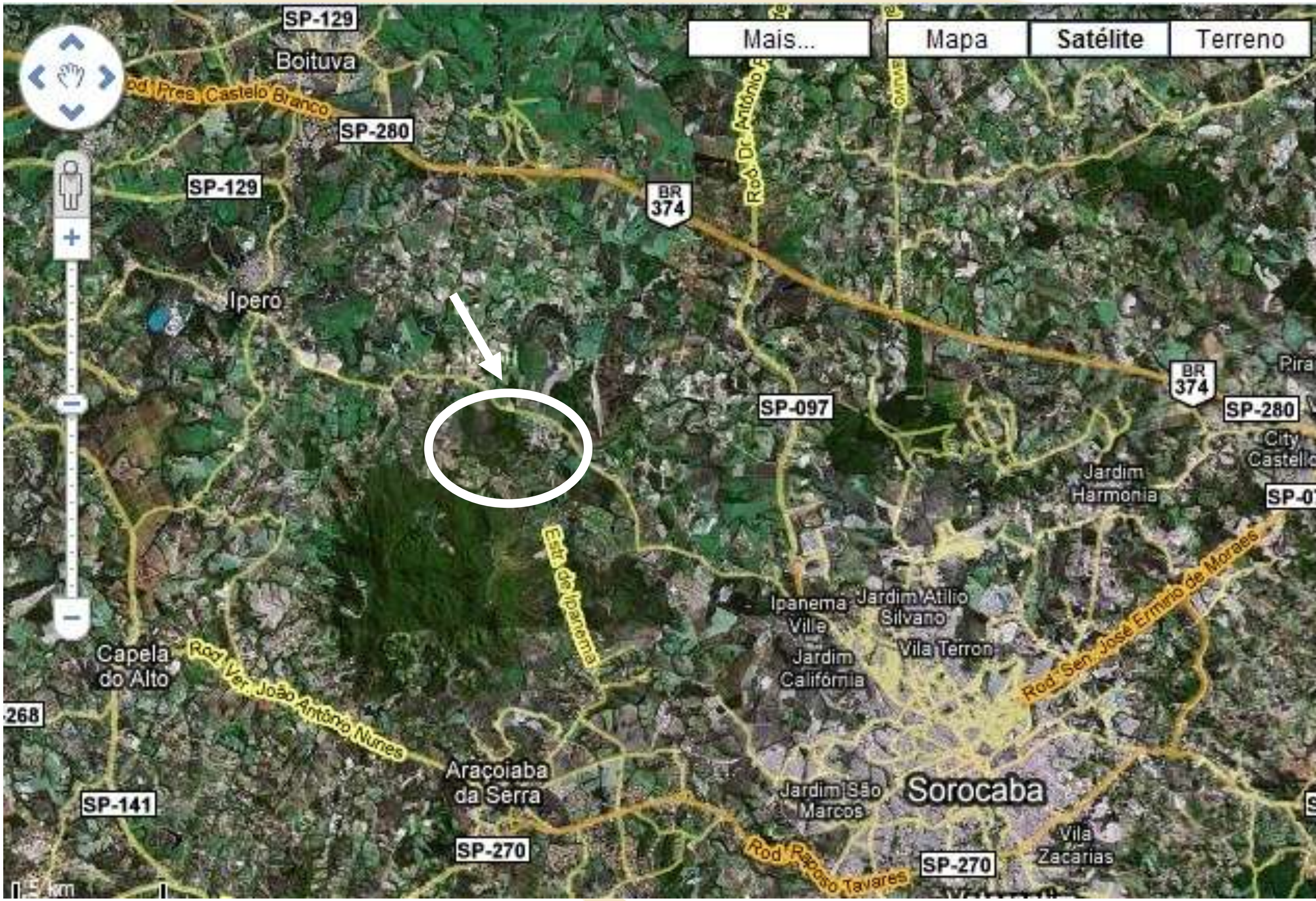
CRONOGRAMA ESQUEMÁTICO RELACIONADO COM AS ETAPAS E DOCUMENTOS DE LICENCIAMENTO



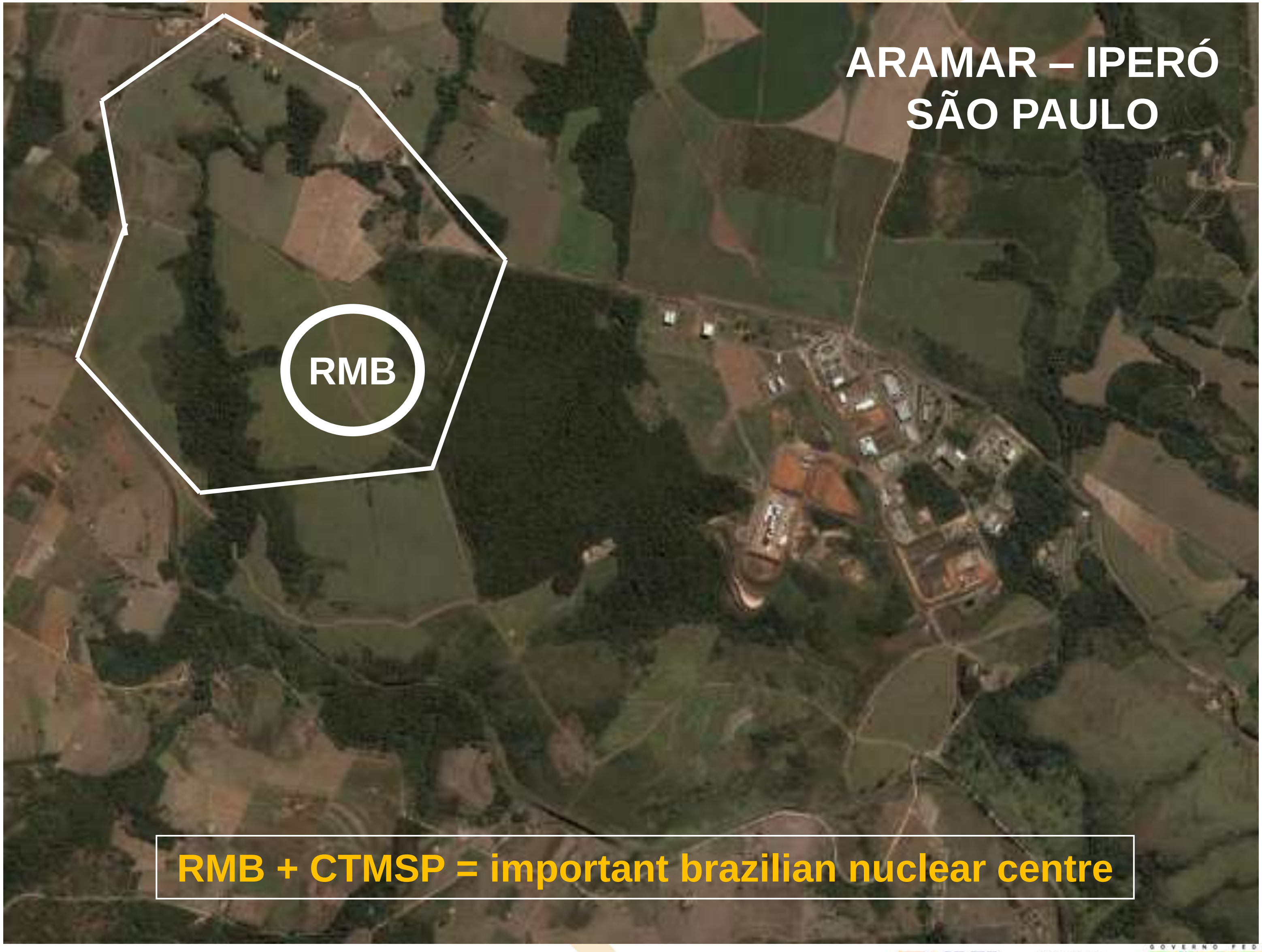
Site

Iperó
State of São Paulo

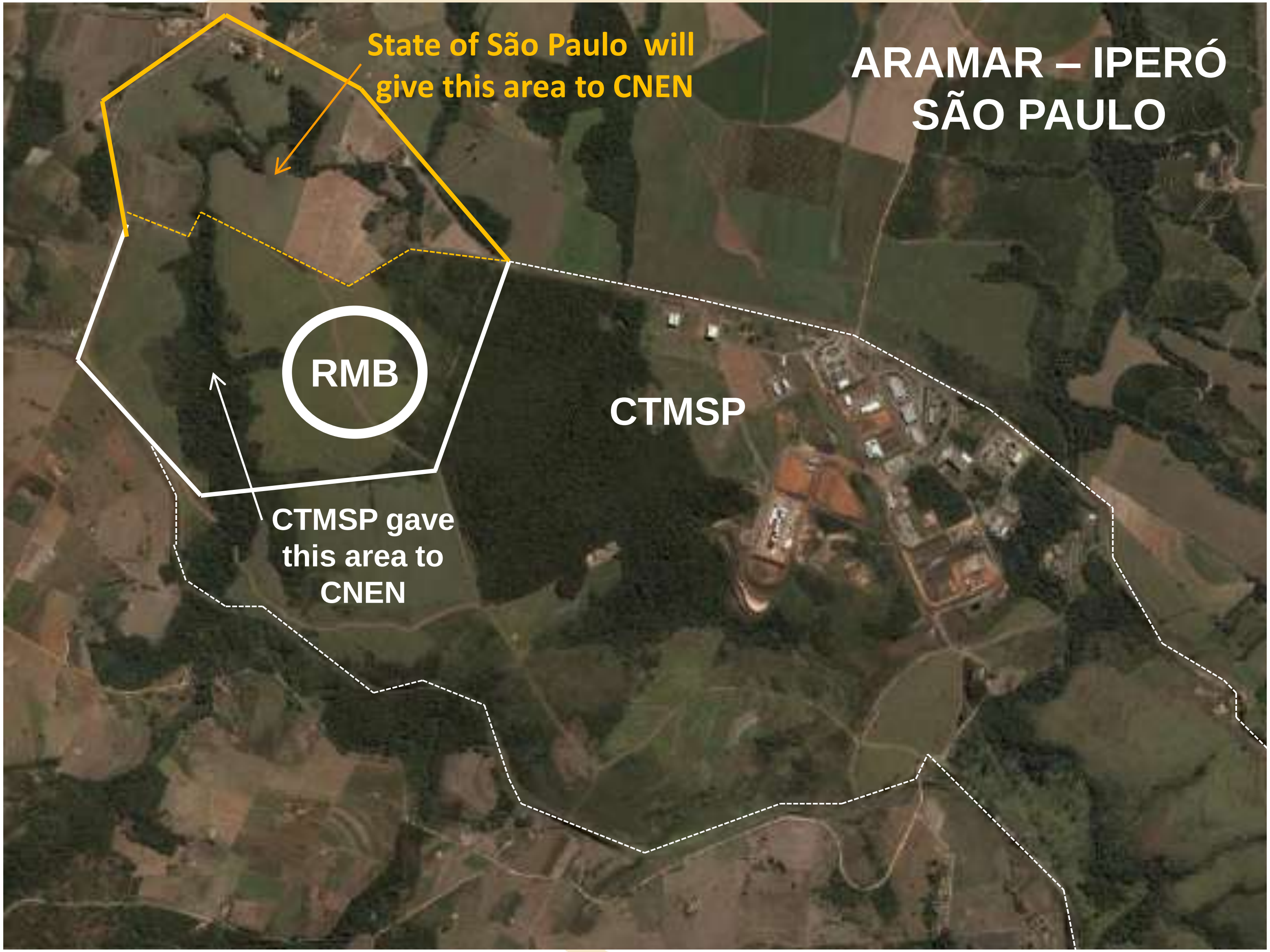
Site


Mais...
Mapa
Satélite
Terreno
SP-129
Boituva
Rod. Pres. Castelo Branco
SP-280
SP-129
BR 374
Rod. Dr. Antônio
Iperó
SP-097
BR 374
SP-280
City Castello
Jardim Harmonia
SP-07
Estr. de Ipanema
Ipanema Ville
Jardim Atílio Silvano
Vila Terron
Jardim Califórnia
Rod. Sen. José Ermírio de Moraes
