LOW LEVEL RADIOACTIVE WASTE DISPOSAL IN KOZLODUY NPP IN BULGARIA

V. STANCHEV
Radioactive Waste Treatment Department,
Kozloduy NPP, Bulgaria

Abstract

Kozloduy NPP is the biggest power plant in the Republic of Bulgaria. It is in operation since 1974 and for the past 25 years it has generated over 263 billion kW·h electric power. The NPP share in the total electric production in 1998 was about 50%. It has six units in operation — four WWER 440 B-230 and two WWER 1000 B-320. In the nuclear reactor operation the generation of radioactive waste (RAW) is an inevitable process. The waste must be conditioned, stored and disposed of in a safe manner. There are no national radioactive waste disposal facilities, for waste generated by an NPP, in Bulgaria to the moment. This situation necessitates the storage of operational RAW to be carried out on site for a long period of time (30 to 50 years). Following the principle for protection of human health and environment now and in the future [1], Kozloduy NPP adopted the concept for conditioning the RAW to a stable solid form and placing the waste in a package which should keep its features for a sufficiently long term so that the package can be safely transported to the disposal site.

1. TREATMENT METHOD

The treatment method comprises:

- Compaction of solid RAW,
- Solidification of liquid RAW,
- Packaging of compacted and cemented RAW in a reinforced concrete container.

It is expected the compacted RAW to be poured with a cemented mixture; also it is assumed that their immobilizing in a cemented matrix is an additional barrier.

2. METHOD OF STORAGE

The safe storage of RAW is achieved by combination of several barriers between the radionuclides and the environment. Kozloduy NPP has chosen the following combination:

(a) Natural barriers
- engineering construction site with suitable geological, hydra-geological, morphology and other characteristics;

(b) Engineering barriers
- matrix with average physical and mechanical indices;
- package (container) with very high strength indices and shielding level; storage facility of high resistance level against ambient impacts and a lifetime term of over 30 years.

Appropriate operational procedures and constant site and environmental monitoring supplement the design safety measures.

3. SITE CHARACTERISTICS

The place for storage facility construction is located on the guarded site of the NPP.

3.1. Main geologic characteristics

The facility site is located on the second non flooding terrace of the Danube river having altitude of 35 m, 4 km to the south of the Danube river midstream [2].

The geologic structure is of Pliocene and Quaternary materials. The total depth of the Pliocene is 100 m.

The maximum level of the underground water is at level 29 m [3].

3.2. Main climatic and meteorological data

The site region is of continental climate. The average annual air temperature is +15°C.
The absolute maximum air temperature is +43.3°C. The absolute minimum air temperature is 6.6°C. The average wind speed is 1.9 to 2.0 m/s.

3.3. Experimental natural phenomena

The probability for tornado is estimated to 9.177×10^{-6}

The current analysis define specified for the site earthquake of 0.2 g intensity.

The latest studies [4] specify that if dam wall breakage occurs ("Zelezni Vrata" dam) would appear a wave which will not be dangerous for the site. The maximum river level in this case would be 31.4 m, which is lower than the maximum river level in natural conditions.

3.4. Human activities

The general conclusion following several studies [5, 6] is that there are no sites and objects in 30 km range that are a potential danger.

3.5. Evaluation of the radionuclides migration with the underground water

The main pathway of the radionuclides existence at the conditioned low level RAW for storage is through the surface and underground water. The only method of limiting the environment contamination, if having leaks of radioactive liquid from the engineering facility, is the choosing of geologic structures, ensuring low speed of radionuclides spreading.

The data from the study [7] specifies that the horizontal spreading would be performed by the alluvial water level. The spreading is performed in two phases:

- Spreading from the surface to the water level;
- Horizontal spreading to the water level.

The average speed of a vertical spreading of ^{90}Sr (which is 3 to 30 times more movable from Cs) is 0.3 to 1.8 cm/y for the geologic site structure. The radionuclides would have reached the level of underground water after 350 ÷ 400 years and more from the moment of their release. The conservative evaluation of the horizontal spreading indicates that a circular area of 1000 m radius contaminated with ^{90}Sr would have appeared after about 150 years, the concentration would have been 2.6%, compared to the initial one. The contaminated area radius, if it is of ^{137}Cs, would have been by the factor of 2 smaller, and the concentration not higher than 0.1%, compared to the initial one.

