CAUTION

NUCLEAR WASTE

Department of
Architecture and Design

Master Degree Thesis
MSc Architecture Construction City
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ATOMIC MONKS

The Italian National Repository of Nuclear Waste

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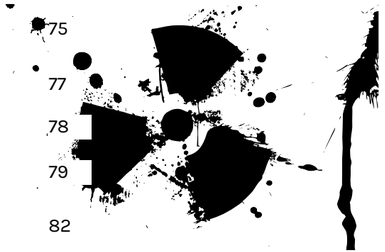


INTRODUCTION

INTRODUCTION

The concept of nuclear evokes a feeling that is difficult to describe and understand. Even though the first perception that comes to mind is danger or a horrific death; there is a well-known issue that what makes someone fear, may make the one desire it, as well. As Claude Parent mentioned about why he designed nuclear power plants and cooling towers even if people were truly against to him, " I'll tell you gladly. At that time there wasn't anything for me that was faster and more powerful than the atom. It was a huge feat to bring this energy into form, to tame it. I found everything having to do with atoms and particle acceleration good. It was great and modern. Back then you thought about atomic waste as little as you would think about car exhaust. It was that simple."

The society became aware of the term in August 1945 with the explosion of the first atomic bomb on Japan territories for the first time. It was a great shock for the entire world. Although, people in US enjoyed very much with the mushroom clouds in Las Vegas, between 50s and mid-60s, later the Chernobyl Disaster, spread the nuclear nightmare throughout the world. Fear was grown with resonance on a global scale. Therefore, radioactive, nuclear or atomic are the words, inextricably linked to events that cause abominable destruction with permanent consequences.

In this sense, it is understandable that everything about nuclear brings suspicion and fear. Even though the use of nuclear power appears imperturbably accepted in many countries of the world, the famous anguish lies as a dormant volcano, awaiting the new catastrophe. Therefore, a structure that contains radioactive material can only elicit fear and repulsion for those who perceive it as a sleeping giant in their own territory. Nevertheless, it is known that there is an issue of fascination, of fear and desire, for threatening things. What is forbidden evokes a particular curiosity. For this reason, nuclear tourism is still alive since 50s; in 2011, Chernobyl, site of the world's worst catastrophe at a nuclear power plant, was officially declared a tourist attraction, it was also the period of the Fukushima disaster.

This thesis aims to exploits the characteristics of nuclear waste and its disposal process, in terms of time, growing of waste, fear and desire, and a human trace. The project proposes a nuclear waste disposal facility which works as a monastery; in the sense of organising a building complex that involves layers of control, where 'atomic monks' will monitor the nuclear waste disposal site and pass down the memory of it for centuries to come. In fact, semiotician Thomas Sebeok once suggested the idea of an atomic priesthood whose responsibility, for thousands of years to come, would be to pass on information about sites of nuclear waste storage and contamination to next generations by using a combination of myths, folklore, and annual rituals.

The structure of the thesis is divided into five parts:

First part is composed of a preliminary overview of radioactive waste; an overall information about its disposal process and timeline; a comparison the disposal time period with the chronological records of the previous 300 years; storage phases of radioactive waste in a surface repository; examples of other nuclear waste disposal facilities in Europe; and finally, the issue of nuclear tourism.

Second part deals with the Italian approach to nuclear waste disposal facility; analysing the storage sites of Italian radioactive waste, currently in operation; and the factors of Italian nuclear waste generation.

The third aims to give information about the current situation of siting process in Italy; to explain the site selection criteria; to analyse the project area and its characteristics.

Fourth part involves the project which contains an introduction, a program layout, security protocols and the proposal. The proposal is divided into three steps, according to the organisation of outside-out; outside-in; inside in, and studied in more detail in the following cases; the masterplan; the repository; the archive.

Finally, in the fifth part, it is pointed out the matter of artifacts, human traces; indicated the life-cycle of facility in the period of 300 years; illustrated how the next 300 years may effect to the proposal.

01 RADIOACTIVE WASTE

NUCLEAR, THE TERRIFYING UNKNOWN

The world already witnessed the dreadful results of nuclear energy a few times. It is, therefore, something that never calls forth a positive perception in the first place; even though, radioactive materials are used in numerous human activities, such as electricity production, diagnostic and therapeutic medicine, scientific research, industrial operations, etc. In a sense, nuclear energy resembles humanity. Like human-being, it inholds great power and potential within a great danger, besides a great tragedy and delight.

First, Ancient Greek philosophers elaborated the idea that all matter is formed of invisible particles, called *atomos* which means 'indivisible'. Later, the 18th and 19th centuries scientists developed the concept based on their experiments. By 1900, it was quite known that the atom contains a greater energy than ever. As British physicist once mentioned "If it were ever possible to control at will the rate of disintegration of the radio elements, an enormous amount of energy could be obtained from a small amount of matter."

Radioactivity is a natural phenomenon, it is the emission of ionizing radiation or particles caused by the spontaneous disintegration of atomic nuclei. Thus, ionizing radiation means that radiation interacts with living cells and, more importantly, the DNA in those cells. Then, it can possibly cause damage to those organic cellular tissues. Obviously, human-being is naturally exposed in a certain level of radioactivity in the environment. However, being exposed to radioactivity in higher level than natural one may increase a health risk. For this reason, the radioactive substances, generated by nuclear energy use must be managed adequately and safely from their creation until their disposal. Geoff Manaugh wrote in his article *The Elephant's Foot,* " This abstract 'thing that is deep inside the reactor' is thus held outside of human contact, separated from experience by a provisional monument: the sarcophagus shell. Sheltered there, precisely because of its temporal excess, in a state of near-immortality—capable of interacting mutationally with living matter for up to a million years—the 'thing' enters into a timeframe more appropriate for mythology. "

Nuclear energy has benefitted mankind in many ways. Yet, the world, therefore faces a very complex issue of nuclear waste and its disposal. The national and international regulations aim to ensure the protection of workers, populations and the environment from all the hazardous risks, deriving from ionizing radiation. The regulations are also considering the impact on future generations.

Radioactive waste is classified in order to have reference parameters for their correct disposals. In Italy Technical Guide n.26, issued in 1987 by ISPRA, classifies nuclear waste into three categories and each type requires for a different waste management and disposal method. The classification takes into account two parameters; the specific activity of waste, for example the number of nuclear disintegrations per second per mass unit of radioactive waste; and the decay period of radioactive waste elements or the half-life of nuclear waste. The radioactive waste disposal facilities are established according to the requirements of nuclear waste classification, as well as the time scale which intensifies the radioactivity of substances, and consequently the risk for nature. Based on the time scale, the nuclear waste is assorted as; the waste that decays the radioactivity within a few months or years; the waste that requires to cease the radioactive risk for tens or hundreds of years; and finally, the waste whose radioactivity conutinues for thousands of years.

RADIOACTIVE WASTE DISPOSAL

Waste is any residue of a process of production, processing or of use, any substance, material, product or, more generally, any movable asset abandoned or its holder destined for abandonment. The 'ultimate waste' is defined as "no longer likely to be treated under the technical and economic conditions of the moment, in particular by extracting the valuable part or by reducing its polluting or dangerous nature ". In addition, radioactive waste is a radioactive substance for which no further use is planned or envisaged. The ultimate radioactive waste is the waste which can no longer be treated under the current technical and economic conditions, in particular by extracting their recoverable part or by reducing their polluting or dangerous nature.

The usual classification of waste, taking into account the level of activity of radionuclides and their half-life period, makes it possible to direct radioactive waste towards the management system adapted to their characteristics. There is no single classification criterion for determining the class of a waste. It is indeed necessary to study the radioactivity of the various radionuclides present in the waste to position it in the classification.

The characteristics of radioactive waste differ from one waste to another, therefore the treatment of nuclear waste occurs in ways that vary according to the category in which they are classified, depending on their physical and chemical nature, level and type of radioactivity, half-life of the main radioactive elements contained.

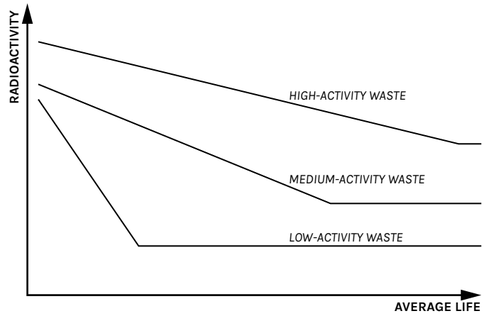
Very low-level radioactive waste is simply stored in protected and controlled conditions until a radioactivity concentration below a predetermined value is reached; after this time they can be treated as common waste.

For low and medium activity radioactive waste the procedure is more complex, and develops in two phases. The preliminary stage is called "conditioning" : the substance is conditioned with a cement matrix in metal containers, with the aim of facilitating its transport and storage. The conditioned waste is then placed in surface repository, isolating them with artificial barriers to prevent any possible contact with the ecosystem.

For high-level waste, on the other hand, both temporary depositories with adequate structures and deep geological repositories for definitive storage. In many countries with an electronuclear supply chain, the actual realization of these temporary storages , so that the deep geological repositories for high-level waste is still being discussed and concerned due to the high environmental impacts of this type of solution. It must be also said that Finland is an exception where the Onkalo repository is at an advanced stage of construction.

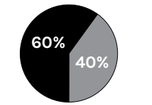
The storage solutions diverges from country to country, according to their classification parameters of radioactive waste the treatment methods can vary. For instance, some countries, such as Japan, have chosen a classification by production chain, whereas in Germany, for example, where disposal facilities are all underground, the classification mainly concerns the exothermic nature of the waste (heat release or not).

Classification Criteria of Radioactive Waste



VERY-LOW/ LOW/ MEDIUM-ACTIVITY WASTE

PROVENANCE



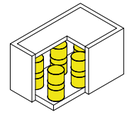
NUCLEAR CENTRAL

RESEARCH, MEDICINE INDUSTRY

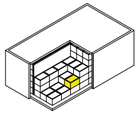
DISPOSAL

FIRST BARRIER:
THE ARTIFACT
The radioactive waste, conditioned with a cement matrix in metal containers (artifacts), ready to be transferred to the National Repository. Each barrel of waste has an identity document,applied a barcode which indicates the information about type of waste.

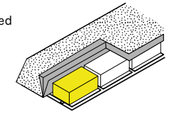
SECOND BARRIER:
THE MODULE
The containers are inserted and cemented in special concrete modules (3m x 2m x 1.7m), designed to last 350 years.



THIRD BARRIER:
THE CELLS
240 modules are inserted and cemented in each reinforced concrete cell (27 m x 15,5 m x 10 m), designed to withstand at least 350 years.



FOURTH BARRIER:[1]
MULTI-LAYER COVERAGE
The cells (about 90) are sealed and covered with multiple layers of material to prevent water infiltration and human, animal or plant intrusion for 350 years.



HIGH-ACTIVITY WASTE

PROVENANCE

NUCLEAR CENTRAL

HA radioactive waste arises from nuclear plant processing, and decommissioning; also nuclear fuel reprocessing and dissolution.

NOTE$_1$: It is foreseen that the operation of inserting the total nuclear waste to these 90 cells will take up to 50 years. Then the surveillance period will begin which is at least 300 years.

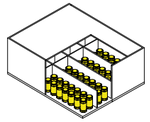
NOTE$_2$: In this thesis proposal, 4 temporary storages for high activity waste are requested to be placed in the national nuclear waste disposal facility.

DISPOSAL

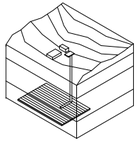
THE CASK
High-performance metal containers, qualified for transport and storage, capable of resisting extreme stresses both mechanical and thermal, in compliance with international standards. They are used for storing the long-lived nuclear waste, radioactive for thousands of years.

STACKABLE METAL RACKS
It is an another method to stock the HA waste. The racks are moved to the dedicated storage aisle in the building to be stored temporarily.

TEMPORARY STORAGE[2]
The casks and metal racks are temporarily stored in special controlled areas for up to 50 years pending their definitive arrangement in a geological repository.

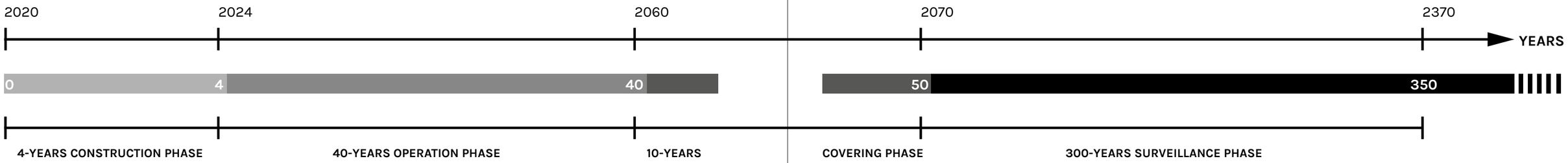


GEOLOGICAL REPOSITORY
Final disposal is foreseen in deep geological formations, with passive safety containment methods or with geological, geotechnical and technological barrier systems.



RADIOACTIVE WASTE DISPOSAL

THE PHASES OF RADIOACTIVE WASTE DISPOSAL



300 YEARS

CHRONOLOGICAL RECORD

1751
the first encyclopedia is published

1769
Industrial Revolution

1789
French Revolution

SCIENTIFIC AND TECHNOLOGICAL ADVANCEMENTS

1804
first steam locomotive

1825
centralized gas lighting in the city of Paris

1876
Alexander Graham Bell patents telephone

1880
Thomas Edison patents electric lamp

1898
M.de Curie discovers radioactivity

1908
first airplane

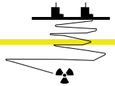
1914
First World War

1939
Second World War

1945
first atomic bomb test and explosion

1969
first landing on the moon

1986
Chernobyl Disaster



2000
ONKALO the world's first permanent radioactive waste repository

1932
first nuclear fission

1981
first personal computer

1991
Internet

2008
Tesla Car

2011
Curiosity the Mars explorer

2013
Large Hadron Collider

300 YEARS

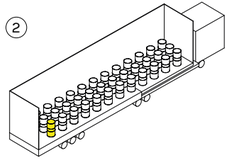
STORAGE PHASE OF THE NUCLEAR WASTE IN THE REPOSITORY

VERY LOW / LOW / MEDIUM-ACTIVITY NUCLEAR WASTE (PERMANENT)

1

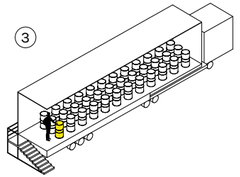
FIRST BARRIER: THE ARTIFACT
The radioactive waste, conditioned with a cement matrix in metal containers (artifacts), ready to be transferred to the National Repository. Each barrel of waste has an identity document,applied a barcode which indicates the information about type of waste.

2



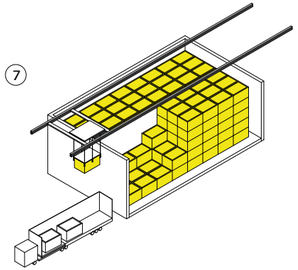
DELIVERY TO THE REPOSITORY
The radioactive waste containers are loaded on a special truck which conveys the waste to the repository.

3



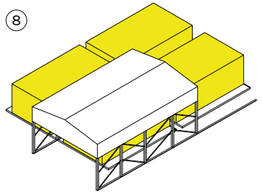
DISCHARGING THE WASTE
Once the truck has arrived to the control point, the barcodes of containers are read to understand what kind of waste they are.

7



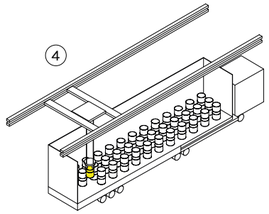
THIRD BARRIER: THE CELLS
240 modules are inserted and cemented in each reinforced concrete cell (27 m x 15,5 m x 10 m), designed to withstand at least 350 years.

8



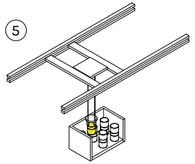
THE MOBILE STRUCTURE
While the cells are being filled with the modules, the mobile structure that moves along the track protects the modules from the external factors, such as rainwater.

4



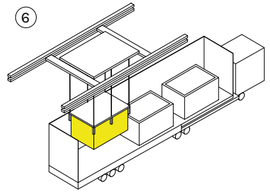
DISCHARGING THE WASTE
After barcode reading, very low/low level radioactive waste containers are prepared for packaging.

5



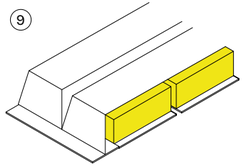
SECOND BARRIER: THE MODULE
The containers are inserted and cemented in special concrete modules (3m x 2m x 1.7m), designed to last 350 years.

6



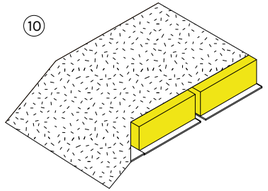
DELIVERY TO THE CELLS
The modules are carried to be positioned in the cells, the third barrier.