Capela do Alto
Rod. Ver. João Antônio Nunes
268
Araçoiaba da Serra
SP-141
SP-270
Jardim São Marcos
Sorocaba
Vila Zacarias
Rod. Raposo Tavares
SP-270
5 km

Site


ARAMAR – IPERÓ
SÃO PAULO
RMB
RMB + CTMSP = important brazilian nuclear centre

Site



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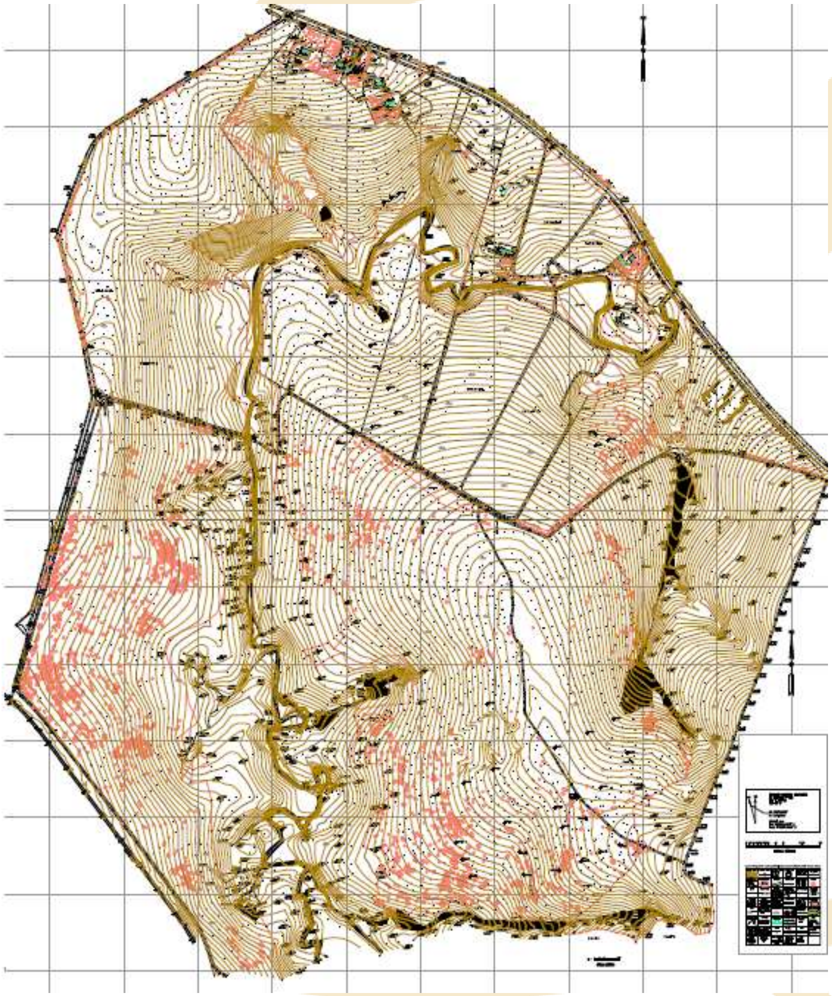
Site works

Topography survey



Ground Survey

Meteorological tower

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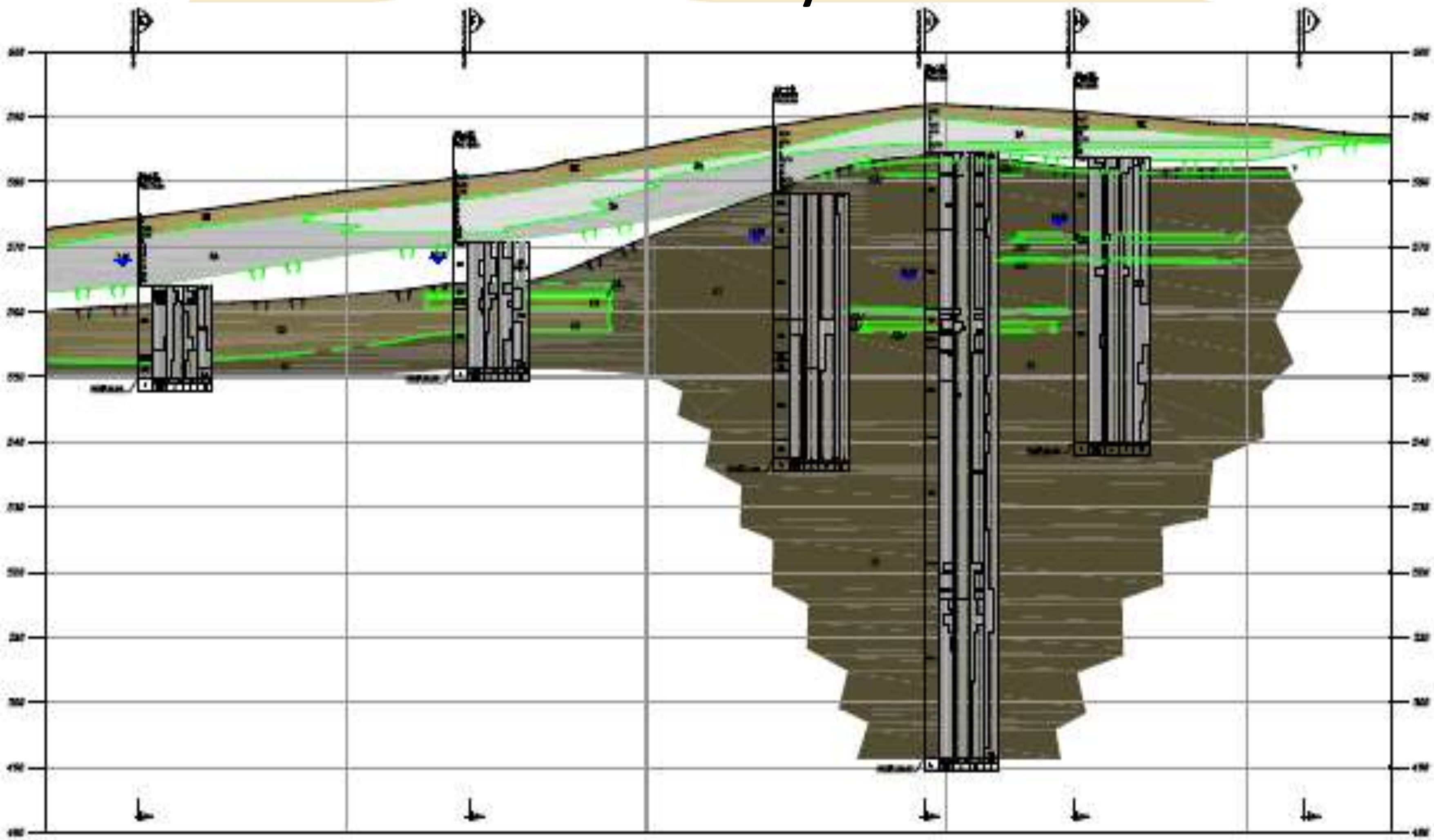
BRASIL