4. MATRIX CHARACTERISTICS

The cemented matrix meets the requirements of OH 0185871-92:

- Compression strength — not less than 3.5 Mpa,
- Resistance to thermal cycles,
- Microbiology resistance,
- Absence of free water,
- Radionuclides' leachability — less than 1.0×10^{-3} g/cm^2/day,
- Homogeneity.

It is considered that this ensures the matrix integrity and the decaying of some organic materials in the matrix would lead to forming calcium salts, which are not soluble and would exercise favorable influence.

The compacted solid RAW meet the OH 0285869-92 requirements. According to the carried out analysis of the compacted drums mass in the container, about 60 g gases can be generated annually. The cement matrix and the concrete have sufficient gas permeability, thus the gases shall pass into the atmosphere without breaking mechanically the matrix and the container.

5. CONTAINER

The container is a reinforced concrete structure with cubic form. Its net volume is 5 m^3 and the gross volume is 7.41 m^3. The wall thickness is 14 cm at the base and 10 cm at the top. The container closes with a lid of 8 cm thickness. The mass of an empty container is 6 t and full is 20 t.

The container allows storage of 0.1 TBq (2.7 Ci) activity. The requirements to the container are specified in the OH 0185755-92 regulation. To be proved the requirements to the container at licensing the container has passed a test program for corrosion resistance, concrete resistance to thermal cycles, reagents and microorganisms, water tightness, compression resistance, seismic resistance, drop test, fire resistance test, and determination of radiation protection level.

The container meets the requirements for transport package type IP-III, according to IAEA Safety Series No 6 [8].

6. STORAGE FACILITY DESCRIPTION

The storage facility is a premise of 72 m length and 37 m width. Adjacent to the storage facility is located the premise for control and management. The floor and the walls are of epoxy coating. The foundation slab is of 1 m thickness and is calculated to bear load of four rows containers by height.

Special attention is paid to the roof and foundation slab waterproof. Bridge cranes using remote control stack the containers. The exact positioning of cranes is performed by bench marks and TV system. The containers are stacked in two areas. Each can take 960 containers.

Drainage system for collection water in the storage facility is provided. The floor of the facility is above the site level and the access of surface and underground water is eliminated. Feedwater is not foreseen for the storage facility. Any water on the floor is collected by the drainage system and is led to an underground tank that is dug into the floor of the facility. Then it is pumped in a tanker-trailer and is transported to the treatment facility. This avoids the falling of water from the storage facility into the ground.

The storage facility ventilation is performed by a natural aeration. Heating and conditioning is not provided. Considering extreme environmental conditions emergency roof fans are provided.

Analysis of the burnable load is carried out. The conditioned RAW are non-burnable. Fire detection in the premises for remote control and supervision is provided.

The storage facility is located in the guarded NPP site to which trained personnel have access only. In addition, installation of signal-security system that avoids the access to the radioactive materials by people without special permission, is envisaged.

7. PERSONNEL HEALTH PHYSICS PROTECTION

During normal operation the outer and inner radiation exposure of the personnel is limited to a reasonably achievable level due to the remote control of the operations on the container stacking in the treatment facility.

The individual radiation control of the people working in the storage facility is performed by individual dosimeters and monitor for radioactive contamination of arms, feet and clothes. The gamma dose rate emission, the surface contamination and the radioactive aerosols are controlled in the storage facility.

Having the analysis of the possible aerosol and radioactive gases emissions the conclusion that they can be ignored because of the long term stay of the liquid RAW before treatment and the repeated thermal treatment in the process of conditioning can be made.

7. CONTROL AND MONITORING

The control of the stored RAW includes visual control for the absence of liquids in the storage facility and air analysis for absence of dangerous concentrations of poisonous gases and radioactive aerosols.