9



THE CAP
After the cells has been inserted and cemented, the cap is constructed to protect the cells from human, animal or plant (tree root) intrusion and minimise water infiltration. It functions like an umbrella, preventing water from penetrating through into the cells and causing it to run off so that it can be collected.

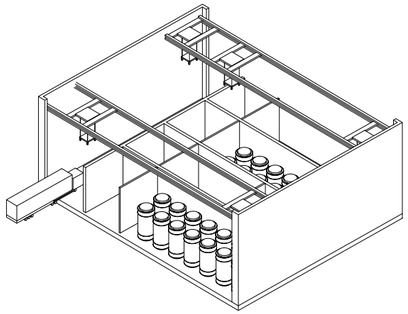
10

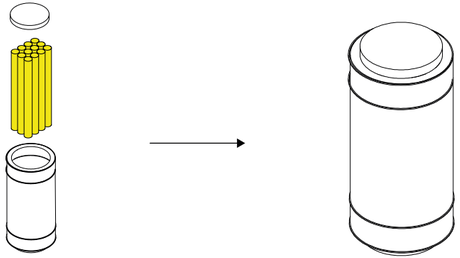


FOURTH BARRIER: MULTI-LAYER COVERAGE
The cells (about 90) are sealed and covered with multiple layers of material to prevent water infiltration and human, animal or plant intrusion for 350 years.

STORAGE PHASE OF THE NUCLEAR WASTE IN THE REPOSITORY

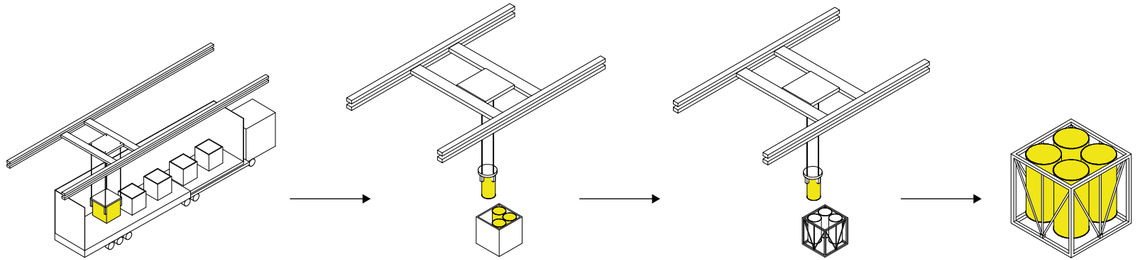
HIGH-ACTIVITY NUCLEAR WASTE (TEMPORARY)





TEMPORARY STORAGE FOR HIGH-ACTIVITY WASTE
The storage buildings meet the highest safety requirements and have the best high-activity waste management technologies that can be kept in the National Repository for up to 50 years pending their definitive arrangement in a geological repository.
Each building is divided into storage aisles that can be reached through controlled access areas for the entry of the products.
Each product is packaged either by using cask or stackable metal rack for their long-term storage depending on the type and characteristics.

THE CASK
They are high-performance metal containers, qualified for transport and storage, capable of resisting extreme stresses both mechanical and thermal, in compliance with international standards.
Inside the building, a set of special equipment allows to carry out specific and handling operations and checks on the casks before placing them in the dedicated storage aisle.



SPECIAL TRANSPORT CONTAINERS
Non-shielding artifacts which can come from the cementation of radioactive waste, are carried to one of the high-activity waste storage.

OPERATION PHASE 1:
The products are transferred through a remote-controlled system, in special rooms, shielding hot cells. In the hot cells, suitable remote-controlled equipment allows the artifacts to be extracted from the transport containers.

OPERATION PHASE 2:
Once they are extracted, the system transfers the products to stackable metal racks from the hot cells. The racks are moved to the dedicated storage aisle in the building.

STACKABLE METAL RACKS

NOTE: A temporary storage can house both the cask and stackable metal racks. It depends on the nuclear waste type; not every kind of high-activity nuclear waste requests a cask in order to be stored.

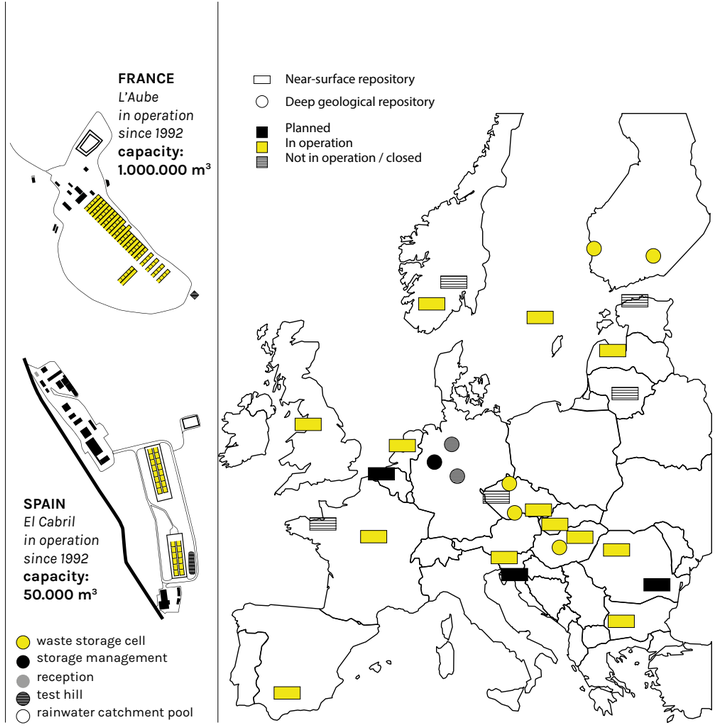
SOLUTIONS IN EUROPE

The world is facing with the issue of radioactive waste disposal with the creation of near-surface repositories , suitable for very-low, low and medium activity waste, and deep geological ones, necessary for high activity waste.

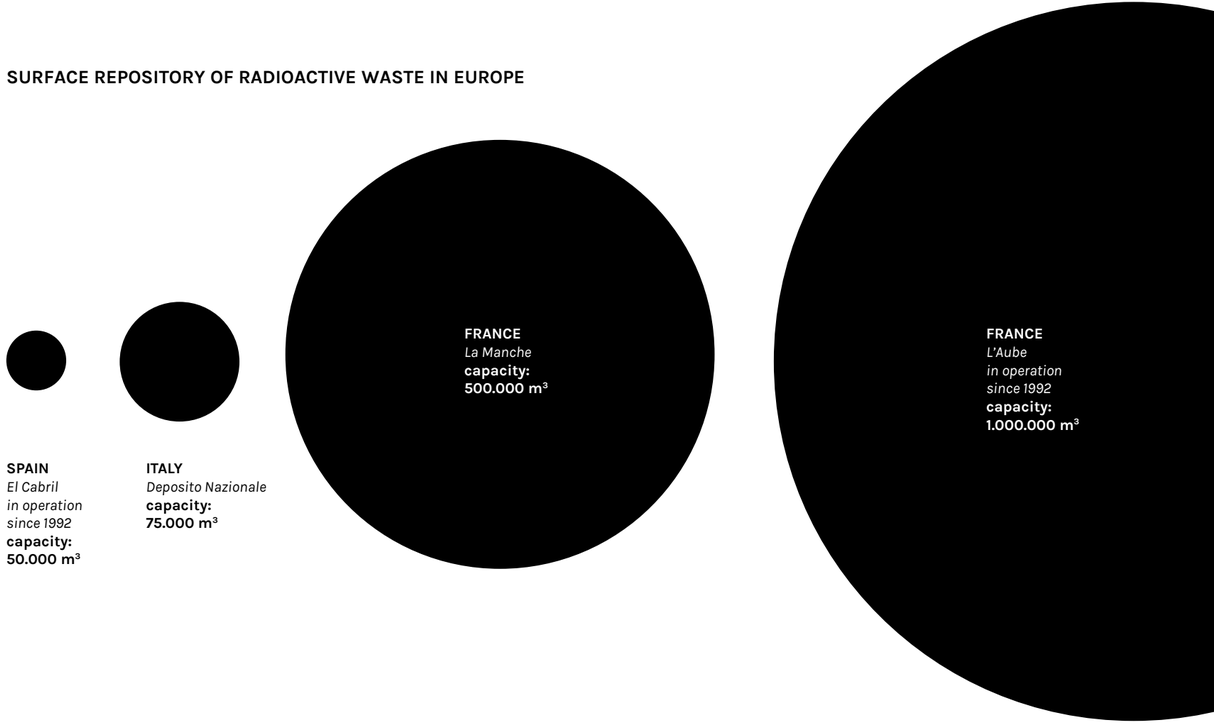
In Europe there are 20 near-surface repositories, of which five are out of service and three are in the planning stage; with regard to deep geological repositories at two disused sites, there are five active and one in progress.

La Manche Disposal Facility, located in the municipality of Digulleville in Normandy(France), La Manche department, is the first surface repository in France, in the post-closure surveillance phase now, houses approximately 500,000 cubic meters of low-activity radioactive waste in an extension of 15 ha. It started to be operated in 1969 and saturated in 1994, the waste deposit was closed and progressively covered by a multi-layered barrier between 1991 and 1997. Since then it has been in institutional operation ,radiological and conventional monitoring and yearly accepting about 1500 guests. Additionally, the two surface repositories of Cabril(Spain) and L'Aube(France), in operation since 1992, both facilities anticipate the possibility of having site visits with an average of 3000 and 4000 visitors a year. The data testifies the curiosity and interest of the population towards these radioactive waste areas.

Most European countries either have in place or are building final repositories for low and intermediate level radioactive waste. Many of these, including France, Sweden, Germany, United Kingdom, Belgium, Finland and Czech Republic, have already begun the design or study of final, geological repositories for high level and intermediate level radioactive waste. Countries with smaller amounts of high level nuclear waste participate in EU programmes for the implementation of the European Geological Repository.



SURFACE REPOSITORY OF RADIOACTIVE WASTE IN EUROPE



NUCLEAR TOURISM

The term ‘nuclear tourism’ first appeared in the 1950s. After the USA used two nuclear bombs on Japan territories in the World War 2, nuclear weapon reached the height of its fame of being a new and the most devastating power. Subsequently, the United States carried out some nuclear weapons above the ground for tests in the 1950s. Since the explosions and ensuing mushroom clouds were visible from Las Vegas, many people traveled to Vegas with the hope of seeing one of these tests take place. There was a hype on media about nuclear weapons as a manifestation of American supremacy. Thereby, an unusual tourism understanding occured in Las Vegas in the 50s and lasted until the mid-60s.

For a while, it was seen as a fancy firework display and an unprecedented experience for the tourists. Las Vegas turned the aboveground tests into a tourist attraction and the mushroom cloud into a symbol. The tourists were having a blast by watching the nuclear blasts. It was fueling their patriotism and pride of victory besides their instinct of having fear and joy at the same time. Hotels and motels set up parties or places to watch it; they even provided food to the spectators.[1] A beauty contest was organized to introduce a Miss Atomic Blast[2], so that beauty salons offered the Atomic Hairdo: for seventy-five dollars, a woman could come up with a mushroom-cloud shaped hairstyle with silver glitter sprinkled on it. The bars tendered the atomic cocktail: brandy, vodka, champagne, and sherry.

Those ‘good old times’ ended with the approval of the Partial Test Ban Treaty in 1963 which concluded the period of aboveground testing, and restricted the blasts to underground. Nevertheless, it was not the end of nuclear tourism phenomenon; yet it was not going to be exclusive to the USA. Allen Palmer, executive director of the National Atomic Testing Museum, says “People were fascinated by the clouds, by this idea of unlocking secrets of atom, but there was absolutely an underlying fear, we were so close by.”


1


2

Even though atomic power was seen for a time as the embodiment of ‘development and modernity’, beginning to the nuclear power era also involved a great conflict of having dreadful memories of nuclear warfare, the Cold War, mutual irrecoverable destruction, the risk of nuclear disaster, as well as being beneficial for applying in nuclear medicine and science. However, this confliction did not halt the people to wonder everything about the nuclear, so that ‘nuclear tourism’ maybe transformed into other forms but have been survived up till now, 2020s.

The world have testified to two horrible nuclear bombing incidents of Hiroshima and Nagasaki, three shocking atomic accidents; Three Mile Island, Chernobyl and Fukushima Daiichi, yet still, this didn't cause people to lose interest in the nuclear. What is feared, may also be desired; thereby Hiroshima and Nagasaki are served as memorial parks which contains the atomic bomb and memorial museums; or tourists can access to Chernobyl exclusion zone, the ghost town, regenerated as a tourist attraction; so the Three Mile Island is now hosting guests in the Three Mile Island Visitor Center.

The examples of turning the nuclear disaster sites, disused nuclear power stations, or sometimes still in operation, places of nuclear testing and famous explosion zones into the tourist attraction points may be diversified such as; Wunderland Kalkar is an amusement park in North Rhine-Westphalia, Germany, a colossal nuclear power plant that could never went into service because of construction problems and protests. Then the site was converted into the park by an entrepreneur. The cooling tower is functioned as swing ride and a climbing wall, now. And Kalkar receives around 600,000 visitors each year. Another example is that China opens a Cold War nuclear military plant to travelers, a decommissioned plutonium and weapons processing facility buried in the Chongqing mountains that contains one of the world's largest man-made caves. Only a third of the plant is currently open, the other areas of the mountain still highly banned to tourists, yet officials are planning to open other sections in the future.

By the 70s, it was comprehended that nuclear power had its outcomes, as strongly effective as itself; highly radioactive materials might overheat and leak from the reactor building; nuclear waste must to be regularly removed from the reactors and disposed of safely for at least three hundred years up to a million years, in this way it does not pollute the environment; recycling of nuclear waste has been discussed, but it creates plutonium which can be used in weapons, and in any case still leaves much unwanted waste to be stored and disposed of; also, extensive, purpose-built facilities for long-term disposal of nuclear waste have been difficult to site. These circumstances started a new challenge about the siting criteria and how the nuclear waste must be conditioned and stored in a safest way.

Currently, there are many surface or deep geological nuclear waste repositories in operation around the world and many of them are open to the visitors, curious about nuclear, this alien thing that must be kept under control for up to hundreds of years. This surely allows the people to construct a memory of it, as well as fuels the nuclear tourism in a new understanding. To exemplify, El Cabril, radiaoactive waste disposal facility in Spain, hosts up to 3000 guests for a year while L'Aube, radioactive waste disposal facility in France, yearly accepts 4000 visitors in average. About 1500 tourists visit La Manche, the first surface repository in France, in the post-closure surveillance phase now, in a year. Moreover, about 13.000 people visits the Onkalo Visitor's Center, the first permanent radioactive waste repository in Finland, each year.

The contradiction of fear and desire makes the people curious and excited, so that they are afraid of the nuclear, yet willing to understand it, to correlate with the nuclear since the time that it has come out. Obviously, visiting any kind of nuclear facility/site is a different and orgiastic experience. How would it be passing by among the ‘nuclear waste coffins’ and even staying in a nuclear waste disposal facility?

02 THE ITALIAN SCENARIO

THE ITALIAN NATIONAL REPOSITORY AND TECHNOLOGY PARK; SOGIN'S PROPOSAL

The National Repository is going to host the radioactive waste produced in Italy, based on the principle, stated by current regulations, that each country has the resposibility to manage its radioactive waste. The principle, established by the IAEA, the UN's International Atomic Energy Agency, is confirmed by the Euratom Directive 2011/70, adopted by Italy with Legislative Decree no. 45 of 2014.

The Repository is equipped with engineered barriers and natural barriers arranged in series, designed on the basis of international best practice and according to the latest IAEA (International Atomic Energy Agency) standards. It will permanently accommodate approximately 75,000 cubic metres of low and intermediate level short-lived waste, and temporarily store nearly 15,000 cubic metres of intermediate long-lived and high level waste.

The National Repository is expected to receive progressively an overall amount of about 90,000 cubic metres of radioactive waste, 60% of which deriving from nuclear plant decommissioning and the remaining 40% from scientific research, medical and industrial applications, including waste produced to date and that which is estimated to be generated over the next 50 years.

The proposal of Sogin an Italian state agency, responsible for nuclear decommissioning and disposal of radioactive waste, involves a Technology Park, to be built along with the National Repository. Technology Park will be conceived as a research centre open to international partnerships and equipped to carry out activities in the area of radioactive waste management and sustainable development, in agreement with the local communities.

WHAT?

SOGIN'S PROPOSAL:

150 HA
THE SURFACE AREA

→ 40 HA

TECHNOLOGIC PARK

It is an Italian choice to add a research center to the national nuclear waste repository.

20 HA

THE DISPOSAL REPOSITORY
75.000m³
low and intermediate level short-lived waste
PERMANENT

10 HA

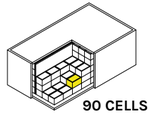
THE WASTE STORAGE
15.000m³
intermediate long-lived and high-level waste
TEMPORARY

HOW MUCH/HOW MANY?