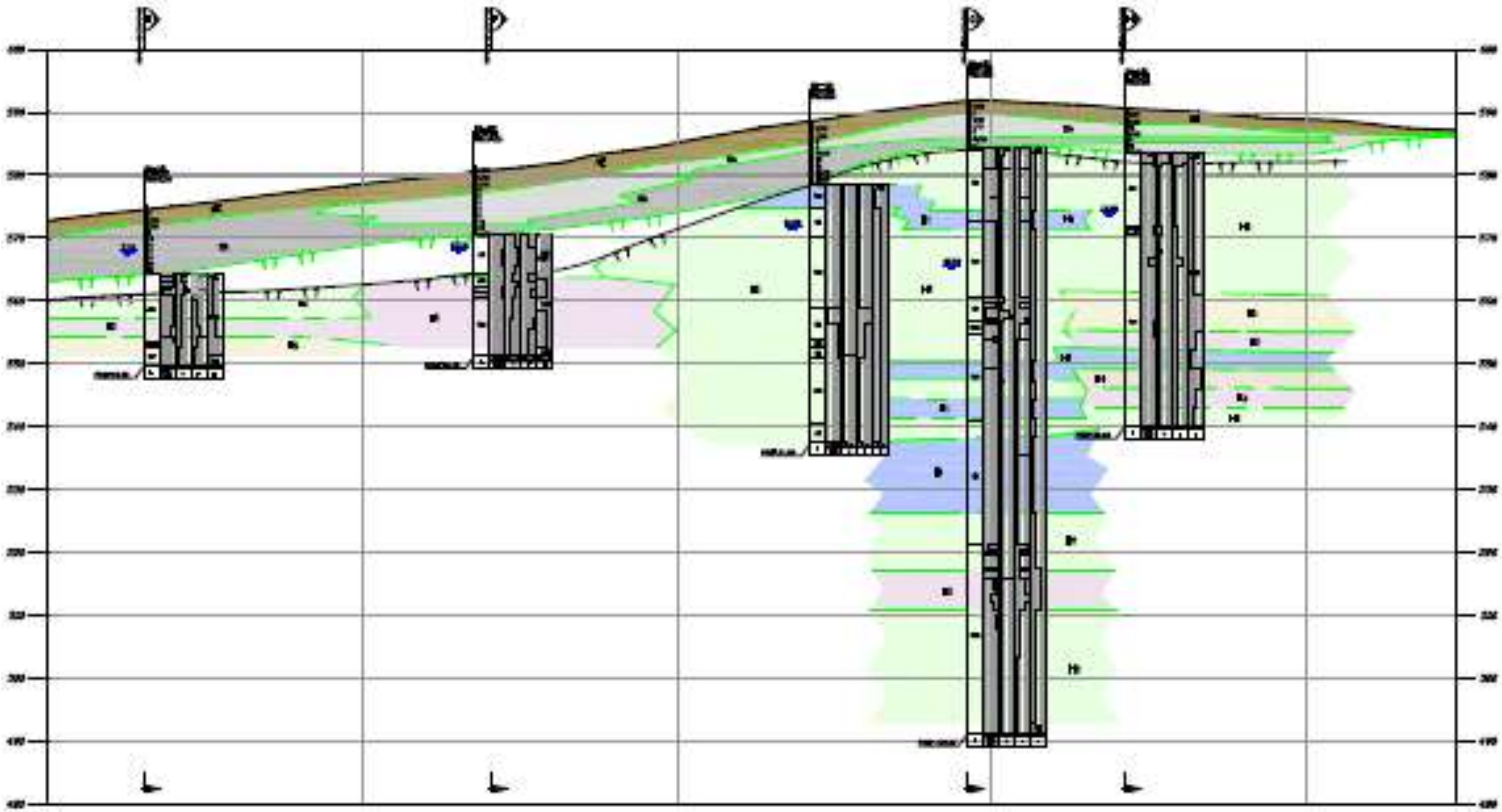
Site works

Ground Survey



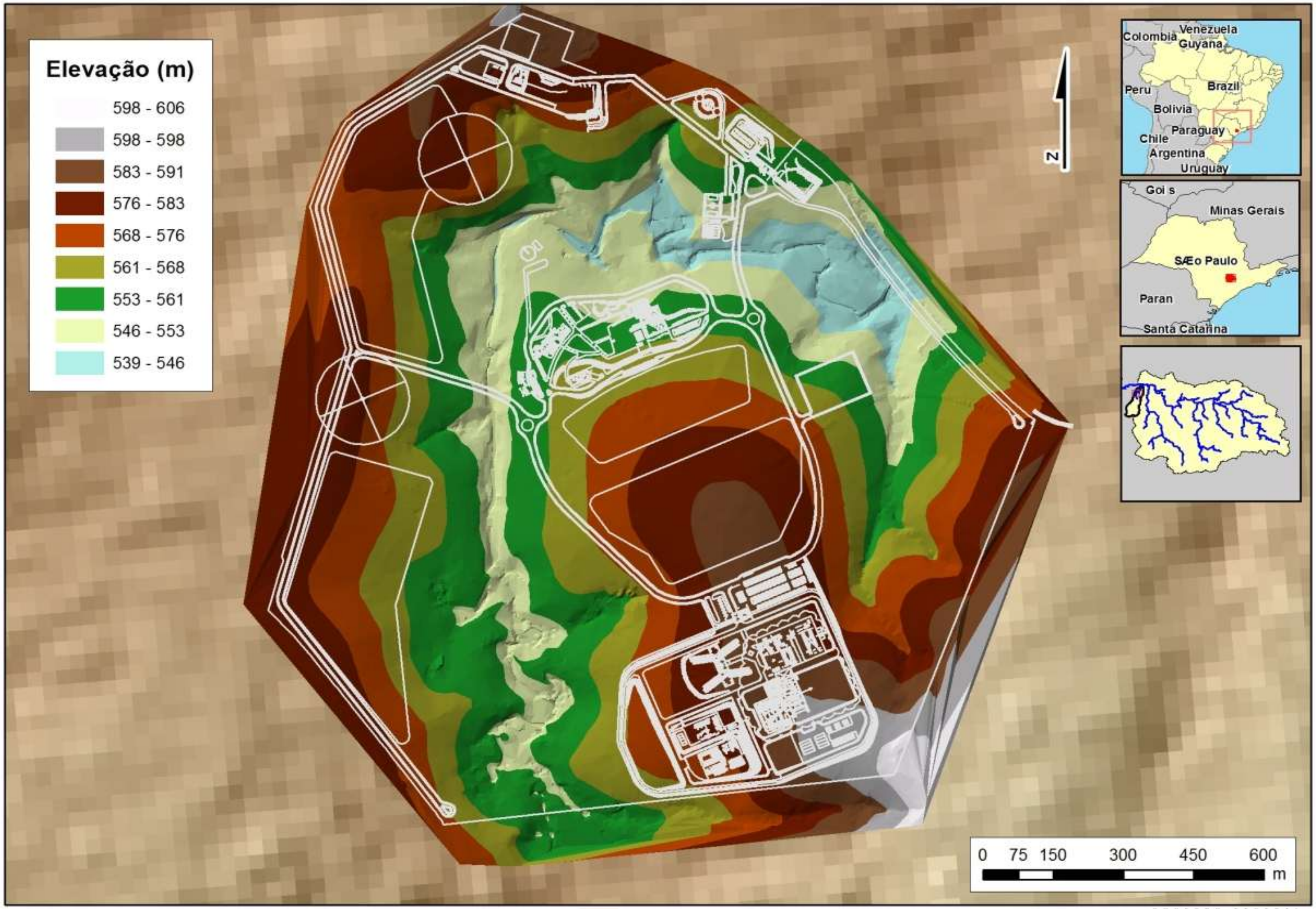
Site works

Ground Survey



Site Works

Hydrology