The environment radiation control personnel perform the monitoring of the storage facilities on routine basis. The concentration of artificial radionuclides in the underground water, air deposits, plants and soil is controlled.

The construction of six additional boreholes to control the underground water around the storage facility is envisaged.

REFERENCES

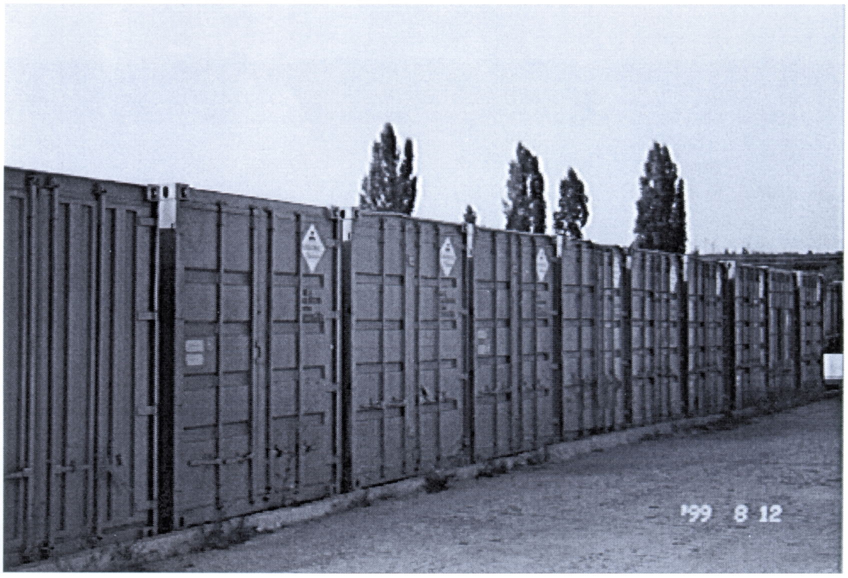
[1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Principles of Radioactive Waste Management, Safety Series No. 11-F, IAEA Vienna (1995).
[2] KOZLODUY NPP, Radioactive Waste Treatment Plant-Basic Design, Bulgaria (1994).
[3] REPORT, Mining-Geological Investigations, MGU, Bulgaria (1992).
[4] KOZLODUY NPP, Investigations and Activities for Site Safety Enhancement- Reassessment of Flooding Maximum Level, Part II, Sofia, Bulgaria (1993).
[5] KOZLODUY NPP, Investigations and Activities for Site Safety Enhancement — Analysis of the Information for Extreme Situation Sources, Sofia, Bulgaria (1993).
[6] KOZLODUY NPP, Investigations and Activities for Site Safety Enhancement — Subsidiary Analysis of the Risk for Kozloduy NPP from the Human Activity Outside the Plant, Sofia, Bulgaria (1992).
[7] KOZLODUY NPP, Investigations and Activities for Site Safety Enhancement-Study of the Possible Sources which can have an Adverse Effect on Kozloduy NPP Safety, Sofia, 1992
[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Requirements for the Safe Transport of Radioactive Materials, Safety Series No.6, IAEA, Vienna 1985).