LOW AND MEDIUM ACTIVITY WASTE

75.000m³ total waste

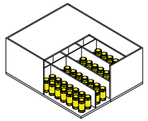
240 MODULES IN ONE CELL



90 CELLS IN TOTAL

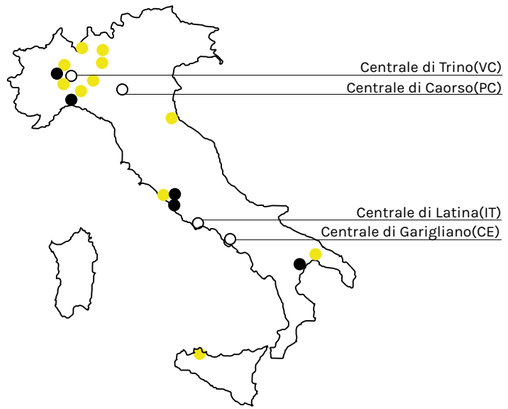
HIGH ACTIVITY WASTE

15.000m³ total waste



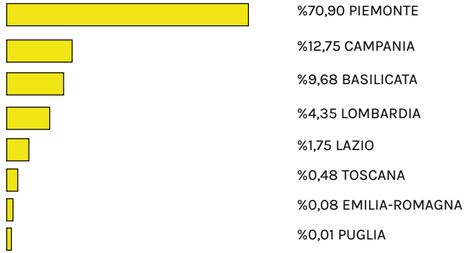
4 BUILDINGS FOR THE TEMPORARY STORAGE

MAIN STORAGE SITES OF RADIOACTIVE WASTE PRODUCED IN ITALY



- in management of Sogin
- in management of other operators
- nuclear central in management of Sogin

THE DISTRIBUTION MAP OF MAIN STORAGE SITES BY VOLUME

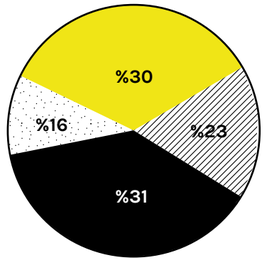


Presently in Italy, radioactive waste is mainly stored in special controlled temporary built storages, located in the sites where the radioactive waste is produced. Throughout the country there are 20 depository, including the four atomic power plants of Trino, Caorso, Latina and Garigliano.

As it is seen in the graph, the quantitative distribution through the regions is that Piemonte with the largest share (%70,90), followed by Campania (%12,75), Basilicata (%9,68), Lombardia (%4,35) and Lazio (%1,75) while Toscana (%0,48), Emilia-Romagna (%0,08) and Puglia (%0,01) hold less than %1 of the total share of temporary radioactive waste storages in Italy.

Nine of the temporary storages are in management of SOGIN which is the public company responsible for the decommissioning of Italian nuclear plants, the management of radioactive waste, also the construction and operation of the National Repository.

THE ITALIAN INVENTORY OF RADIOACTIVE WASTE



- NUCLEAR POWER PLANTS, %30
- FUEL CYCLE, %23
- SCIENTIFIC RESEARCH, %16
- INDUSTRY AND MEDICINE, %31

The radioactive waste generated in Italy originates from various sources. According to ISPRA data %16 comes from scientific research, mainly done by laboratories of biology and medicine, but also from the carbon-14 dating processes used in archeology; %23 consists of nuclear fuel at the end of the use cycle which is the waste is treated abroad and then sent to be stored in Italy; %30 comes from the decommissioning of the nuclear power plants; %31 finally results from industrial activities such as ultrasonic weld or biological sterilization of food and from medicine, both diagnostic and therapeutic.

As stated by ISPRA, the actual amount of unconditioned radioactive waste was 29.725 m^3 in 2015. Obviously, it is needed to face the problem of radioactive waste disposal in Italy.

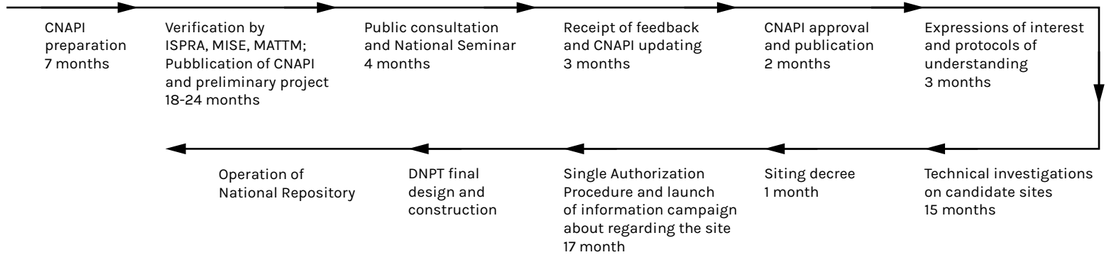
After the nationwide referendum, about nuclear energy after the Chernobyl disaster, was held in Italy in 1987, the Italian government began to shut down the existing plants in 1988. Thereafter, some leading companies in Italy have been striving for the decommissioning of nuclear plants. Hence, there is a high amount of radioactive waste that must be managed and conditioned. Even though, there are on-site interim storage solutions, these temporary storage installations will be dismantled and the waste will be carried to its new and permanent home, to the National Repository.

THE NATIONAL REPOSITORY IN NUMBERS

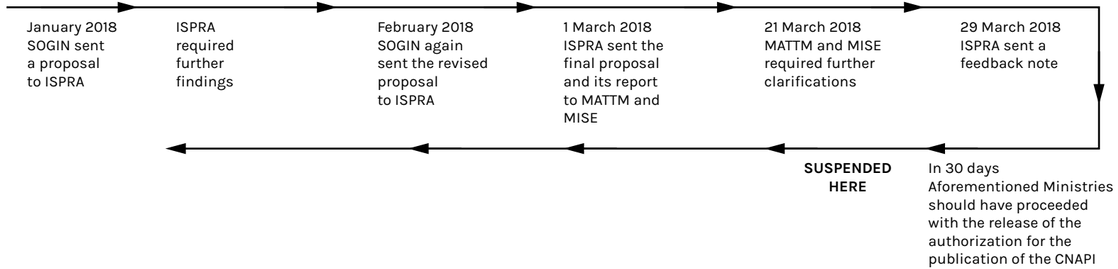
- Approximately 300 DOCUMENTS — approximately, gathered in a database, to be published after the CNAPI authorization
- 1.5 BILLION INVESTMENT — Italians already paid it within their electricity bills.
- 4 MONTHS for public consultation
- 28 CRITERIA OF LOCALISATION by ISPRA
- 4 YEARS for the construction
- 200 ELEMENTS of important mechanical components
- 73.000 T rebars
- 360.000 mc of concrete
- 2000 EMPLOYEE for the construction
  700 EMPLOYEE for the facility
- 40 YEARS operation phase
- 300 YEARS surveillance phase
- IN EVERY 5 YEARS a complementary set of surveillance data

03 LOCALISATION

SITING PROCESS



THE STAGES OF LOCALISATION:



CNAPI is the National Charter of Areas Potentially Suitable for hosting the National Repository and Technology Park, in which the areas whose characteristics meet the criteria set out in the Technical Guide n. 29 of ISPRA (Higher Institute for Environmental Protection and Research) as well as the requirements indicated in the guidelines of the IAEA (International Atomic Energy Agency).

SITE SELECTION CRITERIA

Siting criteria of a near surface disposal facility for low and intermediate level radioactive waste:

_Exclusion Criteria
The following areas shall be excluded:


area of active or quiescent volcanoes


area of high seismic activity


area of interested by superficial faulting


area, characterized by geomorphological and/or hydraulic risk and/or hazard of any grade as well as river belts


area of holocene alluvial deposits


area, located above 700 m a.s.l.


area, characterized by an average slope greater than 10%


area, within 5 km from the current coast line or, if more distant, located under 20 m a.s.l.


area, interested by morphogenetic karst processes or with presence of sinkholes


area, near surface piezometric levels or with piezometric levels which could anyhow interfere with the foundation of the disposal facility


area naturalistic, protected under the legislation in force


area at a unsuitable distance from residential zones


area within a distance of 1 km from highways, all principal suburban roads, and the main and complementary railway lines


area with known presence of underground resources


area with industrial activities involving major accident hazards, dams and artificial hydraulic barriers, airports or operating military shooting ranges

_Investigation Criteria
In the siting phase the following aspects shall be assessed:


presence of secondary volcanic activities


presence of significant vertical movements as a result of subsidence and uplift phenomena (tectonic and/or isostatic)


geological-morphostructural setting and presence of lithotypes with vertical and lateral variation


presence of endorheic type river basins


presence of accelerated erosion phenomena


weather and climatic conditions


physical and mechanical parameters of the soil


hydrogeological parameters


chemical parameters of soil and groundwater


habitats, animal and plant species of conservation importance, as well as geosites


agricultural production of outstanding quality and places of archaeological and historical interest


availability of primary transport infrastructures


presence of relevant or strategic critical infrastructures

THE PROJECT SITE

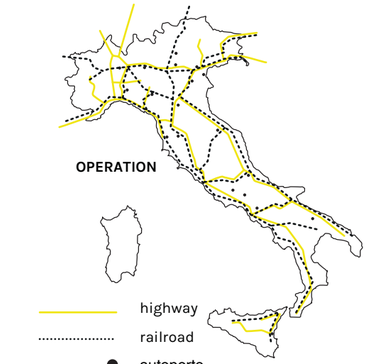
The project covers the National Repository and the technologic park which includes a research center, administration and archive; therefore the site will be designated according to the criteria of Technical Guide n.29 of ISPRA.

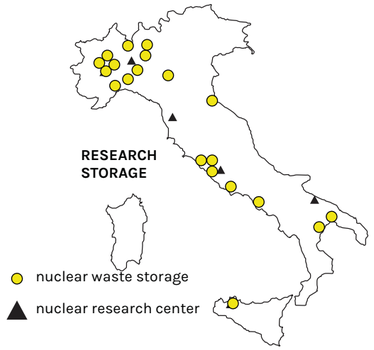
Concordantly, these three analyses; the road infrastructure, accessibility and proximity to existing nuclear research centers and waste depository areas, are also efficient to specify the site of the project.

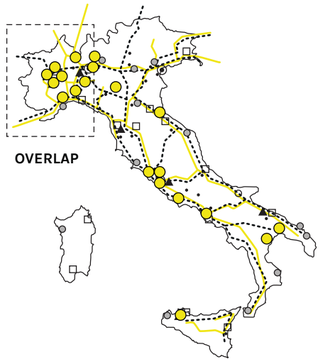
Considering that the superimposition of the maps and the technical criteria, the Piemonte region already reserves 70,90% of the Italian radioactive waste thereby it responds to the main location parameters for receiving the nuclear waste and it is suitable for a design experiment for the national repository.

The identified area is located in Piemonte, about 40 km from Torino, departing from the capital and going towards Caselle, later continuing to Levone, One reaches the very entry point of the commune. The project site looks towards the provincial road 34.

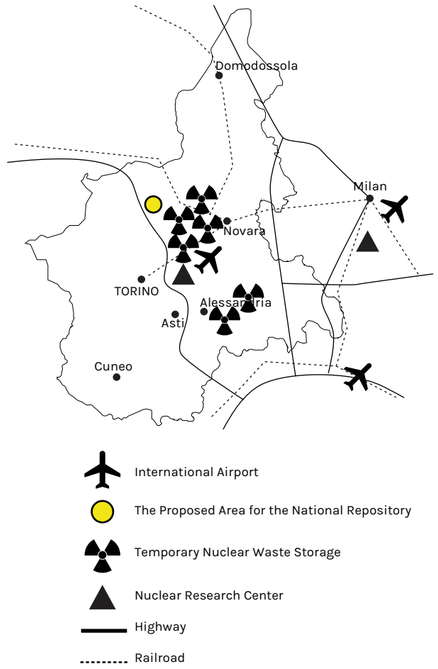
The site is dominated by farming areas and woodlands, also a few rural houses.



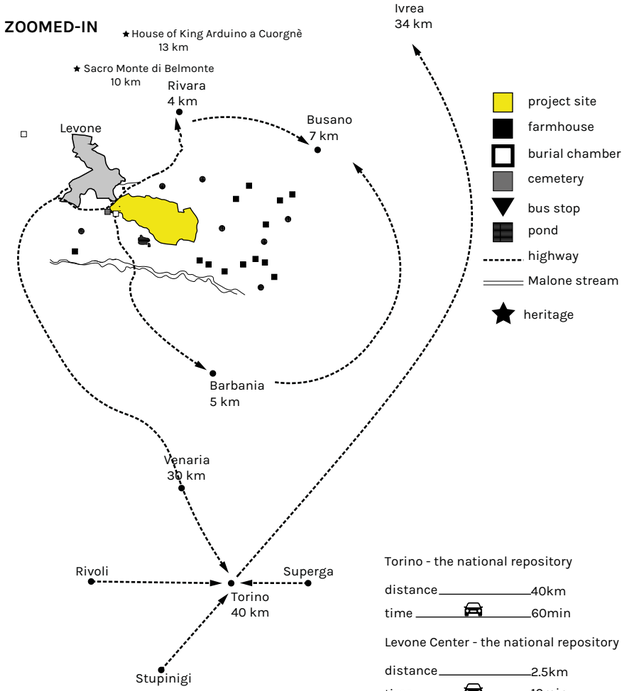




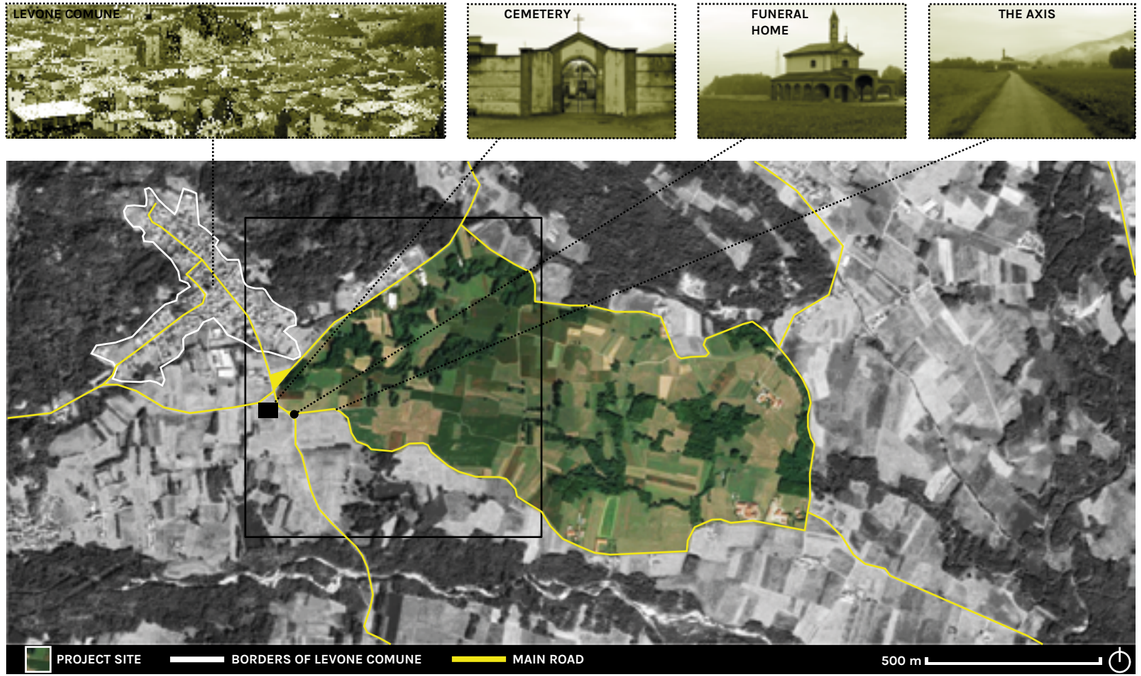
PIEMONTE REGION

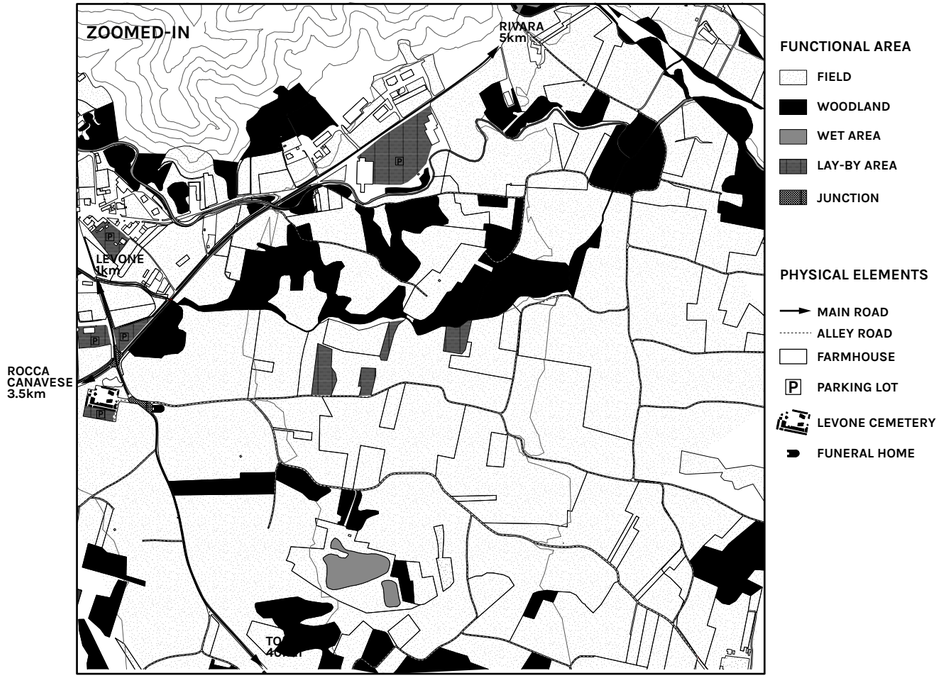


ZOOMED-IN



THE SITE CHARACTERISTICS





04 THE PROJECT

INTRODUCTION

A nuclear waste disposal facility is perceived as a forbidden, dangerous, hostile place. The place that evokes hidden fears; has to be isolated from any kind of intrusion at least for 300 years, because of security reasons. These complexes are part of a separate sphere, excluded from the public life of a community. Therefore this separation means that the repository goes through a sort of sacralization.