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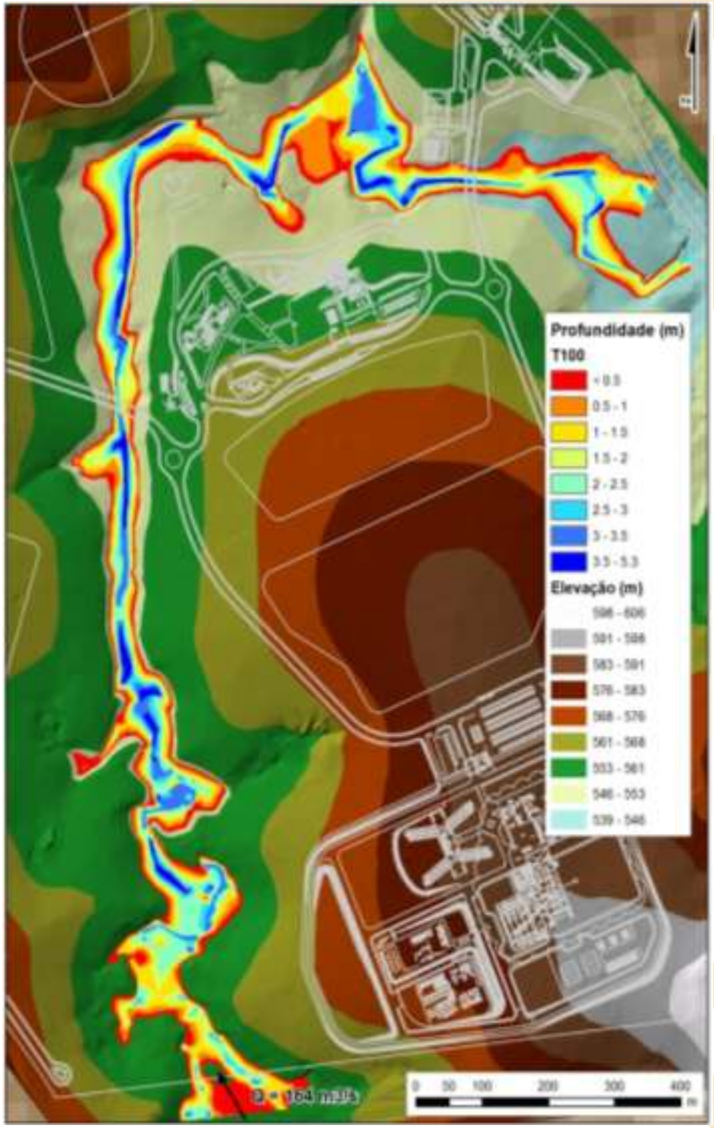
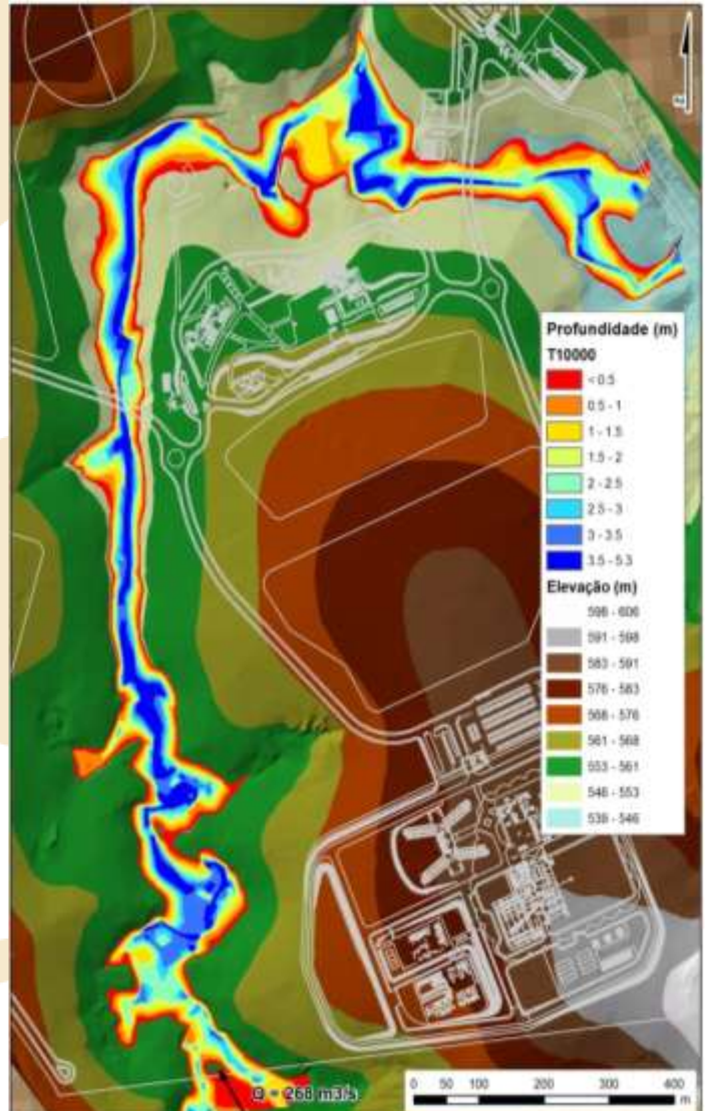
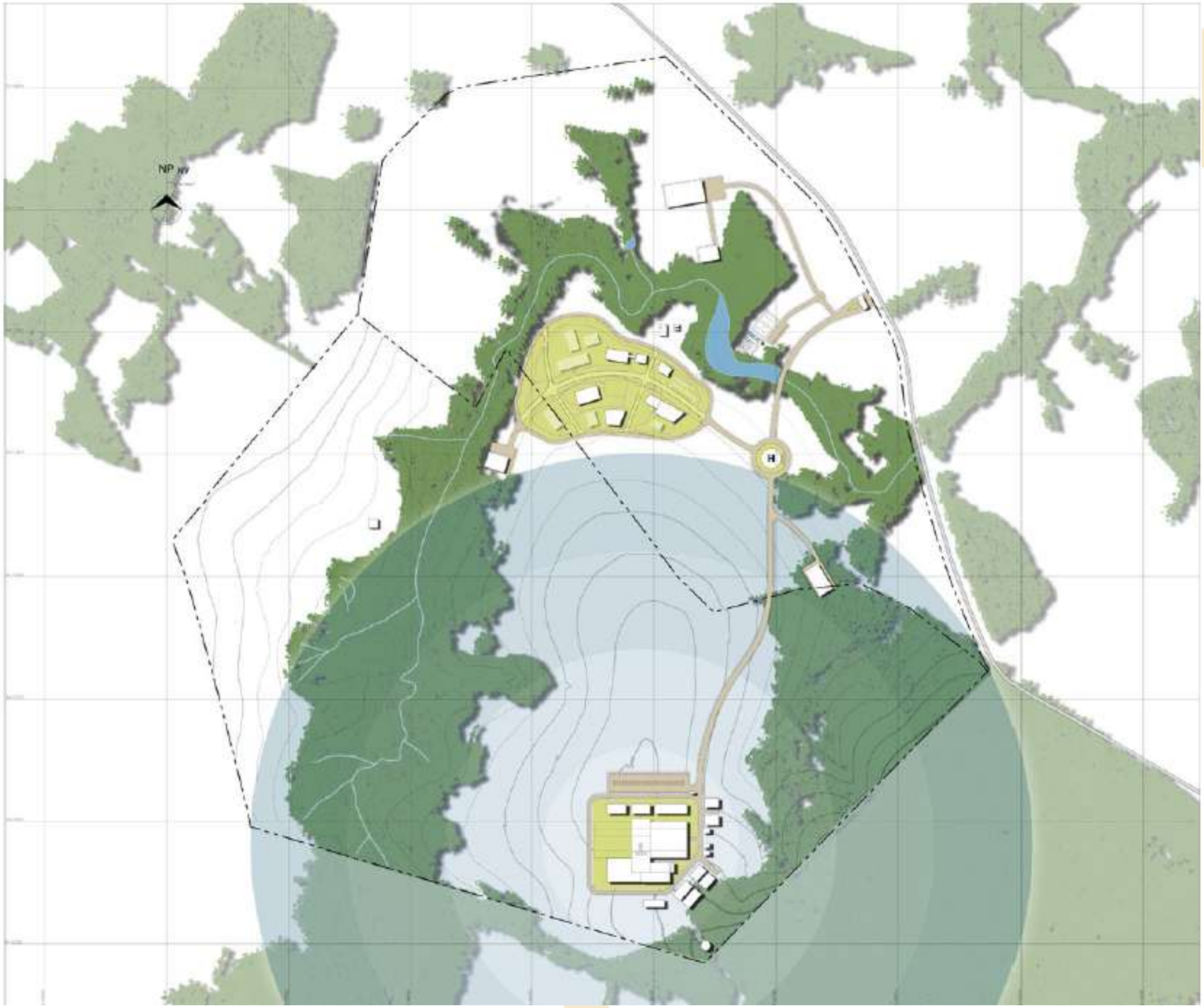
Hydrology