Treatment Method

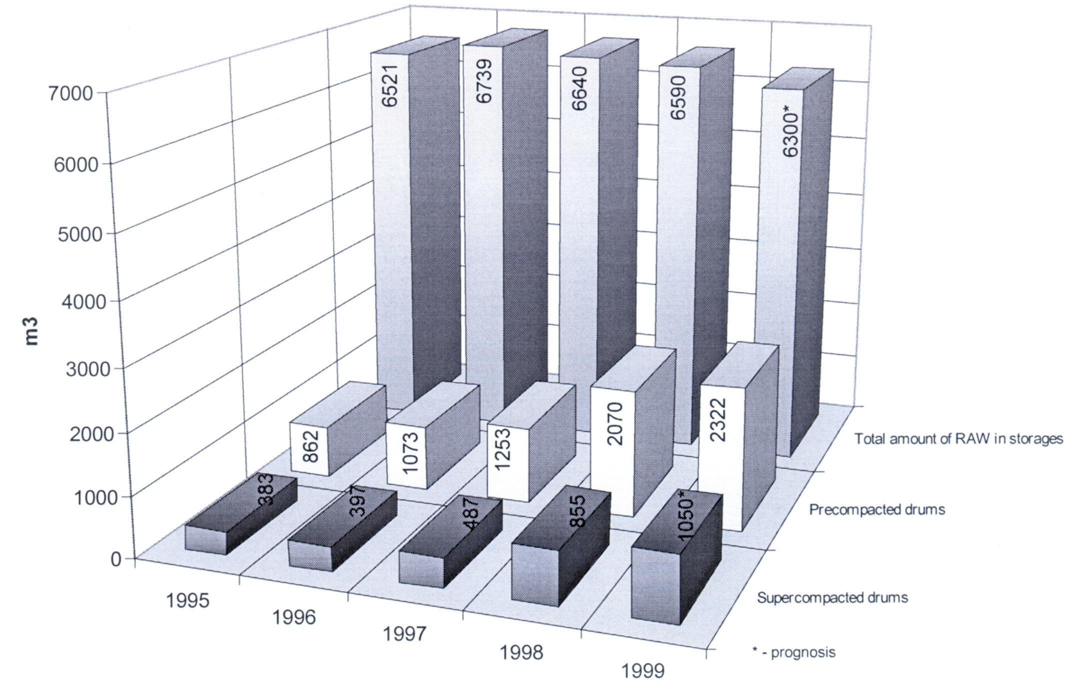
- Retrieval, Sorting
- Compaction
  - Precompaction - 50t. compactor
  - Supercompaction - 1000t. compactor

Solid RAW Storage

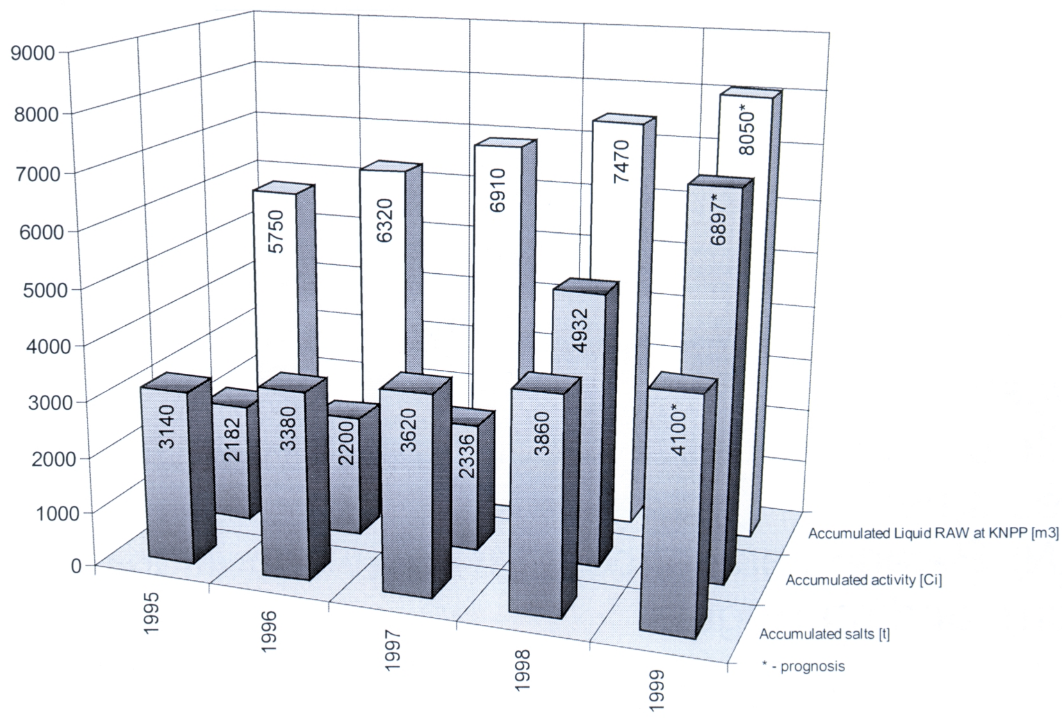
- In reinforced concrete silos
  - by 1990 non treated
  - since 1990
    precompacted and
    packaged in steel drums
    supercompacted (”pills”)
- In reinforced concrete containers
  - supercompacted (”pills”)
- In 40 ft. “Sea-land” containers
  Transient waste
  (0.3 < P_γ < 10μSv/h)