The nuclear waste repository is dangerous and sinister in one sense; sacred and blessed in the other. Forbidden zones are the places where can exorcise one's fears; thus curiosity. Radioactivity spreads a kind of ominous charm, both intriguing and anxious. Exploiting this intrinsic feature of the Repository is transforming it into an attractive place for the public. Even though a nuclear waste disposal site may involve many repulsive qualities of the waste, this place is meant to be safe. The need of democratic monitoring of the complex, also allows to be viewed by the people at large. All the waste that arrives to the site is already contained in envelopes aimed to avoid leakages of radioactivity. For this reason, working here as researcher or employee is possible; as well as visiting. It is, therefore, a tool to recognize and enhance the hideous beauty of place. Like in the Tarkovsky's movie Stalker, the visitors have to overcome many obstacles and respect a strict protocol to avoid unleashing unknown forces by following the guide so that they might reach to the mysterious place, called "The Area", where all the wishes come true.

In the "*Underworld*" (De Lillo, Don, 1997.), it is written as "'I'll tell you what I see here, Sims. The scenery of the future. Eventually the only scenery left. The more toxic the waste, the greater the effort and expense a tourist will be willing to tolerate in order to visit the site. Only I don't think you ought to be isolating these sites. Isolate the most toxic waste, okay. This makes it grander, more ominous and magical. But basic household waste ought to be placed in the cities that produce it. Bring garbage into the open. Let people see it and respect it. Don't hide your waste facilities. Make an architecture of waste. Design gorgeous buildings to recycle waste and invite people to collect their own garbage and bring it with them to the press rams and conveyors. Get to know your garbage. And the hot stuff, the chemical waste, the nuclear waste, this becomes a remote landscape of nostalgia. Bus tours and postcards, I guarantee it.'
Sims wasn't sure he liked this. 'What kind of nostalgia?'
'Don't underestimate our capacity for complex longings. Nostalgia for the banned materials of civilization, for the brute force of old industries and old conflicts.'"

The national repository of nuclear waste requires to be monitored and the information must be archived for at least 300 years, thereby it will inevitably constitute a national memory. For instance, the nuclear reactor in Hanford, Washington, has been declared a national historic site, the Department of Energy explains, "National Historic Landmarks, can be nationally significant districts, sites, buildings, structures, and/or objects that possess exceptional value or quality in illustrating or interpreting the heritage of the United States." Accordingly, nuclear waste disposal complexes are one of them, as well. Within their own time scale, 300 years, and exaggerated existence, these structures are as the ones that were built in the Baroque Period (17th-18th centuries) and now the people visit in 21th century. In the book *I confini del Paesaggio Umano,* Leonardo Benevolo explains that Torino, the capital of the Piemonte Region, is surrounded by the set of landscape arrangements made by the Savoy Sovereign and this enormous halo of settlements of Rivoli, Superga, Venaria Reale and Stupinigi creates a large perspective triangulation around the city, closed within its mighty fortifications. Consequently, these colossal structures are still enduring the time and even visible from the city center as the delegates of well-preserved memory.

Eventually, a surface nuclear waste repository may contain many superimposed meanings; it is a gigantic environmental sculpture; the information about it must be archived and kept in a structure for 300 years like a holy scripture; yet not directly accessible, therefore for the ones who wants to see it have to pass through a multi-layered control and follow the guide as if it is a ritual for reaching to the 'sanctum'.

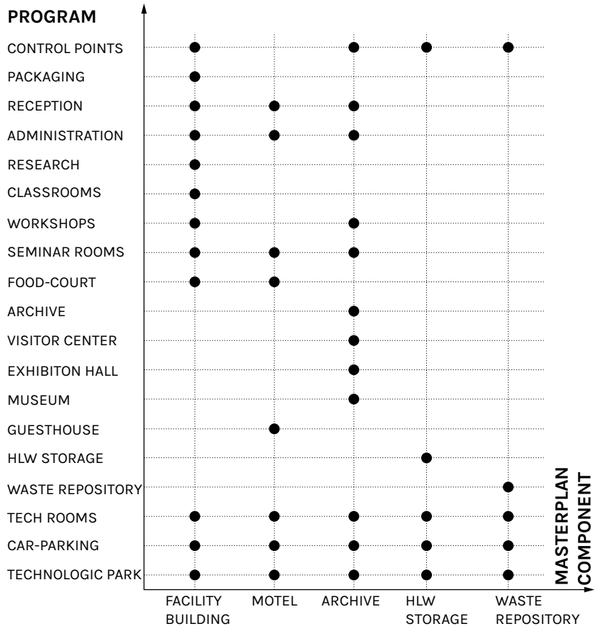
PROGRAM STRUCTURE

PROGRAM ORGANISATION AND LINKING

PROGRAM	m²	ACCESS PROTOCOL	USER
CONTROL POINTS	2000	○	R E
PACKAGING	1000	○	R E
RECEPTION	1000	▨	R E V
ADMINISTRATION	3000	▨	E
RESEARCH	6000	○	R
CLASSROOMS	500	▨	R
WORKSHOPS	500	▨	R V
SEMINAR ROOMS	1000	▨	R E V
FOOD-COURT	1000	▨	R E V
ARCHIVE	2000	○	R E
VISITOR CENTER	500	▨	V
EXHIBITON HALL	1000	▨	V
MUSEUM	1000	▨	V
GUESTHOUSE	3000	■	R E V
HLW STORAGE	10 HA	○	R E
WASTE REPOSITORY	20 HA	○	R E
TECH ROOMS	3000	○	E
CAR-PARKING	3000	▨	R E V
TECHNOLOGIC PARK	-	▨	R E V

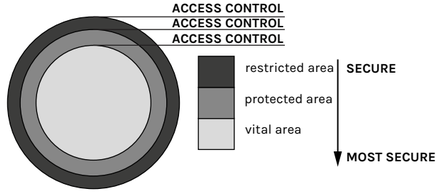
■ **UNESCORTED**
▨ **PARTLY-ESCORTED**
○ **ESCORTED**

R researcher
E employee
V visitor



SECURITY PROTOCOLS OF A NUCLEAR WASTE REPOSITORY

THE AREAS; OUTSIDE-IN



A record should be kept of all persons who have access or keys, keycards and/or other systems, including computer systems that control access to nuclear material.

ENTERING TO A NUCLEAR FACILITY

Each person-**whether they are employees, researchers or visitors**-must pass through metal and explosive detectors and all their hand-carried items are screened by X-ray.

ACCESS CONTROL

DOCUMENTED STAFF

documented means; individuals who are become part of the industry's behavioral observation program which includes pre-access, and random drug and alcohol tests, also behavioral monitoring by supervisors and peers.

UNESCORTED ACCESS

VISITORS

after the security checks, restricted numbers (at a time) of visitors may enter the limited access area and may start to a visit tour; all the visits and the visitors are recorded.

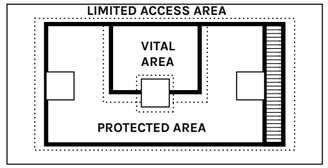
ESCORTED ACCESS

EITHER WAY, IT IS MONITORED AND RECORDED ALL THE TIME

PHYSICAL PROTECTION IN USE AND STORAGE

computer based sytems are used for the physical protection

nuclear materials should be used or stored at least at protected area



between two protected areas;
_the number of access points
_the number of authorized person
_the number of vehicles

should be kept to the minimum necessary

the barrier of limited access area
central alarm system, all around
the physical barrier of protected area
access/verification points
designated parking area

POSSIBLE THREATS

unauthorized removal

insiders

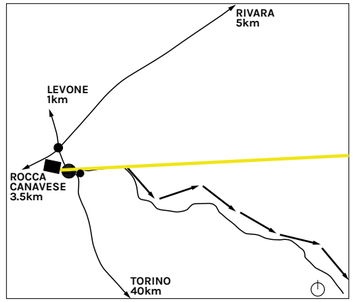
missing nuclear material

cyberattacks

sabotage

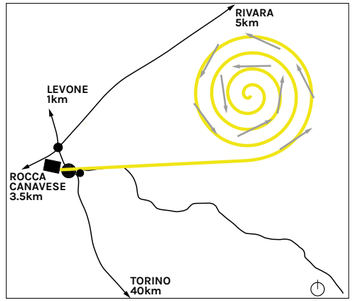
4.1 THE MASTERPLAN; OUTSIDE-OUT

MASTERPLAN SETTLEMENT TACTICS



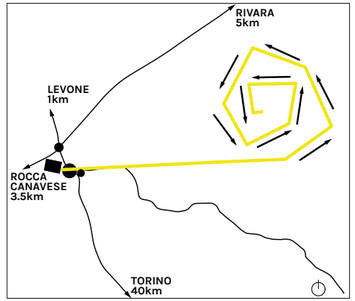
THE PROCESSION AXIS

A nuclear waste surface repository must be preserved and monitored for at least 350 years. This scale of time is way beyond a human life-cycle, therefore all the memory of it must be archived and pass down to next generations. These people will dedicate their lives in some way, to conserve and transmit the holy information to younger ones. Accordingly, it enables a ritualistic procedure that the generations of three centuries have to follow. For that reason, the entire complex is organised along an axis. The axis, from the junction through the site, leads the procession which involves multi-layer of control, fear and desire; so that atomic monks can move along in an orderly ceremonial way to keep the records for the coming generations and monitor the sacred one; the repository.



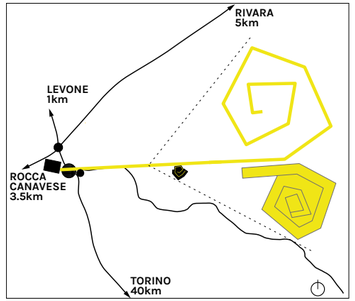
COILING THE PROCESS INTO A SPIRAL

This is the process of nuclear waste disposal, so that the procession is for reaching to the repository at the end. Because the sacred one is kept in the core of complex. The axis asks for a panoptic centre; yet, coiling the linear process into a spiral represents something more democratic; everything is visible from the borders rather than only from a centre of control. It also allows that to have a compact spatial organization instead of an overlong linear settlement. The program requires a nuclear waste disposal area with 90 cells. Hence, placing the cells(27mX15,5mX10m each) on to **an inward spiral** both enables an equal distributed control and extensive view even from the beginning of the journey.



SUPERIMPOSITION

The final form of repository is conceived by merging the inward spiral form with the surrounding traces of alley roads. Bending the axis into a deformed spiral is the result of series of superimpositions; **Spirals** are growing figures that embodies the accumulation of something; accordingly here, it accumulates the waste, earth and memory. **The deformed inward spiral** melts into the project site so that it is more connected with the landscape. **As a functional approach,** a canyon-like nuclear waste area works like a basin, provides a drainage for the nuclear waste cells; additionally, it allows to a rational organization of the entire process of disposal. Digging the area enables to accumulate the earth that will cover the waste at the end. Consequently, the accumulation of nuclear waste, earth fill and memory are predetermined in the plan.



THE TRINITY OF SPIRAL

The spiral form refers to the accumulation; the canyon-like waste disposal area generates its earth heap next to it; the heap will be used for covering the waste; the memory will be archived as far as the waste is accumulated. Hence, there is a symbotic dynamic between the waste, earth and memory; one of them cannot be accumulated without the other. Therefore the spiral form is applied to the trinity, consisting of repository, heap and archive. The whole process of digging, accumulating, covering and monitoring actually indicates the phases of the nuclear waste disposal process.

THE MASTERPLAN IN 2060

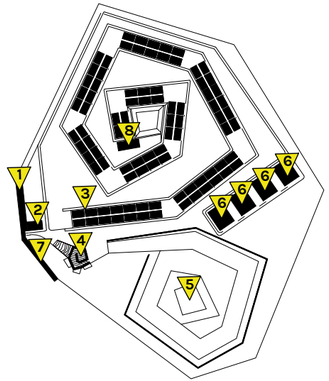
The masterplan represents the condition of entire complex in 2060. After 40 years of operation phase, started in 2020, the total nuclear waste, sacred matter, is inserted to the reinforced concrete coffins. Now, in 2060 they are ready for the covering phase. In next months, the earth heap will be used for covering the 'sarcophagus' shells. In the proposed masterplan, an environmental sculpture that consists of the spiral trinity awaits to be experienced. Long facility buildings work as a boundary walls of the site. They establish the threshold, also frame the main gateway of complex. Passing through the threshold; the rubble masonry gate, working as 'Propylaea', allows a protagonist to reach the square where One can view the canyon-like repository, archive and earth heap behind. The procession axis connects the junction to waste disposal area, in other words, it leads the visitors from the profane to the sacred zone so the ritual begins. The atomic monks come to visit the repository, 'the sanctum', for the holy contradiction of fear and desire. Besides, a delivery truck can reach to the repository, directly from the junction by following the axis.

The masterplan proposes two, long facility buildings that work as a boundary wall of the complex. One of the building includes a main reception and control point (both for the waste delivery and visitors), a waste packaging area (before its disposal), also a research center that is comprised of research labs, classrooms, library, workshop and leisure activity areas, food courts and technical rooms. The other is functioned as an administration unit, infirmary and motel. The axis first intersects to the square. The square works as a main distribution point of the researchers, employees, visitors and waste. Around the entire complex, there are green buffer zones. Outside of the threshold, there is a large car-parking area of the complex. Inside of the site there is a small lay-by area where the trucks can wait for delivering the waste according to their types. Here in the site, the spatial sequence of the axis requires a ceremony that comprises of pre-liminal, liminal, and post-liminal rite which the atomic monks rigorously follow to complete the journey.

The pilgrimage progress begins in the Control Point where ID documents of guests are checked and collected. After, the protective equipments such as helmet, reflective vest, etc., are handed over, the visitors continue along the axis by strictly pursuing a set of protocol. When they arrive to the square, the trinity of spirals welcomes them. First, the the sunken path of archive takes the atomic monks into this repository of memory and the path leads them to the heap. Behind the archive there is the earth heap which is formed as an outward spiral. Thus, the visitors proceed to this hill which allows to walk on it and view the entire landscape; until the earth heap is used for burying the nuclear coffins. Finally, through the main gateway, they can experience the canyon-like repository; the atomic monks can walk around the concrete sarcophagus shells. After the visitors arrived to the undermost point of the repository, they will upwardly continue to reach the axis of procession. So that the atomic monks walk through the main access point to complete the pilgrimage. The procession ends, when the visitors take their documents back and go across the threshold. This ritualistic journey builds a public memory of the site, as if it is a new national landmark; besides, the entire ceremony indicates how the nuclear waste disposal is operated, in a way it is a pedagogic progress for the public.