Site Works

Environmental Impact Analysis



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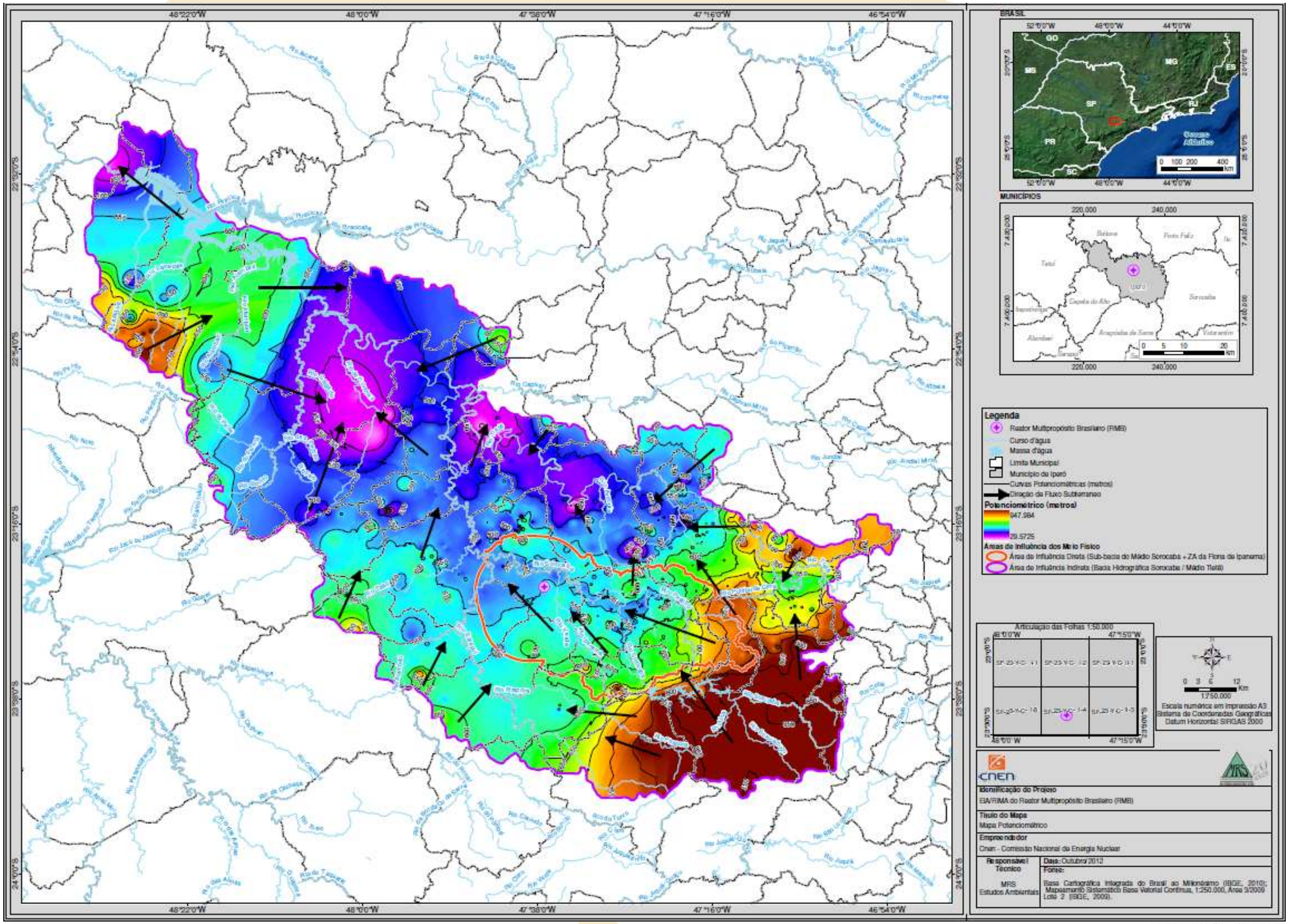
Site Works

Environmental Impact Analysis



Site Works

Environmental Impact Analysis

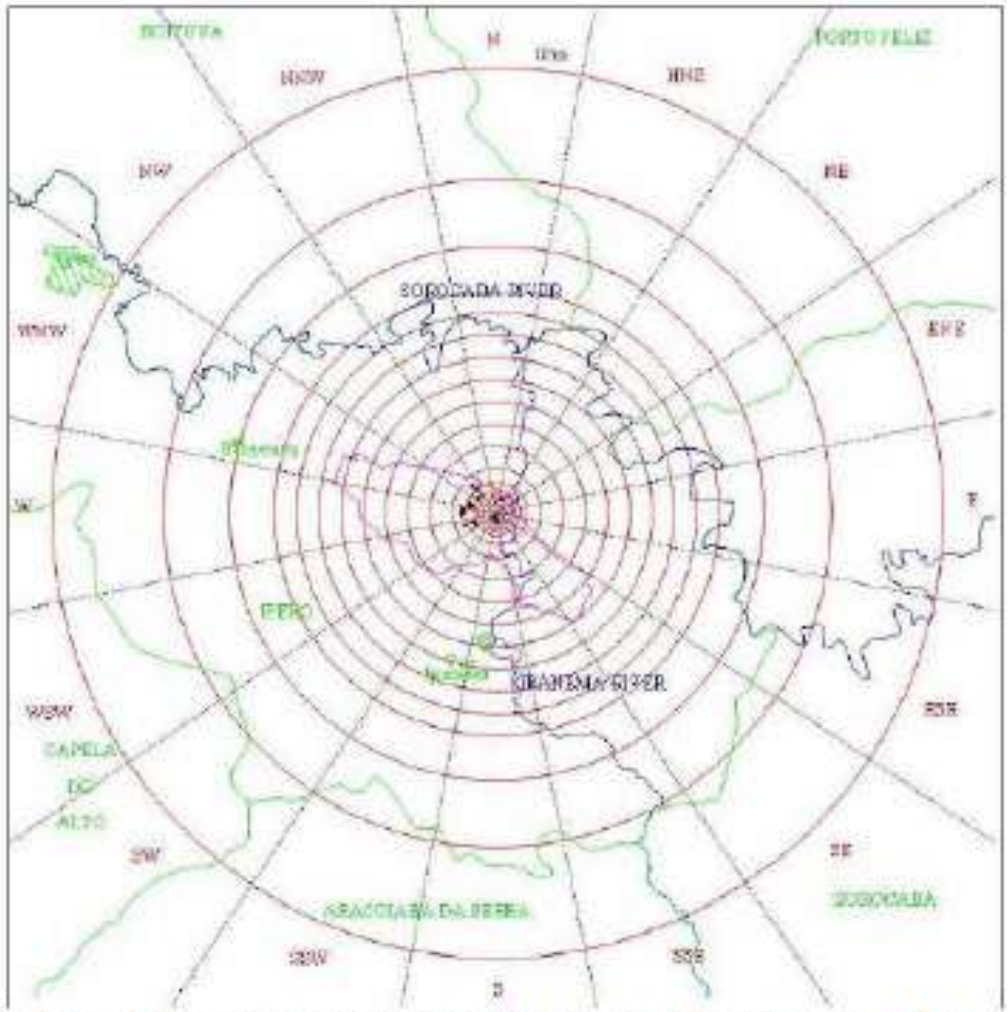
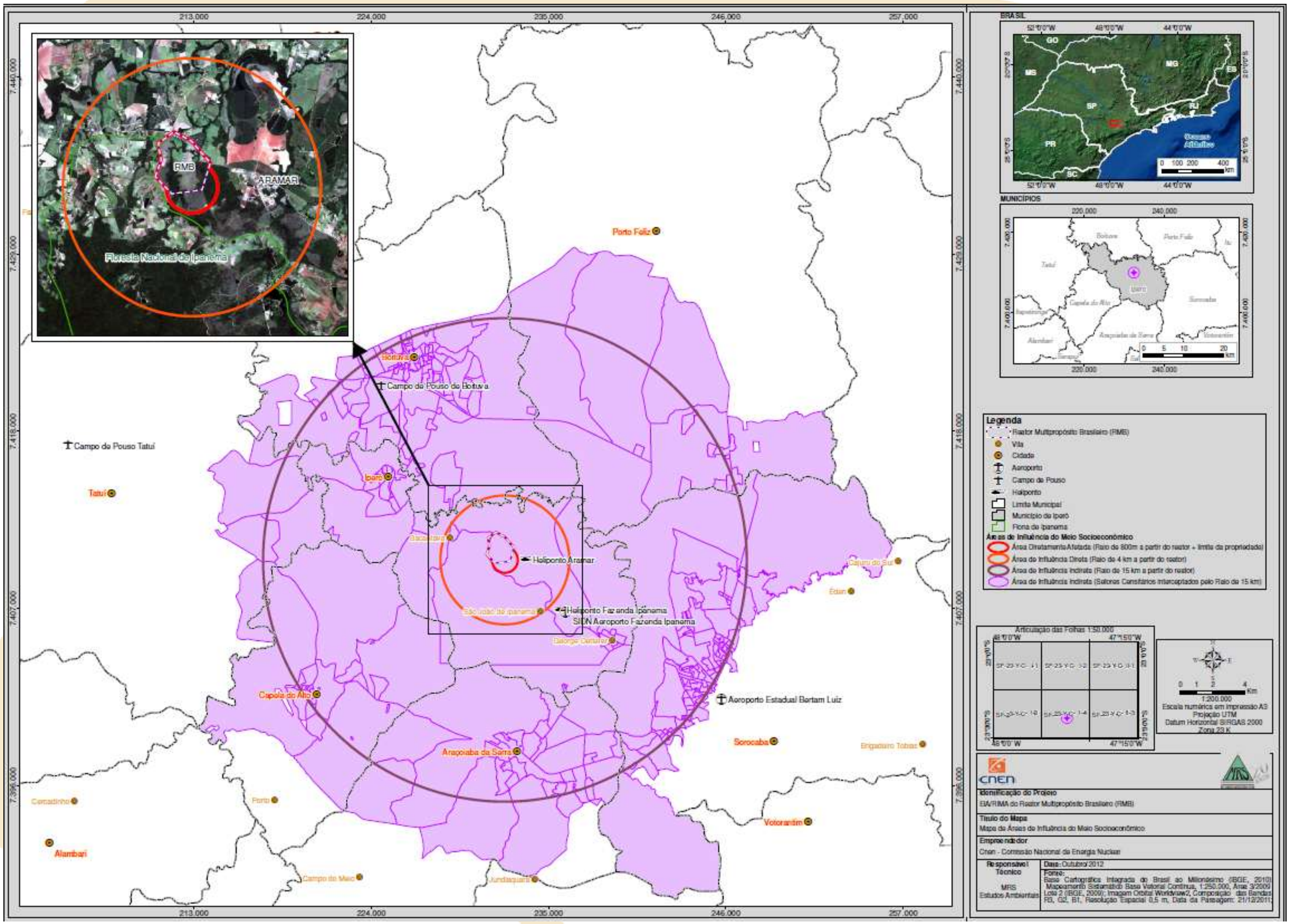