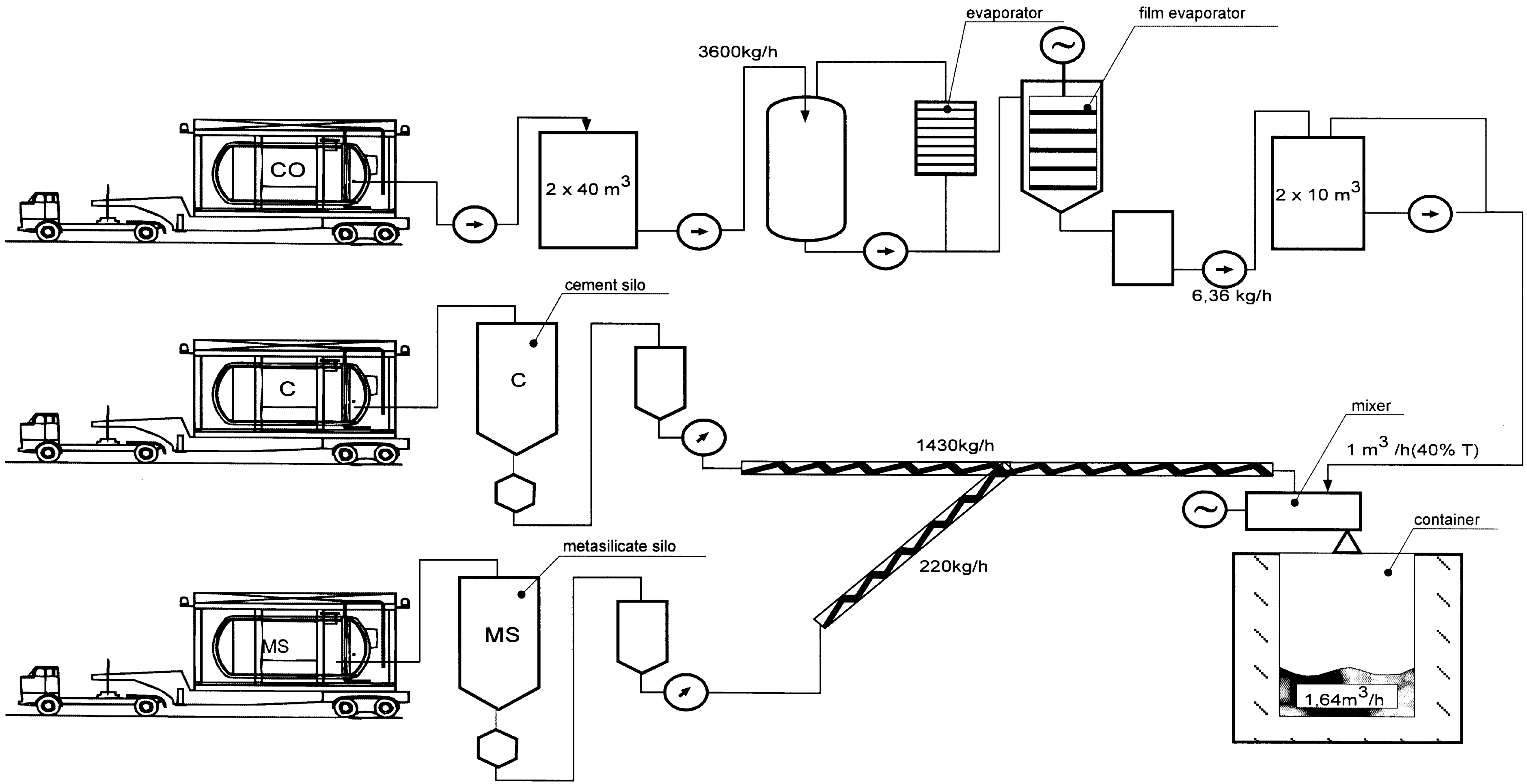
Accumulated Solid RAW by Years