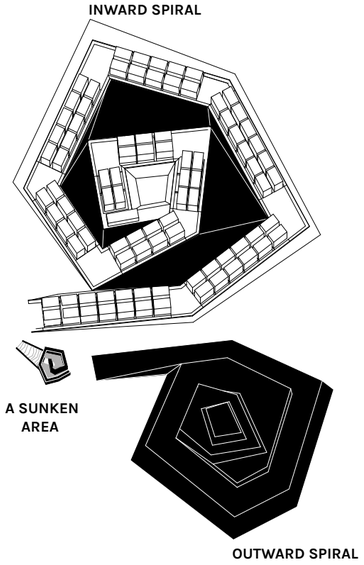
MASTERPLAN DIAGRAMS

SPATIAL ORGANISATION

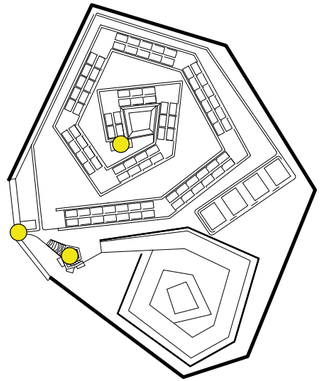


1 ..... Research Center
2 ..... Waste Packaging Unit
3 ..... The Repository of Nuclear Waste
4 ..... The Archive
5 ..... The Earth Heap
6 ..... Temporary HLW Storage
7 ..... Administration Unit-Motel
8 ..... Weather Station

THE SPIRAL TRINITY



SECURITY ELEMENTS



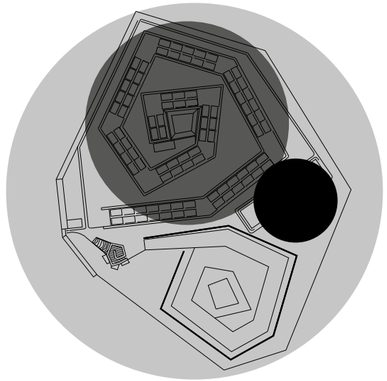
Control Point

Fence

FEAR-DESIRE

RADIOACTIVITY LEVEL

SECURITY ORGANISATION



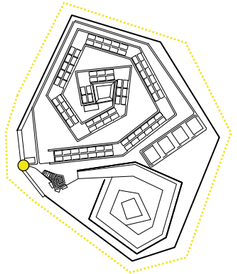
SECURITY-DANGER

Restricted Area | Protected Area | Vital Area

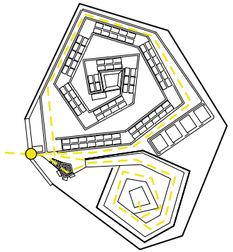
MASTERPLAN DIAGRAMS

SECURITY PROTOCOLS

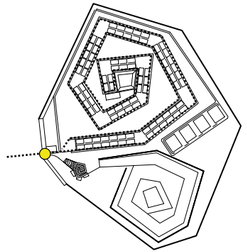
VISITORS; OUTSIDE THE FENCE



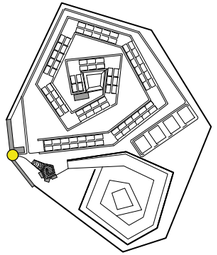
VISITORS; THE PILGRIMAGE PROGRESS



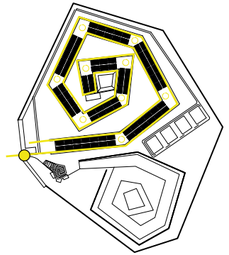
VISITORS; WITH SPECIAL REQUEST (ARTISTS,ETC.)



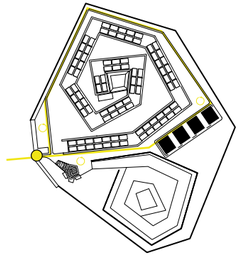
STAFF OCCUPATION IN THE SITE



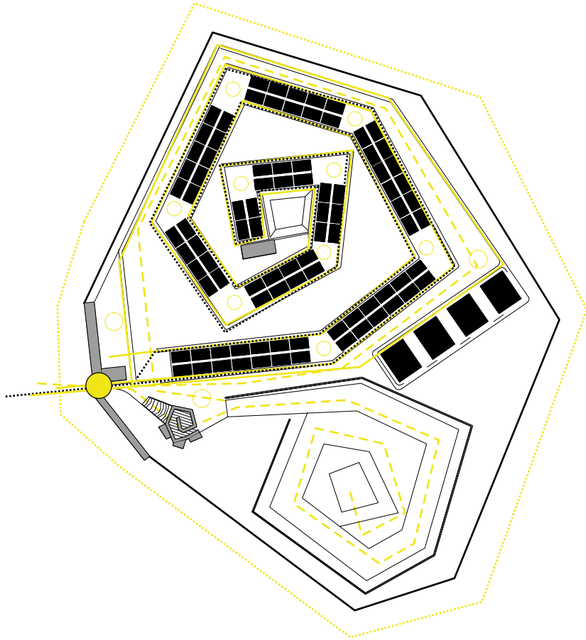
NUCLEAR WASTE DISTRIBUTION;
VERY-LOW, LOW AND MEDIUM LEVEL



NUCLEAR WASTE DISTRIBUTION;
HIGH LEVEL NUCLEAR WASTE



SUPERIMPOSITION OF THE PROTOCOLS



VISITORS; OUTSIDE THE FENCE

VISITORS; THE PILGRIMAGE PROGRESS

VISITORS; WITH SPECIAL REQUEST (ARTISTS,ETC.)

VEHICLE; TRUCKS

FENCE

CROSSROAD

MAIN CONTROL POINT

NUCLEAR WASTE OCCUPATION

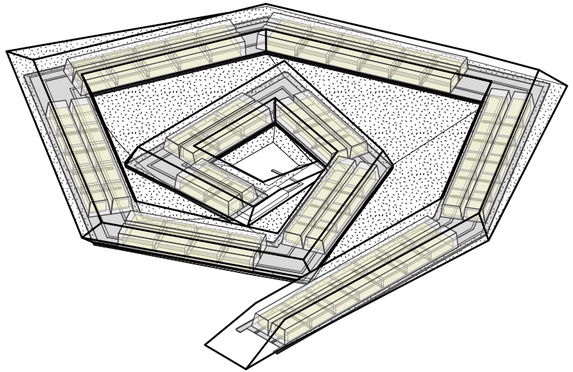
STAFF OCCUPATION

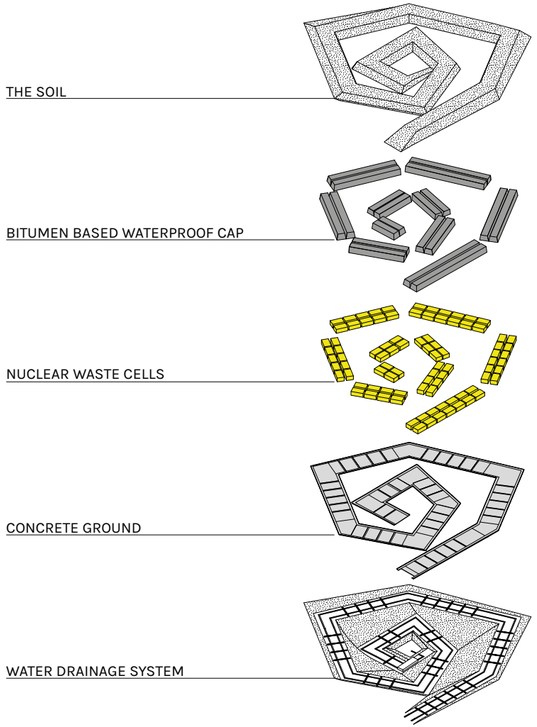
4.2 THE REPOSITORY; OUTSIDE-IN

THE SYSTEM

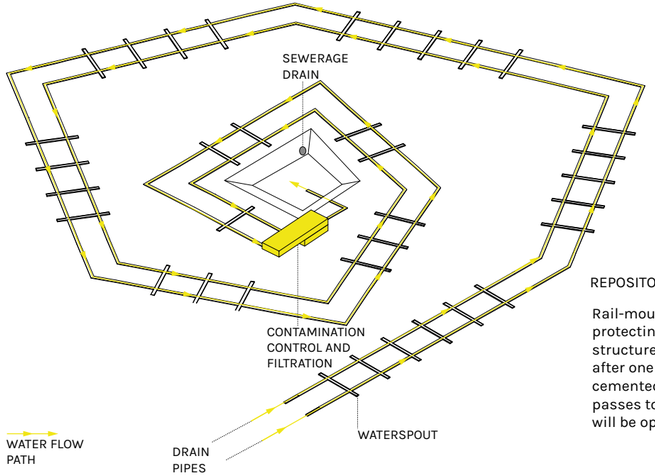
The system, formed as a downward slope, easily transmits the rainwater to the catchment area that works like a basin.

Water drainage structure is partly underground; between the cells, there are rainwater collection boxes which transfers the water to drain pipes and ensures the cells is not affected by the wet.





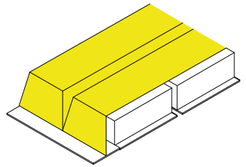
THE SYSTEM
WATER MANAGEMENT



There is a waterspout in every 2 waste cells, to collect the rainwater and ensure preventing water infiltration. Drain pipes transmits the wet into the water catchment pool, connecting the sewerage drain system.

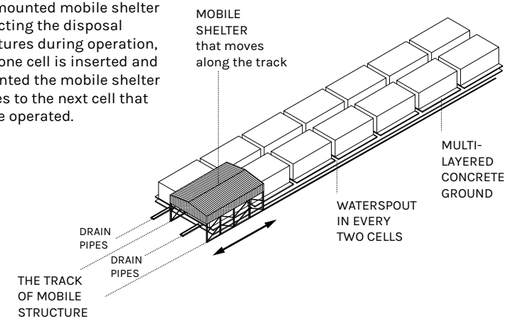
EXPERIMENTAL CAP

Experimental cap structure, 1:1 scale, to study the behaviour of an envelop design which, after operation of the site, will ensure the long-term covering of the disposal area.

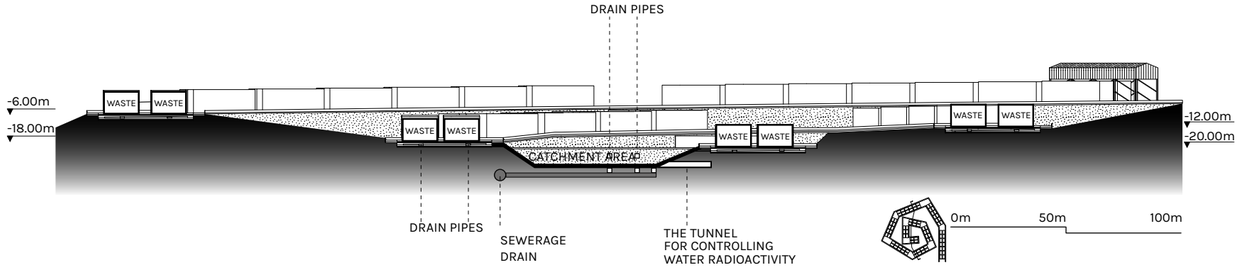


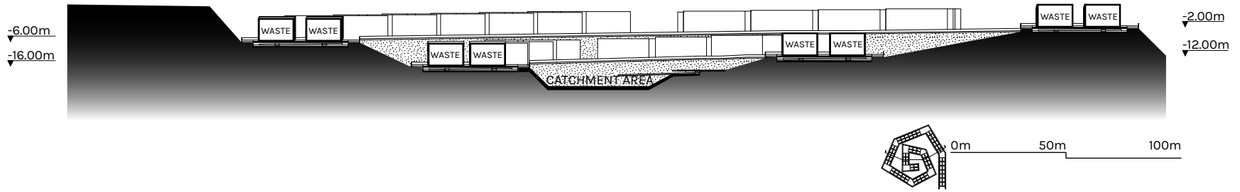
REPOSITORY OPERATION

Rail-mounted mobile shelter protecting the disposal structures during operation, after one cell is inserted and cemented the mobile shelter passes to the next cell that will be operated.



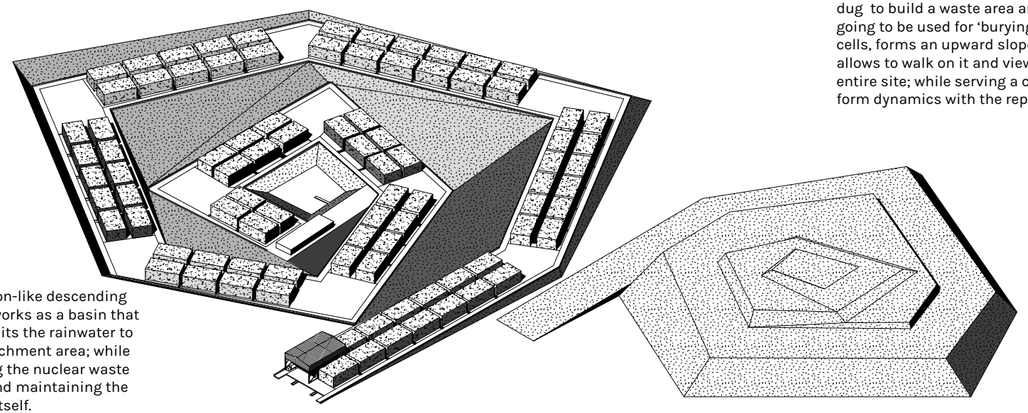
THE SYSTEM
SYSTEM SECTION





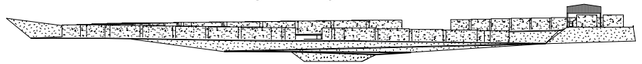
DOWNHILL AND HILL

A waste heap of the earth which is shaped after the ground is dug to build a waste area and going to be used for 'burying the cells, forms an upward slope that allows to walk on it and view the entire site; while serving a contrast form dynamics with the repository.



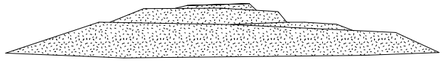
A canyon-like descending slope works as a basin that transmits the rainwater to the catchment area; while hosting the nuclear waste cells and maintaining the route, itself.

The relation between the repository and heap can be called as 'symbiosis' in that the heap existence depends on excavation of earth for building the repository, and the completion of the operation process relies on having the enough amount of earth.

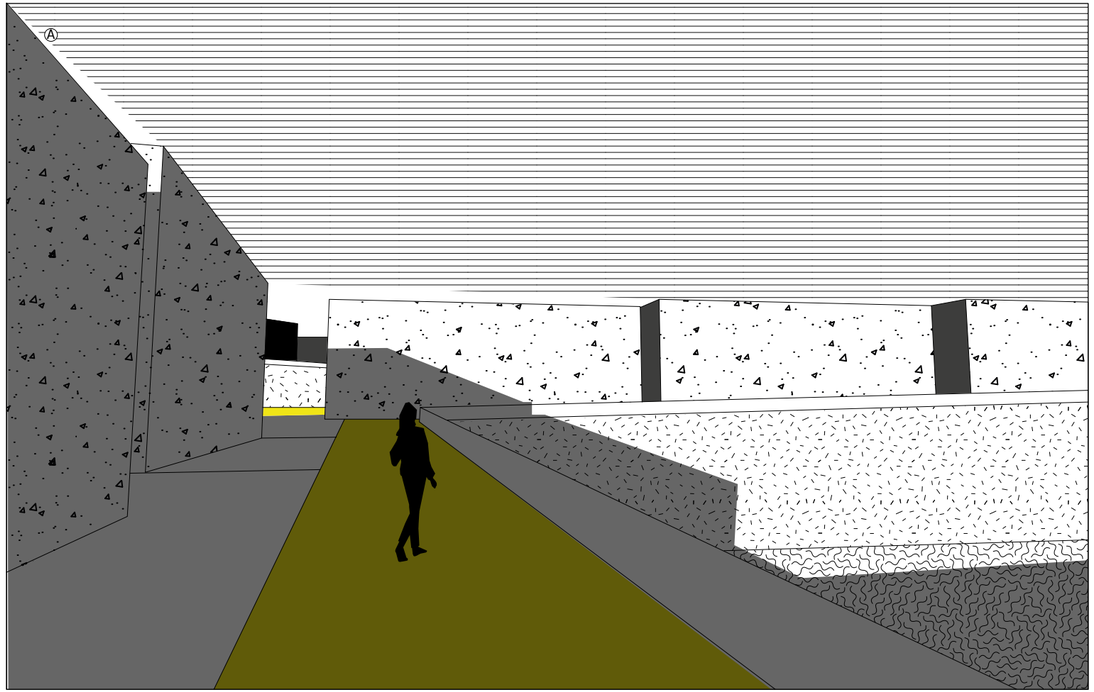


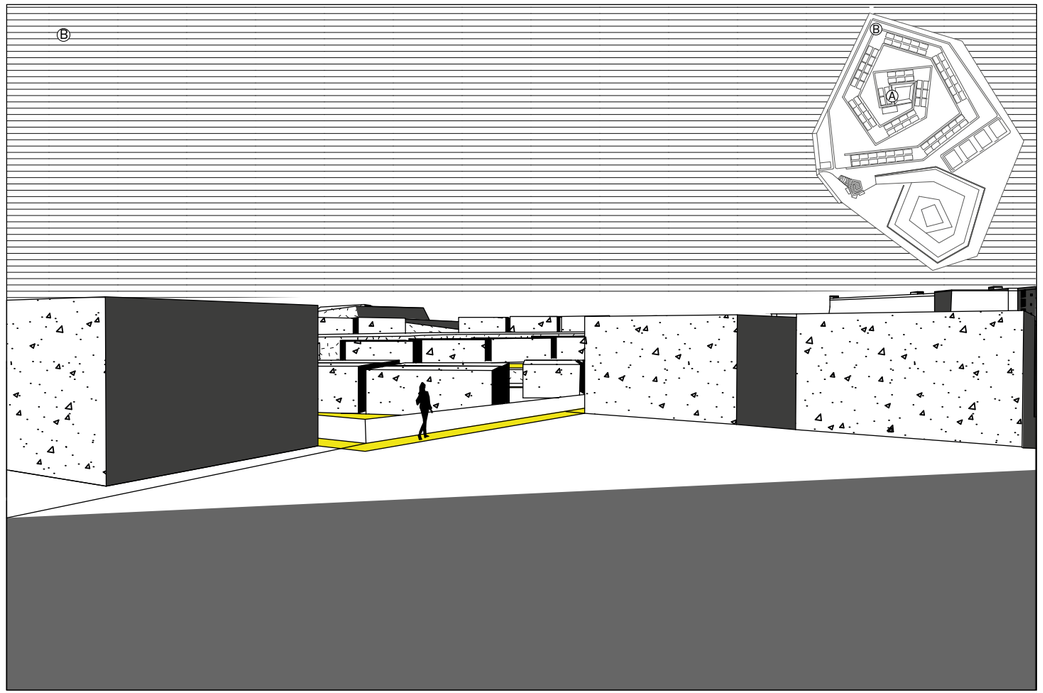
INWARD

OUTWARD



Two reciprocal slopes embody spiral-shaped geological formations. The end result is that a new sculpturesque landscape.