Figura 4 - Setores de difusão atmosférica e prováveis áreas de maior impacto de efluentes aéreos do RMB: setores NO, NNO e N.

Site Works

Environmental Impact Analysis



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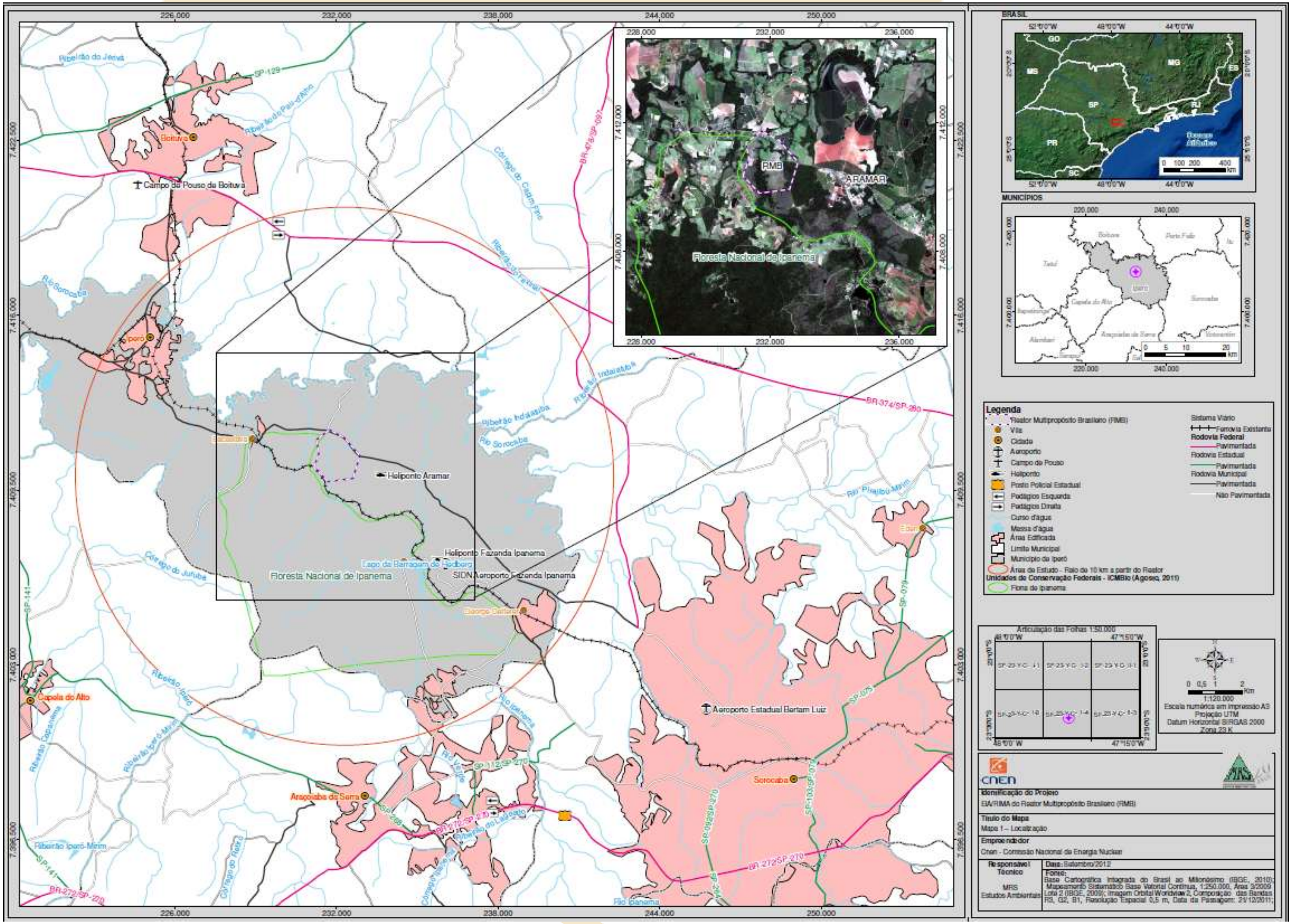
Site Works