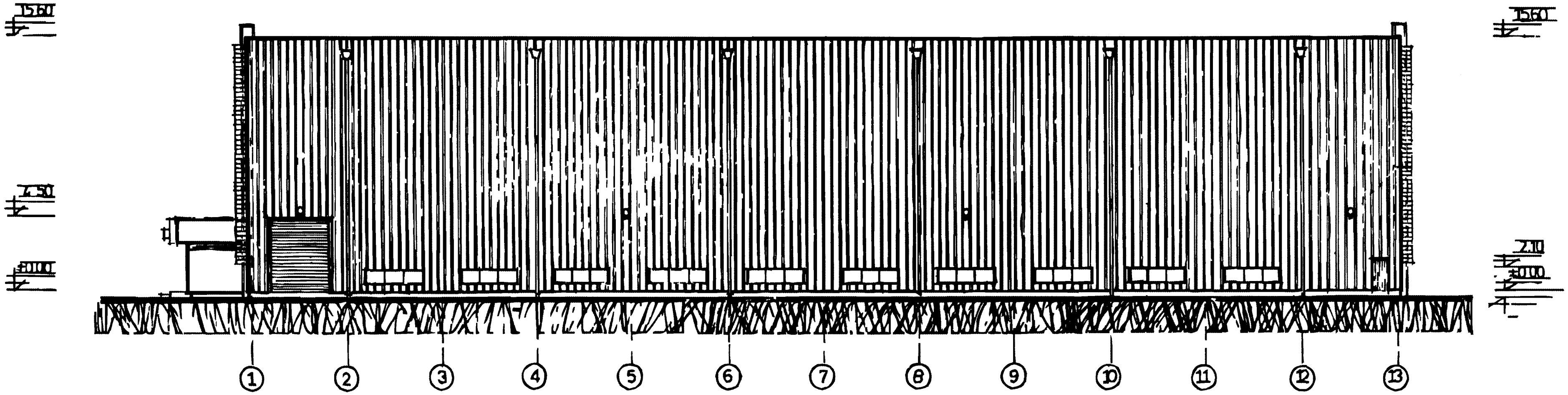
Accumulated Liquid RAW by Years

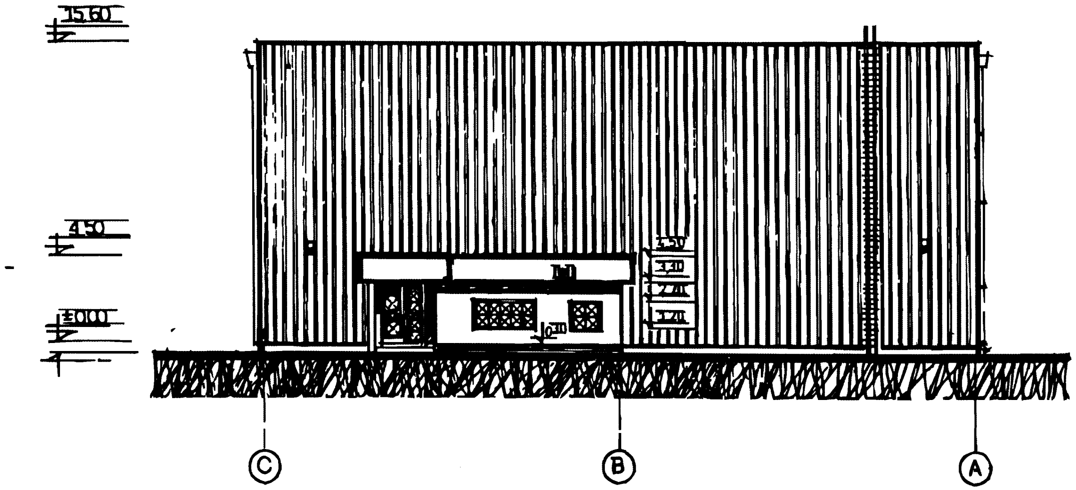