4.3 THE ARCHIVE; INSIDE-IN

THE FORM APPROACH

Having an artificial canyon-like repository forms its earth heap which will be used to envelop the nuclear waste cells approximately 40 years later. In fact, the earth will fill the canyon; there will be no heap anymore, yet the earth will be dispersed to cover the waste cells. This condition can be related as a mutual, but paradoxical in a sense. Hence, without one there will be no other and the entire procedure will be interrupted.

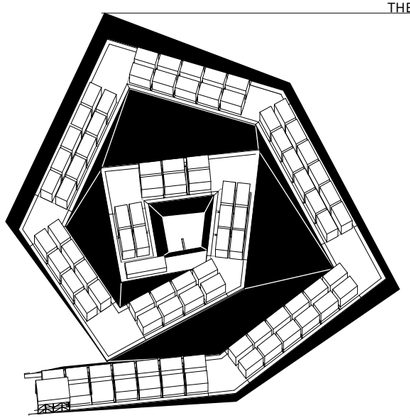
With the addition of the Archive, this relation is even more consolidated. As the nuclear waste cells are being inserted, the more information will be archived while the heap is functioned as an alternative gathering place to view the landscape. This trinity of the complex interoperate to maintain the entire disposal process. The spiral scheme is an infinitely growing figure and it refers to accumulation. The entire process relies on the accumulation of earth, waste and information. Therefore the spiral form is applied into this trinity. While the waste disposal area is conceived as an inward spiral; the earth is shaped as an outward one, so that it is a heap; and finally for the archive the information is inserted to the spiral scheme, yet this time the spiral frames the sunken place. It gently takes the visitors underneath of the spiral into an excavated, voluminous area that is surrounded by the spiral and covered by the canopies at top, then it directs the atomic monks through the heap where they can monitor the nuclear cells and whole landscape.

It is conceived that the archive will endure during 350 years which comprises of 50 years of operation and 300 years of surveillance period. Hence, the spiral form allows for an infinite extension for the information, if there will be a need. Just as Le Corbusier's proposal *Museum of Unlimited Growth* for Tokyo National Museum of Western Art, the idea is similar; a building that can eternally grow. By regarding the time issue and possible extension, the spiral is envisaged as a masonry structure, comprises of masonry concrete blocks. In a sense, masonry structure refers to the accumulation as well. For any extension, a concrete block will be put on the top of another and it will form this masonry spiral. After 350 years, the archive might be the new Baroque of the period.

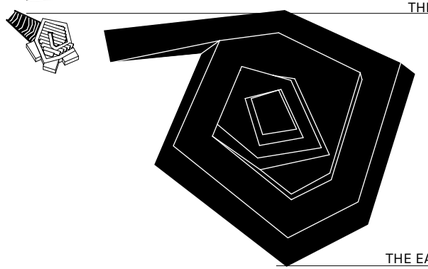
In the entire process of disposal, the dynamic collaboration between these three spiral, also allows to witness the progress, itself. For instance, in the ongoing process, the earth heap will tail off to be used as the final layer of the barrier for burying the cells as if they are coffins; the nuclear waste repository will become a sunken area, very well connected with the landscape; the archive will be standing as a masonry spiral, open to the possible extension. As a consequence of that the archive and the sunken repository conceives the final landscape.

IN 2060; THE TRINITY

THE REPOSITORY



THE ARCHIVE

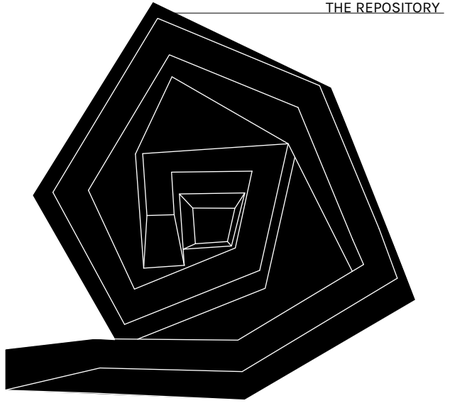


THE EARTH HEAP

The spiral form is turned into the waste diposal area, hill, and archive; the entire process is about the accumulation of waste, earth and information. Herewith the spirals work as "coiled timelines. "

IN 2370; THE GIGANTIC ENVIRONMENTAL SCULPTURE

THE REPOSITORY



THE ARCHIVE

At the very final stage, there would be a gigantic environmental sculpture, probably captured by nature, within its monumental object to guard the memory as the fortress.

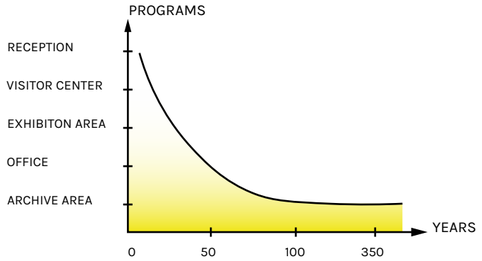
PROGRAM STRUCTURE

PROGRAM	m²	ACCESS PROTOCOL	USER
RECEPTION	100	▨	V E
SERVICE	100	■	V E
VISITOR CENTER	300	▨	V E
EXHIBITION AREA	300	▨	V E
OFFICE	300	○	E
ARCHIVE AREA	1000	○	E R

■ **UNESCORTED**
▨ **PARTLY-ESCORTED**
○ **ESCORTED**

R researcher
E employee
V visitor

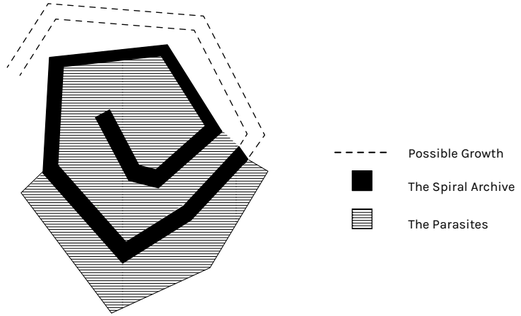
LIFE CYCLE OF THE PROGRAMS



PROGRAM ORGANISATION AND LINKING

The Archive building is one of the most eventful structures of this nuclear waste monastery that will keep the records/memory and must be stood within the repository for at least 350 years. As it is seen in the program structure and the life cycle of the programs, archive areas dominate the total space of the building; because it is the main function. The accumulation of the information will continue until the very end, so that the archive will be operated for at least 300 years within the repository. Yet, other functions such as offices for employees, visitor's center, or exhibition area might be disappeared or their way of use might be transformed over time, in other words, those functions do not have to remain up to the end of surveillance phase.

As the spiral form represents the accumulation, the archive is conceived to be hosted in the concrete masonry spiral scheme which allows to a possible enlargement, if it is needed in the coming years. On the other hand, the other 'temporal' functions are conceived as parasites of the building. They are organised as 'attachments' to the main masonry structure. In the process, they may either be disassembled or assembled according to the need.



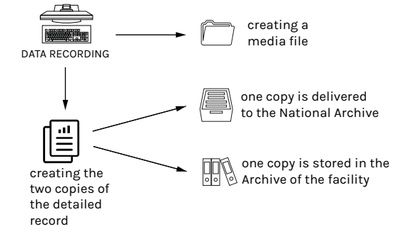
CONSTRUCTING THE MEMORY OF THE SITE

The surveillance phase of the radioactive waste repository will last for at least 250 years and this period exceeds human lifetime. For this reason, it is needed to be developed a method to ensure that the memory of the site is preserved as long as possible,in a format that can be easily accessed, understood and used by everyone and passed down to future generations. Therefore, the information must be conserved as a scripture in the most appropriate maintenance conditions and in a suitable place.

The language and symbolism used must be identified and comprehensible for the purpose, also long-term markers must be developed. Accordingly, it is evolved a generic system based partly on technical and regulatory information and partly on involving local residents in ensuring that this memory is passed on through the generations.

THE FLOW OF THE WASTE DOCUMENTATION

When the conditioned waste arrives to the disposal facility, it is first identified by a bar code. The information relating to the waste is recorded so as to make possible the traceability of the product once stored. All the data relating to the radioactive waste in the center will be part of the memory to be transmitted to next generations.



The data contained in the Archive will be updated not only during the operational phase of the repository, but also during the surveillance phase every five years and then ten years.

DETAILED RECORDS

more that 11,000 documents

approximately 500.000 pages

taking up a space measuring just over 60 linear metres

covering all the phases in the life of facility

a complementary set of surveillance data in every 5 years.

two copies on 'permanent paper'; one is for the National Archives, the second, identical copy, is kept in the Archive of the disposal facility.

PERMANENT PAPER

It respects the ISO 9706 and 11108 standard which guarantees chemical and physical stability of the paper for long periods of time.

The detailed records are technical documents to preserve the memory of all the phases of the disposal facility. It is intended to inform the professionals and the next generation of professionals; so that they can make decisions about the fate of the site in the future.

BRIEF REPORTS

summary of the key information about the disposal facility, such as;
_the facility's design,
_how it is operated,
_how the waste is contained,
_the repository area,
_the risks that may last for more than 300 years.

the report comes in three formats, presented in the form of reference sheets; each produced using different level of information;
_the basic information file for a mainstream reader,
_the key information file, going up a level with more detailed information,
_the technical data, the final level of the information.

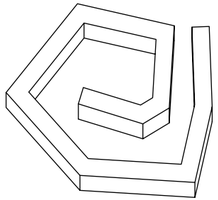
has the main purpose of warning against the risks of intrusion into a potentially dangerous site.

The brief reports are regulatory documents, aimed to be as widely accessible as possible. It is a resume of the key information about the disposal facility that needs to be passed on to future generations and to remind them of the very existence of the facility and the risks.
It is intended to distribute the reports, firstly to the local residents of the area then at international level.

TACTICS

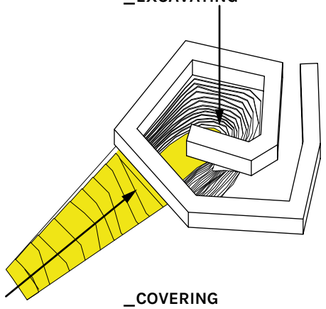
FORMAL LAYOUT

_FILLING



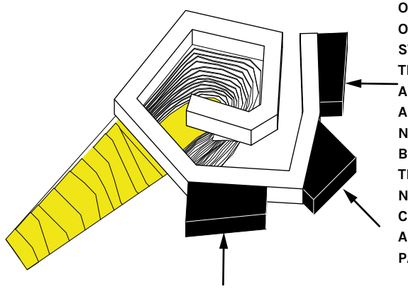
SPIRAL : AS A GROWING FIGURE; IT REFERS TO THE ACCUMULATION; SO THAT ALL THE ARCHIVE IS INSERTED TO THE MASONRY SPIRAL FORM; AS AN ACCUMULATION OF MEMORY.

_EXCAVATING



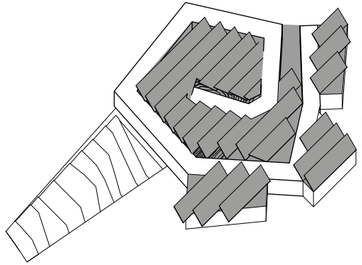
ESCAVATED LANDSCAPE DEFINES THE PUBLIC AREA; THE VISITORS GO DOWN TO THE SPIRAL; IN THIS WAY, WHILE THE PUBLIC CAN EXPERINCE BEING INSIDE OF A SPIRAL; SURROUNDED BY MASONRY ARCHIVE WALLS, THEY CANNOT REACH TO THE PRIVATE ARCHIVE AREA.

_ATTACHING



ATTACHING THE STAFF OFFICES AS PARASITES OF THIS MASONRY STRUCTURE REFERS TO THAT THESE NEW ADDED STRUCTURES ARE NOT THE PERMA-NENT ONES. THEY CAN BE DISASSEMBLED IN TIME, IF THERE IS NO NEED. THEREFORE, DRY CONSTRUCTION IS APPLIED TO THESE PARASITES.

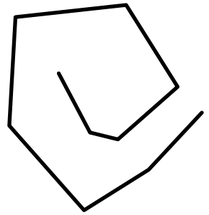
_COVERING



IT IS PLACED A SAWTOOTH CANOPY ON THE TOP OF EXCAVATED AREA AND PARASITES; WHILE A FLAT TRANSLUSCENT ROOF IS APPLIED ON THE TOP OF SPIRAL ARCHIVE. IT ALLOWS TO DIFFERENTI-ATE THE PERMANENT ONE AND SHORT-TERM ONES.

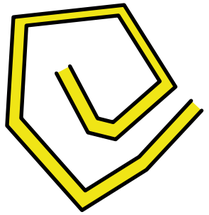
ORGANIZATIONAL LAYOUT

_THE SPIRAL



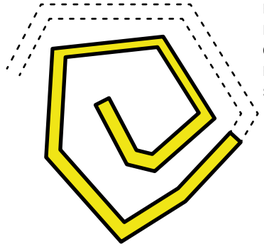
SPIRAL : AS A GROWING FIGURE; IT CAN GROW EVERMORE;IN THIS CASE IT REFERS TO THE ACCUMULATION; AS FAR AS THE LIVING-BEINGS EXIST, THE WASTE WILL GROW, THE MEMORY WILL GROW, THE INFORMATION WILL GROW.

_COUPLING



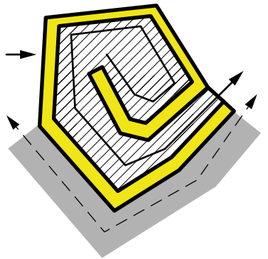
COUPLING THE SPIRAL ALLOWS TO HOST THE ACCUMULATED ONES; SO THAT THE WASTE AND MEMORY CAN BE INSERTED INTO A SPIRAL. THIS TIME, THE SPIRAL HOUSES THE ARCHIVE; THE REPOSI-TORY OF INFORMATION.

_EXTENDING



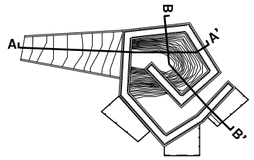
A SPIRAL CAN EXTEND FOREVER; SO IF THERE IS A NEED, THE ARCHIVE CAN POSSIBLY GROW BY EXTENSION OF THE SPIRAL.

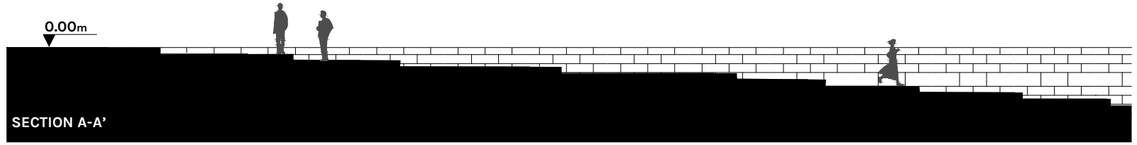
_PLACING



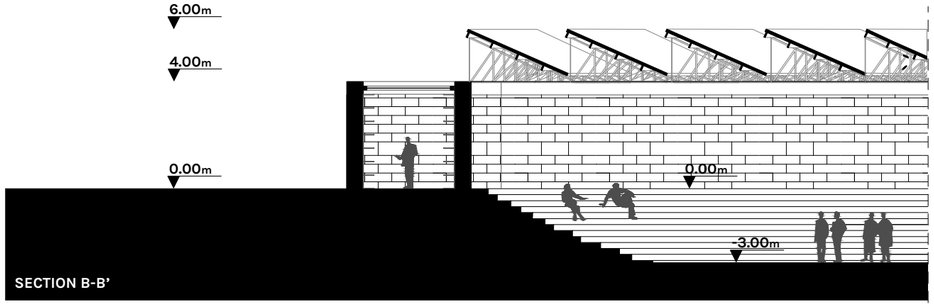
WHILE THE ACHIVE IS PLACED IN THE SPIRAL SCHEME; INSIDE OF THE SPIRAL WELCOMES THE PUBLIC AND OUTSIDE OF THE SPIRAL ALLOWS TO ATTACH THE STAFF OFFICES. THEREFORE, THE FLOW OF PUBLIC AND STAFF WILL NEVER INTERRUPTED BY EACH OTHER.