Environmental Impact Analysis



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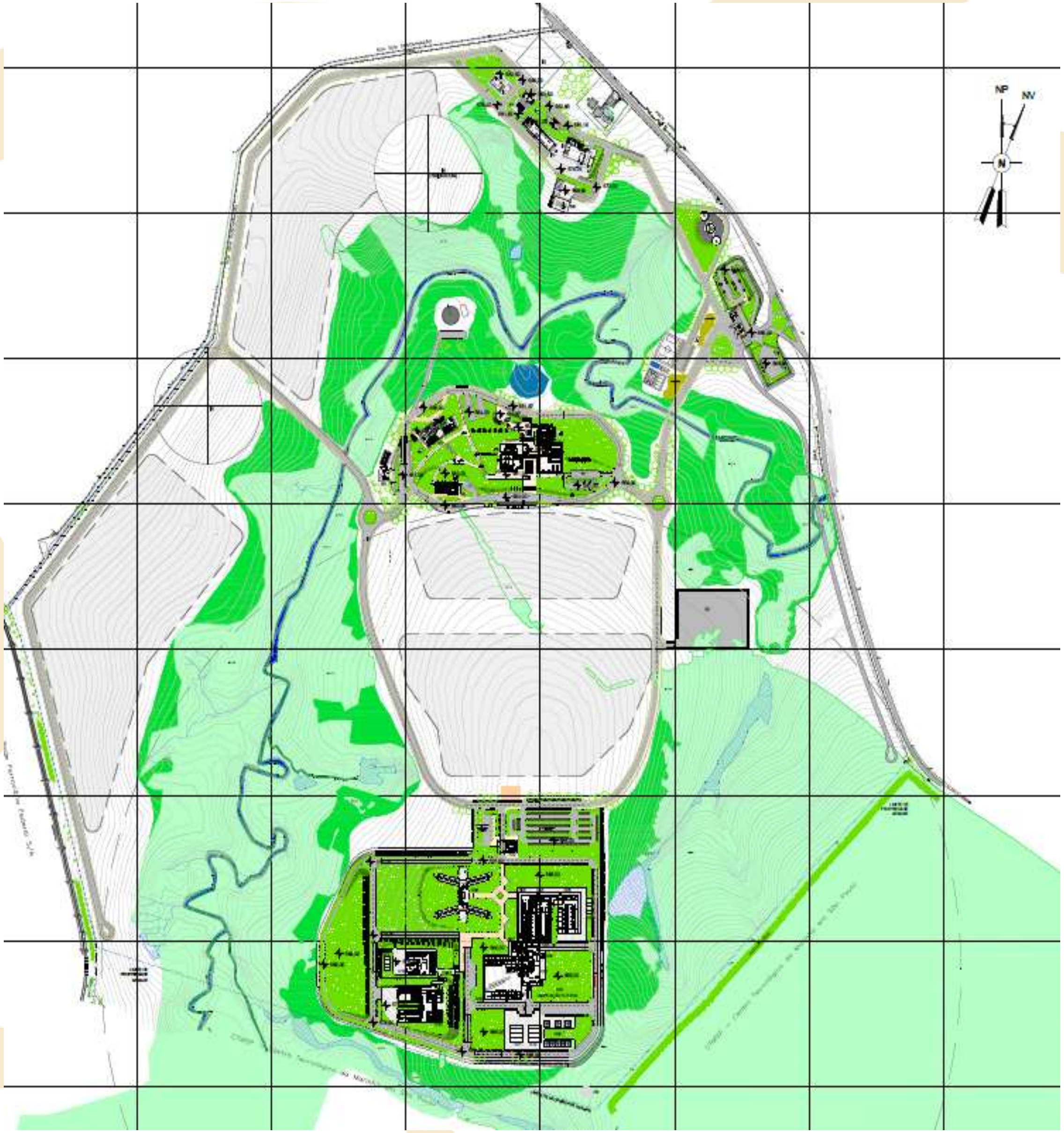
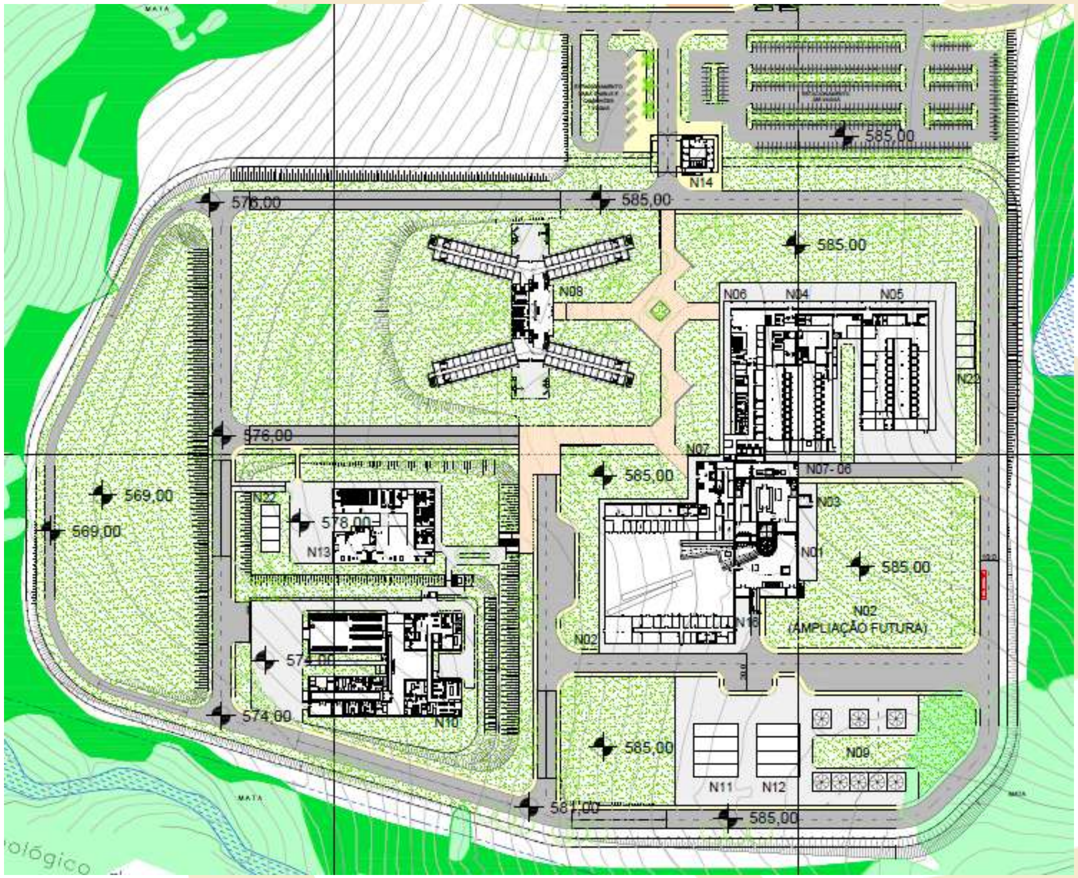
RMB Site Plan



RMB R&P Buildings



N01 – Reactor

N02 – Neutron Beam Laboratory

N03 – Spent Fuel and Material Handling

N04 – Radioisotope Processing

N05 – Post-Irradiation Laboratory

N06 – Radiochemistry Laboratory

N07 – Operation Office

N08 – Researchers Offices

N09 – Cooling Towers

N10 – Waste Treatment and Storage

N11,N12 – Electrical Cabins

N13 – Workshop

N14 – Access Control

RMB Buildings

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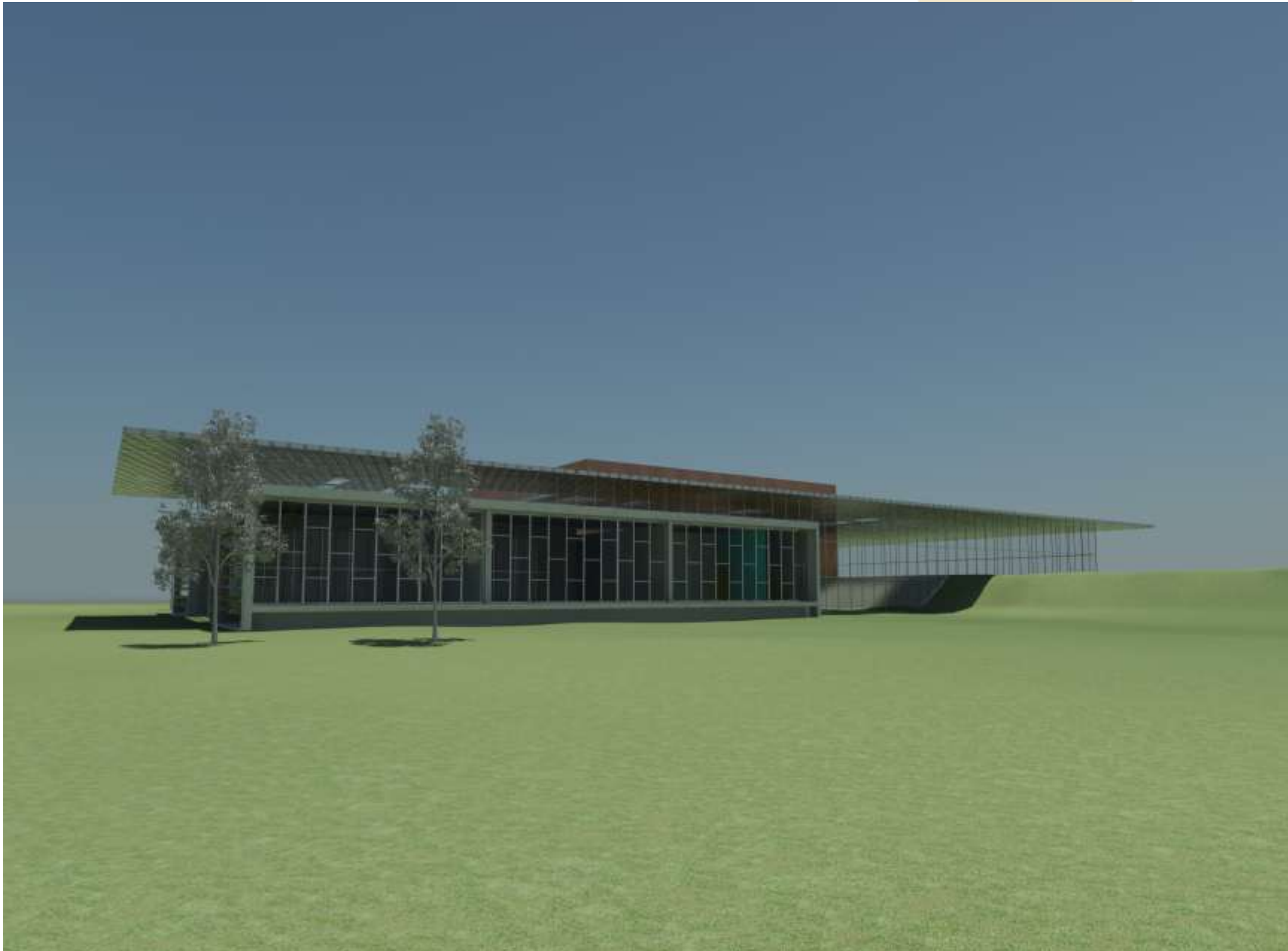