Liquid Waste Solidification System - Block Diagram

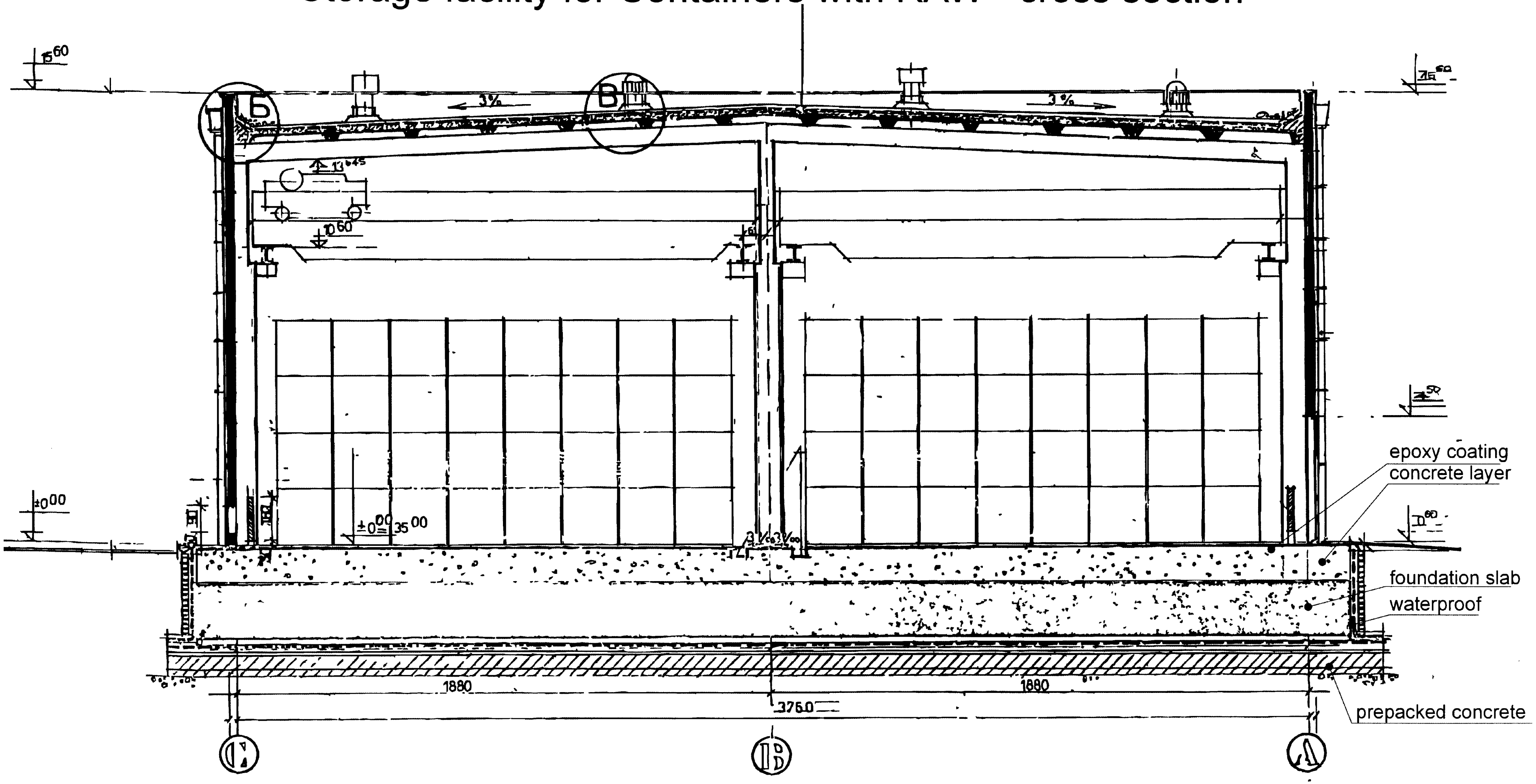