1/200 SECTIONS





SECTION A-A'



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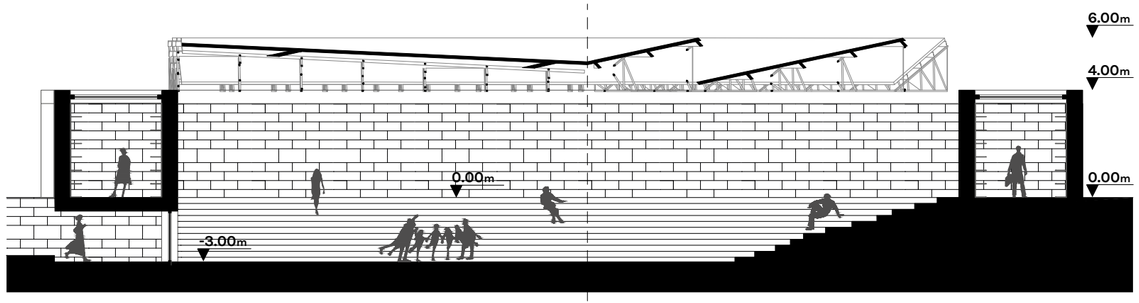
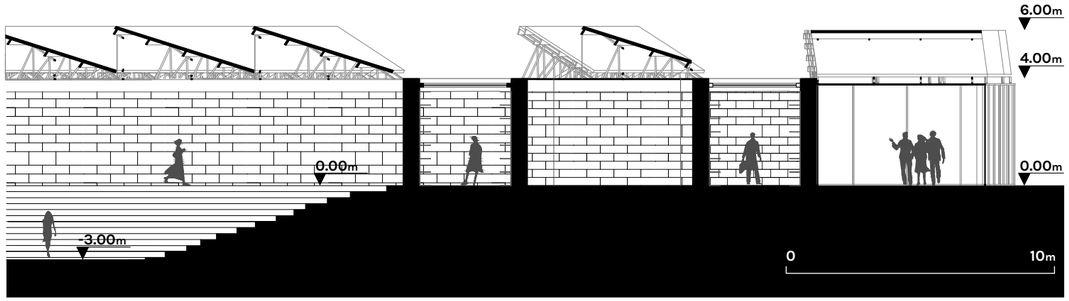
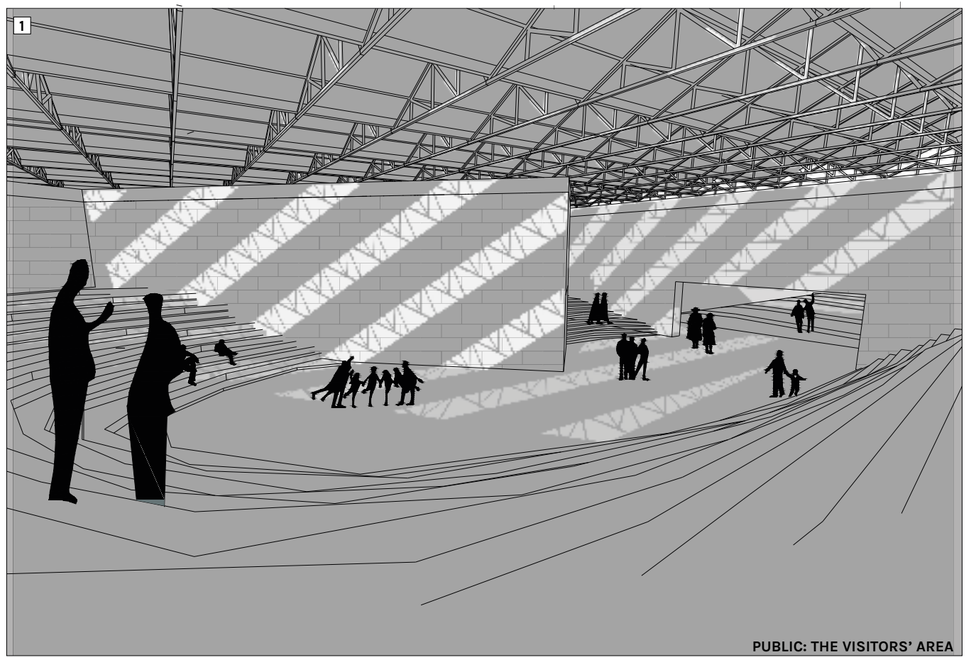
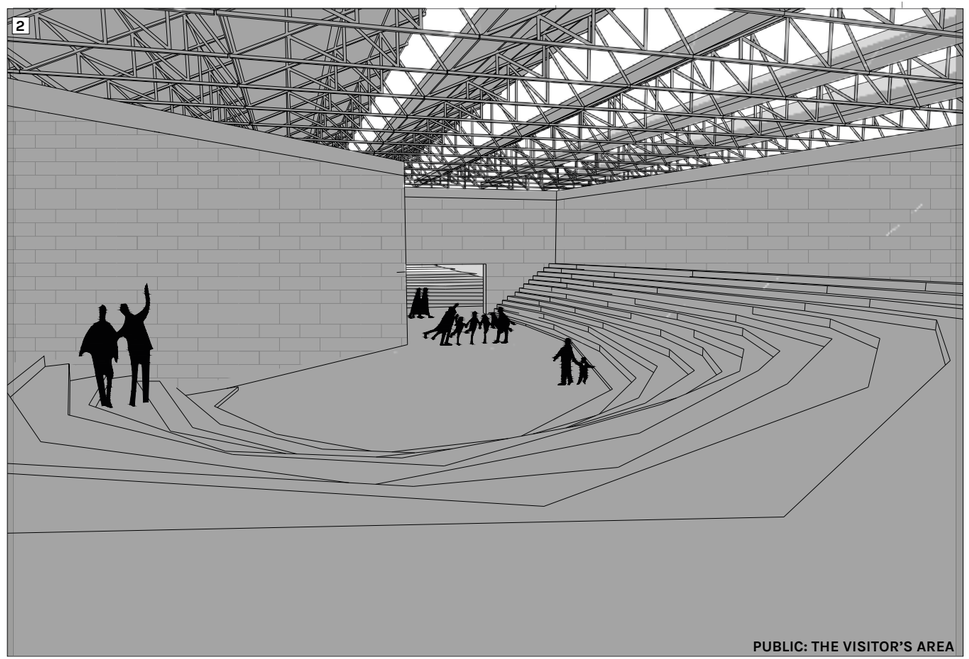




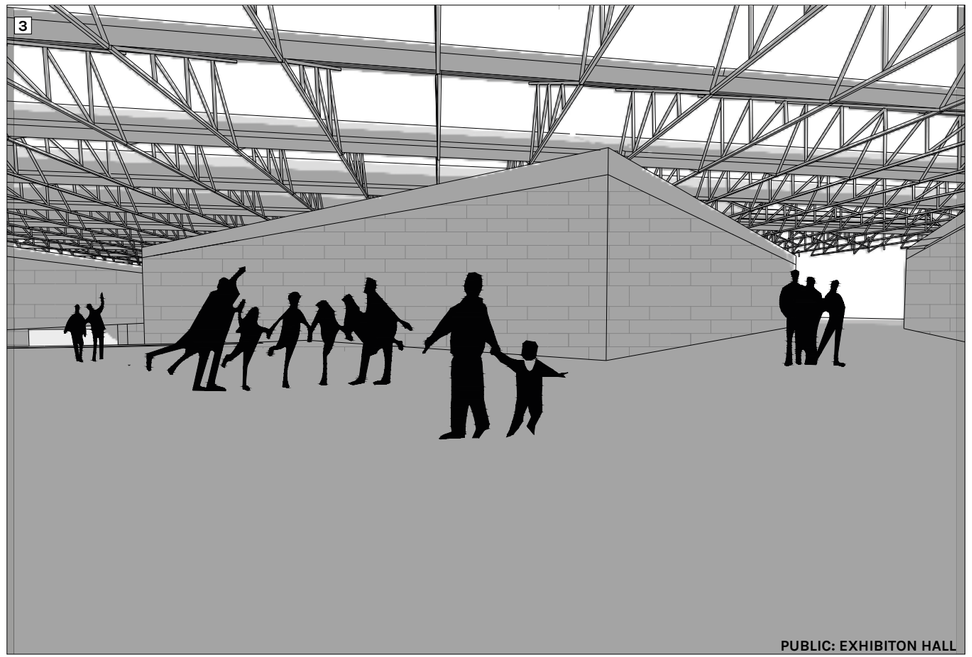

1,2
3
4
1,2


1
PUBLIC: THE VISITORS' AREA

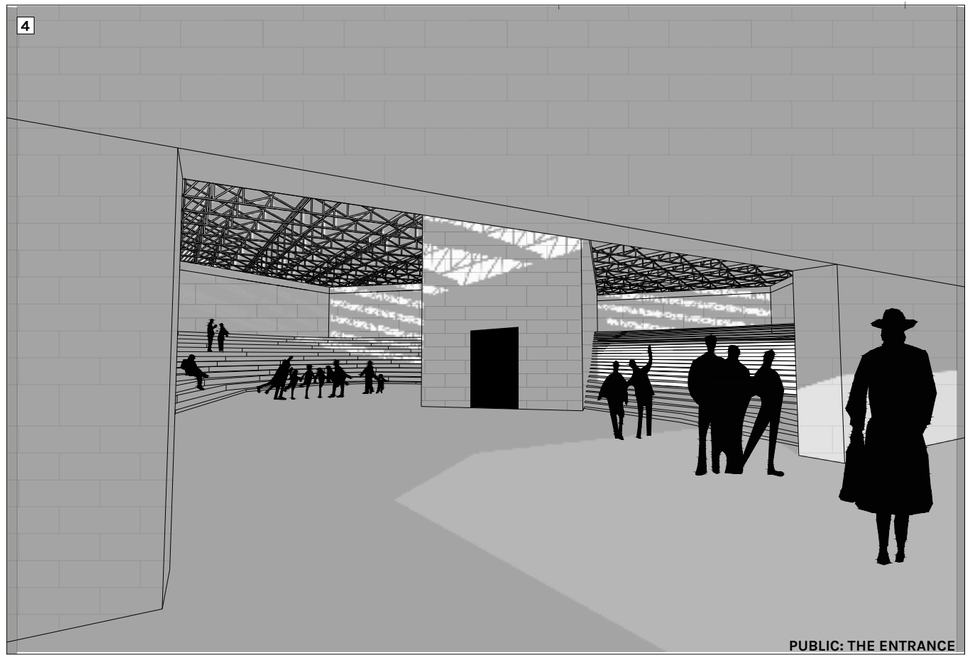

1,2
3
4
1,2


2
PUBLIC: THE VISITOR'S AREA


1,2
3
4
1,2


3
PUBLIC: EXHIBITON HALL


1,2
3
4
1,2


4
PUBLIC: THE ENTRANCE

THE PILGRIMAGE PROGRESS

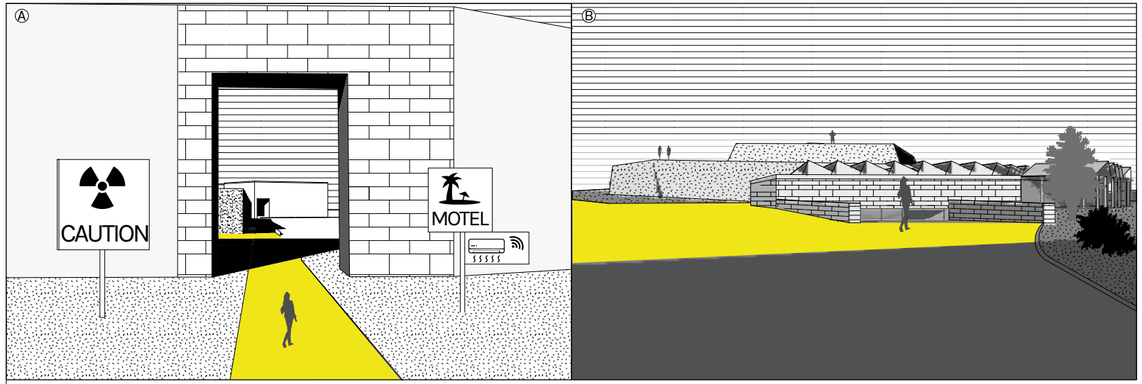
MAIN ENTRANCE

THE SQUARE, BEGINNING OF THE RITUAL

BASE POINT OF THE EARTH HEAP

PRE-LIMINAL RITE

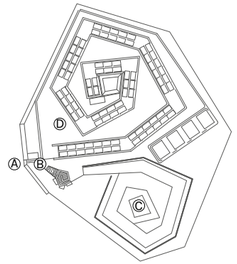
LIMINAL RITE



THE PEAK POINT OF THE HEAP

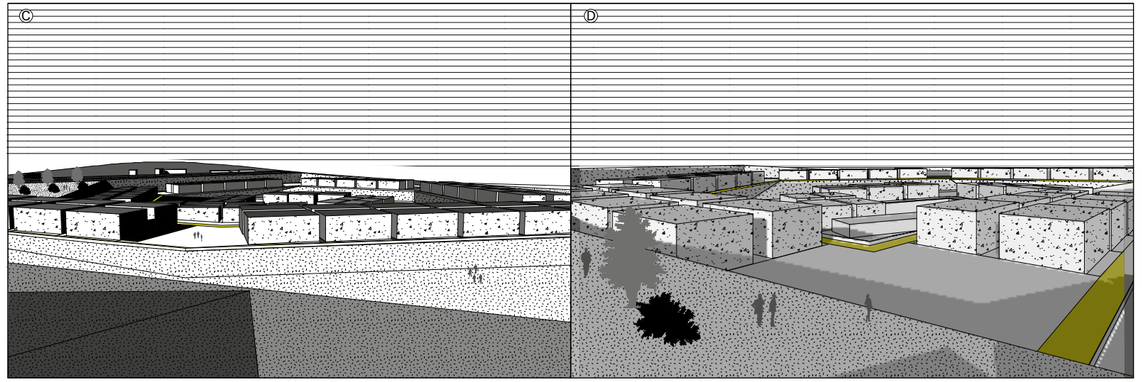
THE RETURN

THE SPOTING STOP



LIMINAL RITE

POST-LIMINAL RITE



05 THE TRACES; 300 YEARS

THE TRACES

In every period of humanity, mankind always instinctively wanted to pass down a memory from himself, a testimony of his existence, an inheritance from his living from ancient times until now, and this instinct will surely continue as long as the human-being exists . Cave paintings, ancient civilisations, ancient architecture and monuments, the enduring scriptures, Medieval Age, Renaissance, The Age of Enlightenment, The Modern Period, The Post-Modern Period and accordingly their understanding of art and architecture, so on and so forth, all of these indicate that human aspires to extend to the eternity no matter which period is that.

However, today's world has its own specific concerns that shape today's understanding of art and architecture so that traces. Now, we are in an era which we face with the contamination, climate change, global warming, ozone depletion, increasing radiation level, as well as a rapid fluctuation generating many abandoned spaces, wastelands, ruins and residuals; a rapid consumption of the sources and products therefore industrial mass production and consequently an increasing waste. As Rem Koolhaas mentioned "Junkspace will be our tomb. Half of mankind pollutes to produce , the other pollutes to consume". Accordingly, it can be said that we are in the period in which we actually must condition our waste, and if we cannot, dispose it in the most efficient and secure way. Because the waste do not dissolve or evaporate, like Timothy Morton says in his book Hyperobjects "When we flush the toilet, we imagine that the U-bend takes the waste away into some ontologically alien realm. Ecology is now beginning to tell us about something very different: a flattened world without ontological U-bends. A world in which there is no 'away'."

The waste is now becoming a challenge for every one in every kind of scenario. For that reason, it should not be surprising to refer that the traces which the people living in 21th centruy and beyond, will pass down can be formed/generated out of waste. For instance, nuclear waste requires minimum duration of three centuries up to hundreds to decay its radioactiviy, so that the nuclear waste repositories, both surface and geological, and their markers surely will become one the artifacts in future with the gigantic and designed landscapes.

In other words, these environmental sculptures may evoke the similar feelings on the next generation, just as the impact of Giza Pyramids on us today.

Operating a nuclear waste repository is a complex process. If it is a surface repository, as it is studied in this thesis project, after burying the nuclear waste cells, the surveillance phase starts and it proceeds until the 300 years is completed. When we consider the very rapid technological, social and cultural evolution of the last three hundred years, certainly various alterations would take place over time.