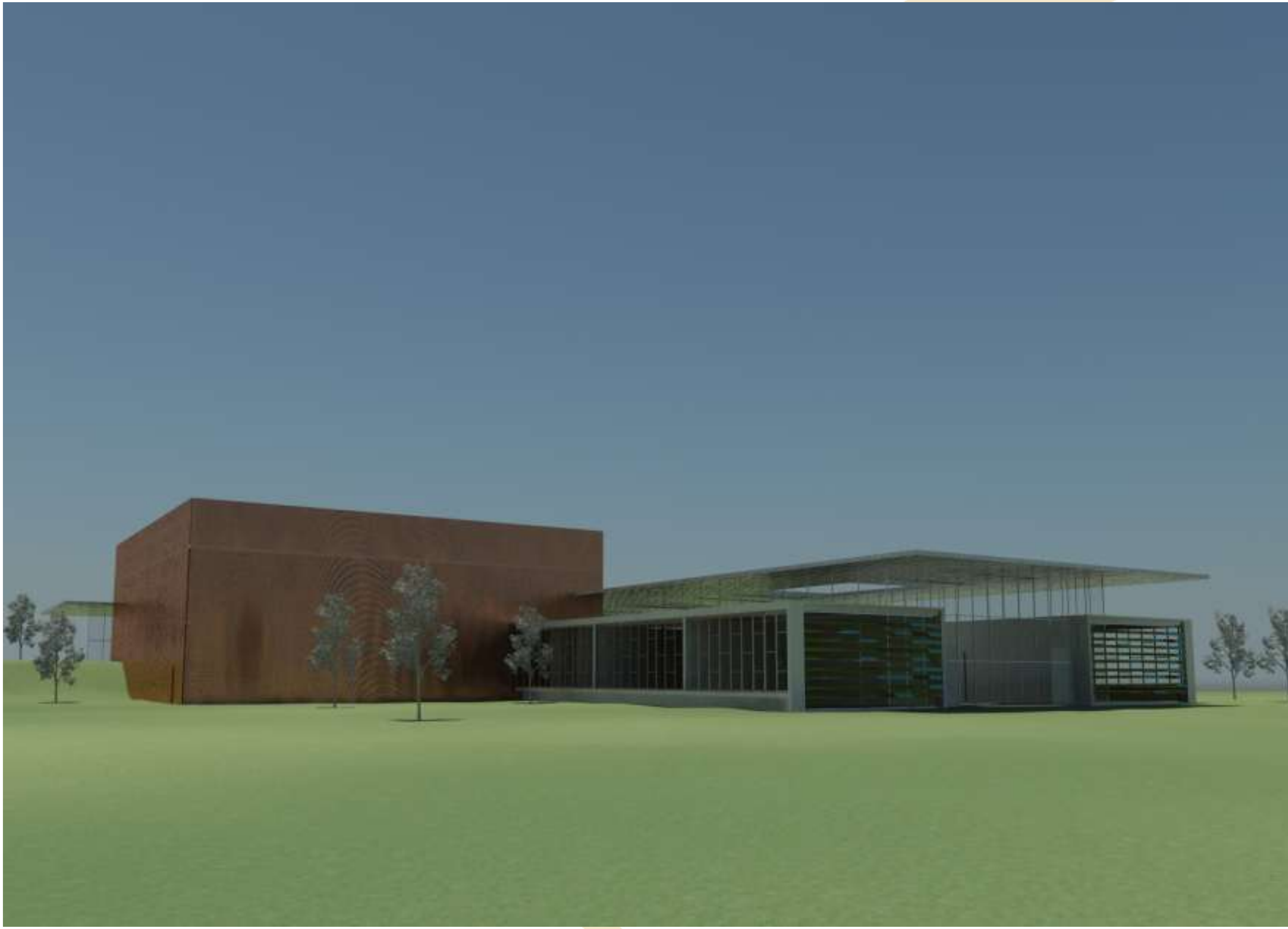

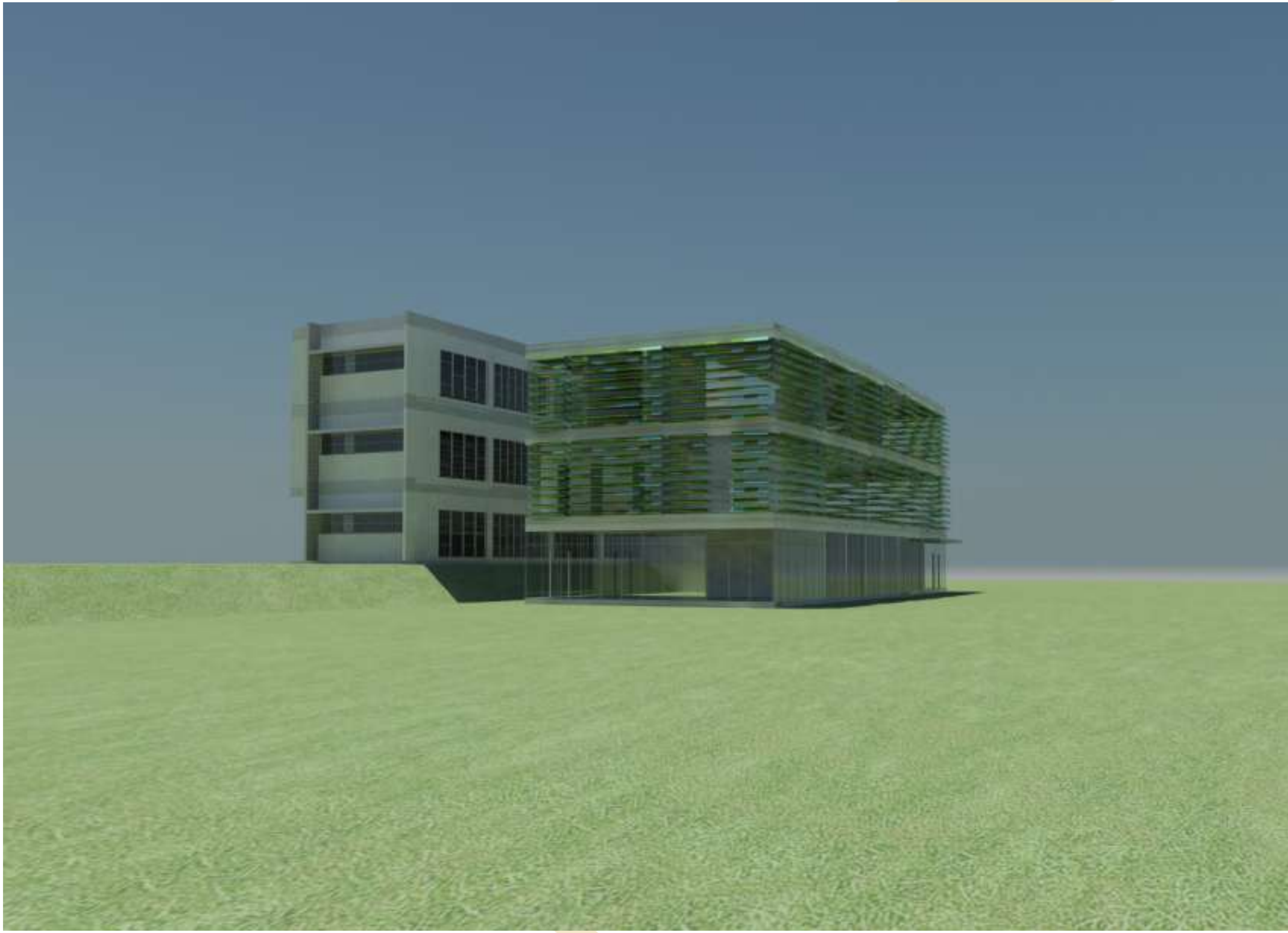

CNEN Comissão Nacional de Energia Nuclear

Ministério da Ciência, Tecnologia e Inovação

GOVERNO FEDERAL BRASIL PAÍS RICO É PAÍS SEM POBREZA

Thank you!