In the proposed nuclear waste disposal facility, comprised of the trinity of repository, earth heap and archive, also, the motel and the research center, a few elements will disappear or modified in the continuum such as the artificial hill will be used for covering the nuclear waste coffins after 40 years of operation, or two facility building, the motel and research center can be either modified according to the new use or diassembled. In every case, the repository and archive will endure at least 350 years by rendering a colossal, sculptural mound and the monument, placed next to it, within other territorial traces of the elements, not existing anymore. Accordingly, the archive is constructed as an architectural artefact to keep informed and updated the next generations about the entity of nuclear waste disposal area in the process of 350 years , so that the archive can be perceived as a library and school of this nuclear waste disposal monastery. However, if we consider that just 250 years have passed since the publication of the first Encyclopedie and now the world is getting prepared to send human explorers to the Mars. In this perspective, we understand that the design of a nuclear waste repository must cope with the evolution of conditions which cannot be degraded to a proposal. Thereby, even if the archive is capable of preserving human knowledge for the centuries to come, still this gigantic, manmade landscape inevitably will evoke the fear, curiosity and adoration.

THE TRACES

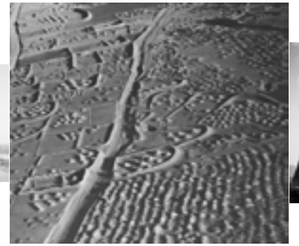
Gobekli Tepe,
pre 10th millennium BC
Sanlıurfa, Turkey

Alignements de Carnac,
5000-3000 BC
Carnac, France

West Kenneth Long Barrow,
3670-3635 BC
Avebury, England

Stonehenge
3000 BC
Salisbury, England

Giza Pyramid Complex
Cairo, Egypt

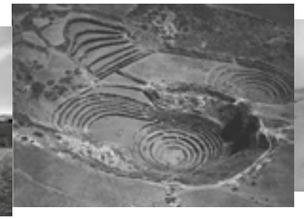


The aerial view of
cemeteries near Lanchow,
China

Cooling Tower,
patented by Frederik van Iterson
and Gerard Kuypers, 1918

Cactus Dome, 1970s
Marshall Islands, Pacific Ocean

Silbury Hill,
2400-2300 BC
Avebury, England



The amphitheaters of
Muyu-Uray between
Cuzco-Machu Picchu, Peru

Xiaohe Cemetery,
2000 BC
Xinjiang, China

Necropolis Banditaccia
900-300 BC
Cerveteri, Italy

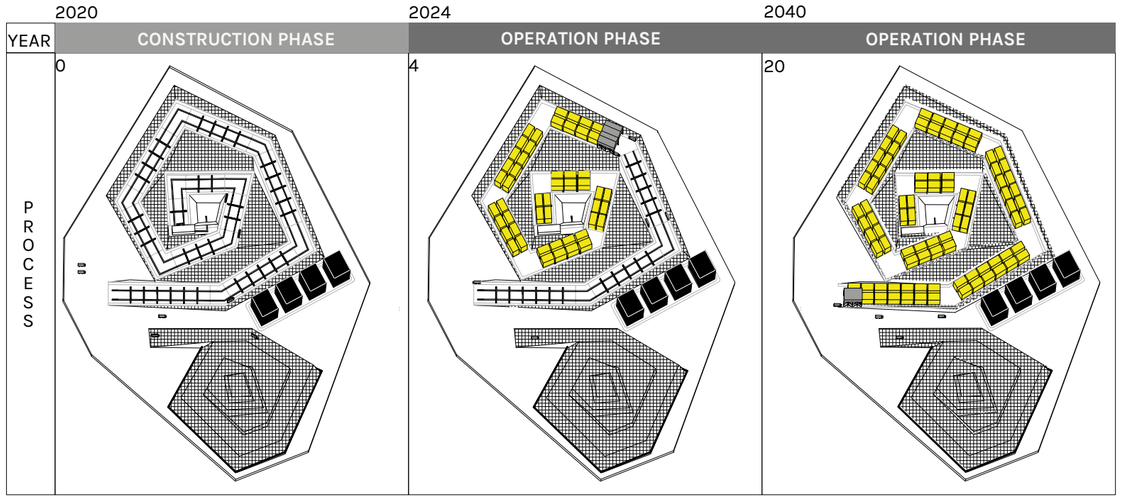
Robert Smithson, Spiral Jetty, 1970
Utah, USA

Robert Morris, Observatory, 1977
Flevoland, Netherlands

Richard Serra, Sea Level,
1989-1996
Zeewolde, Netherlands

Gilles Clément, Parc Matisse,
1990
Lille, France

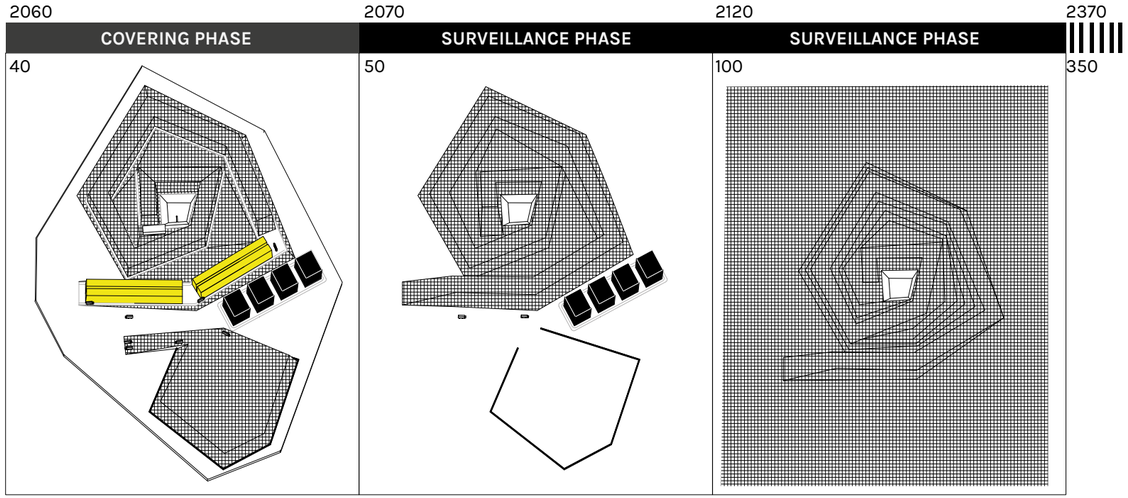
LIFE CYCLE OF THE NATIONAL REPOSITORY OF NUCLEAR WASTE



-The earth is dug
-The canyon-like repository and earth heap are formed,
-Water drainage system is constructed.

-50 nuclear waste cells are inserted and cemented,
-Water drainage system works as a basin.

-90 nuclear waste cells are inserted and cemented,
-Operation Phase is completed.



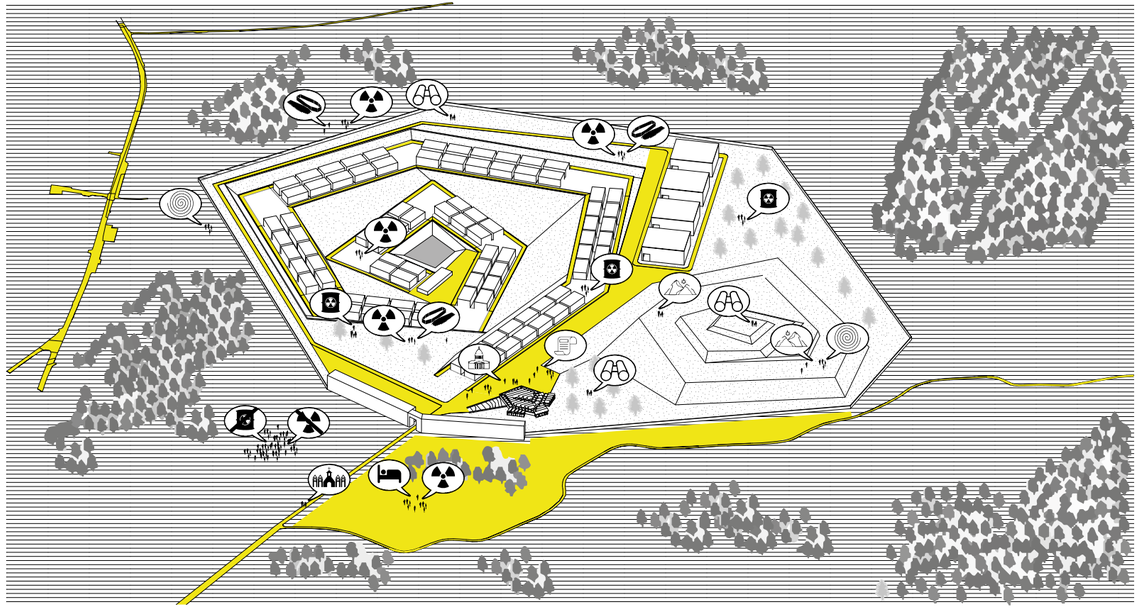
-The Cap is constructed,
-The earth heap is being used for burying the waste,
-The permanent cover is built.
-Covering Phase is completed.

-Now, the waste ground is being monitored,
-The high-activity waste storages are being discharged,
-The fences are disassembled.

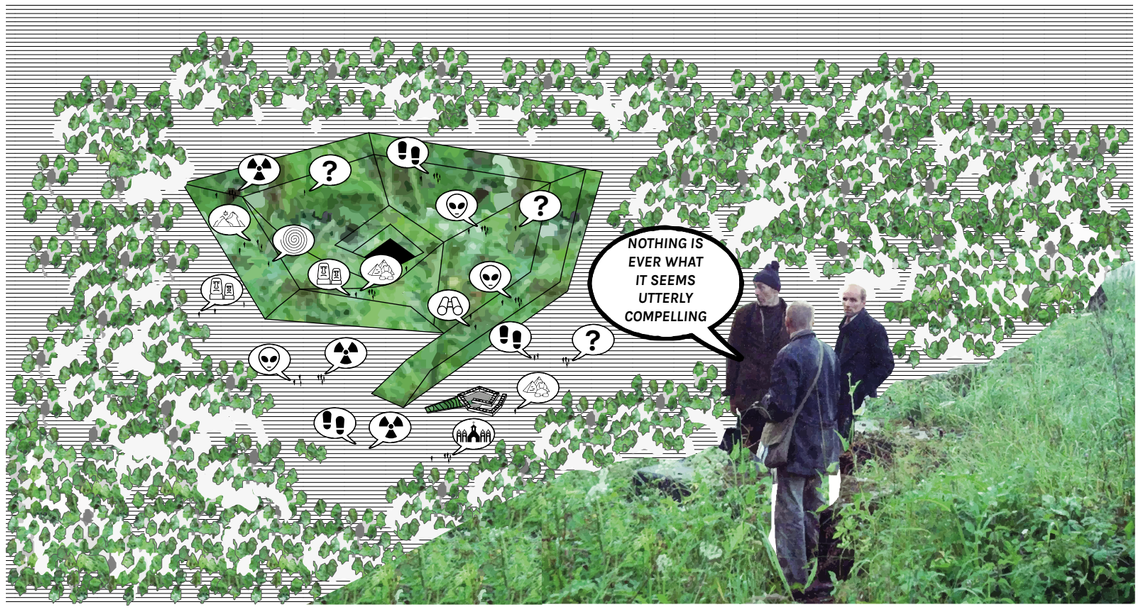
-The waste ground is melting into the nature,
-Yet, there is the trace of artifact.
-300 years of surveillance phase is going to end in 2370.

MONITORING THE "THING"

IN 2060



IN 2370



CONCLUSION

This thesis was based on a study for designing a near-surface nuclear waste repository with a technological park in Levone, Italy and according to Italian regulations. While, low and medium activity radioactive waste is kept in the repository permanently for 300 years; high activity radioactive waste is stored in higly equipped storages, temporarily for 50 years. Also, the technological park requires a research center and archive. The project site is designated according to the technical guide for localisation of ISPRA, L'Istituto Superiore per la Protezione e la Ricerca Ambientale.

The aspects of nuclear waste disposal process such as large scale of time, being fearful and evocatory, bigness of the nuclear waste repository, landscape and the issue of accumulation were the key points of this thesis. The repository requires 90 concrete nuclear waste cells, 27x15,5x10m each, for low and medium activity ; and 4 storage buildings for high activity radioactive waste. The nuclear waste disposal process involves 4 phases; Construction Phase (0-4 years), Operation Phase (40 years), Covering Phase (10 years), and the Surveillance Phase (300 years). Each phase has its own procedure. Not every structure of this complex must be preserved until the very end. Yet, the disposal area and archive are the ones that have to be maintained and monitored for at least three centuries. So what is indeed like, they are the ones where the nuclear waste and memory is accumulated. Therefore, if the disposal area is called as repository of waste; the archive is a repository of information, as well. The process relies on how much nuclear waste is stored, that much information and memory is archived. This ritualistic condition gave the idea of organising masterplan in a ceremonial sequence, like a procession. Accordingly, the visitors can become a part of this ritual as atomic monks who spreads the information and construct a public memory.

The project is organised in three stages; outside-out, outside-in, inside-in. Therefore it follows from the general layout of masterplan, to nuclear waste repository , finally to the archive. The masterplan is studied as a ceremonial path in which the atomic monks reach to the sanctum; the nuclear waste repository at the end. The accumulation of waste, information and earth (in the beginning) allows to conceive and apply the spiral form as the typology of growing figures to the repository, archive and earth heap.

Consequently, while the nonsacred structures (the research center, administration and motel) establishing the threshold between the profane and sacred area; the trinity of spiral forms the narrative of the entire process of nuclear waste disposal.

In the first 50 years, three spirals welcome the visitors; the inward spiral for the nuclear waste disposal; the outward spiral for its earth heap that later, will be used for covering the cells; and the spiral scheme for the archive that allows the articulation of possible growth in the next years. After covering phase, there will be a canyon-like spiral for hosting the buried nuclear coffins and the archive as a dynamic spiral form that can be grown or reduced according to the need of memory accumulation. In the next 300 years, it is conceived that the canyon-like repository will melt into the landscape and be captured by nature; while the archive will be still enduring and storing the holy scripture.

ACKNOWLEDGEMENT

Firstly, I would like to thank to my mentor, Professor Giovanni Corbellini, for encouraging me all the time to go forward, to read and to expand my vision; for making me passionate about the topic; also for his excellent guidance during the thesis period, for his extraordinary lectures, patience, availability, and knowledge; and for having worked together with me to achieve this outcome.

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And finally, thanks to my beloved parents and sister for their support and patience all the time; for always being there when I need.

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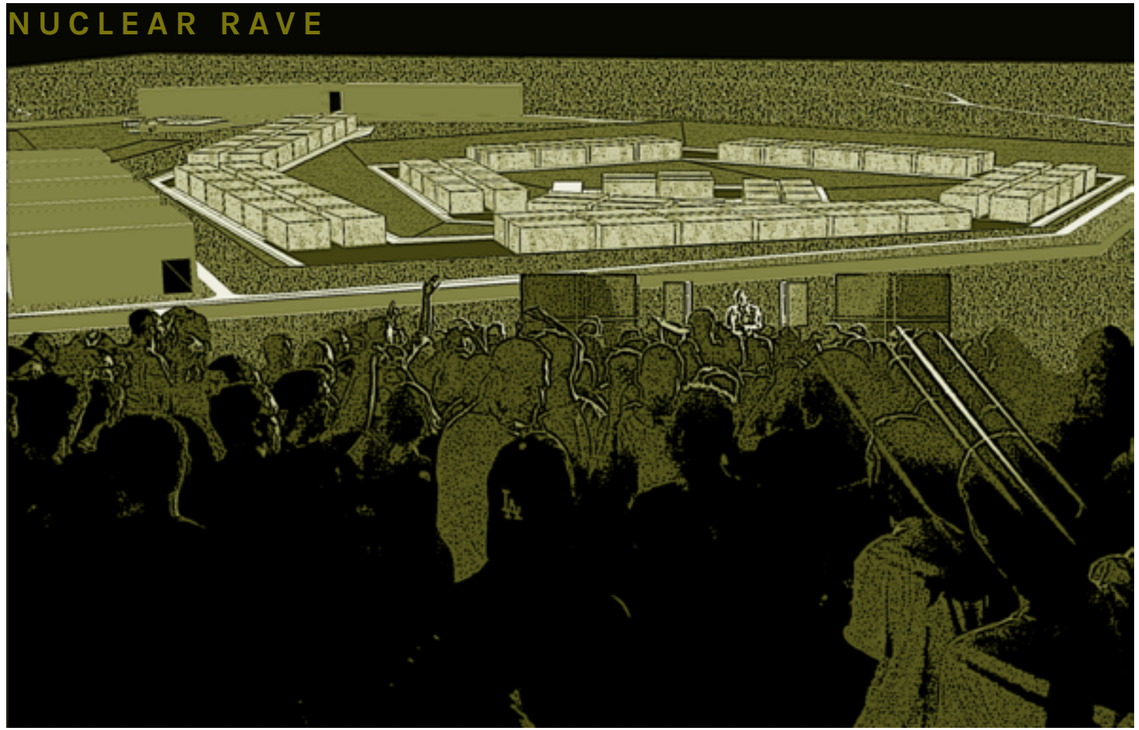

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