Storage facility for Containers with RAW

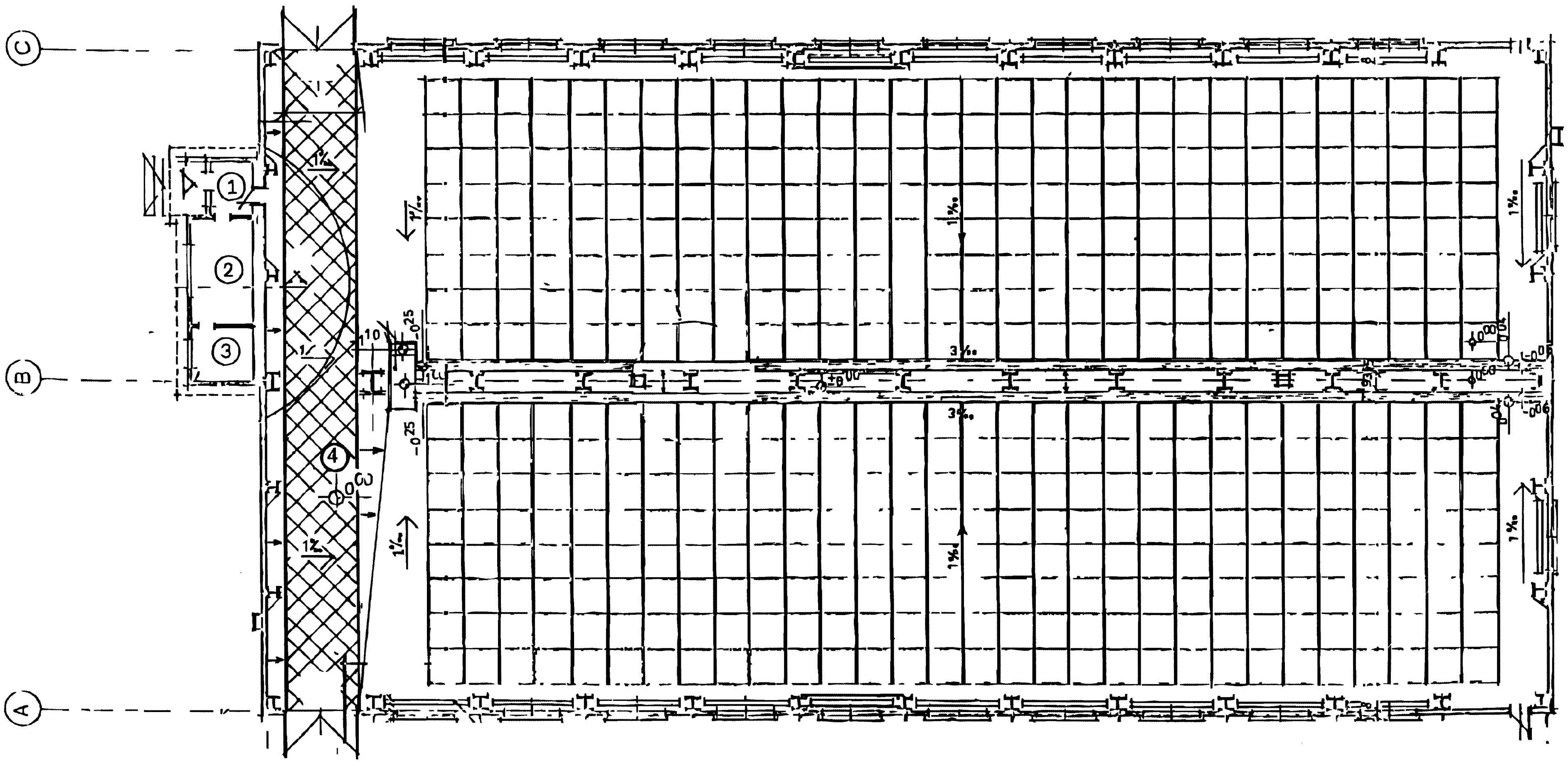




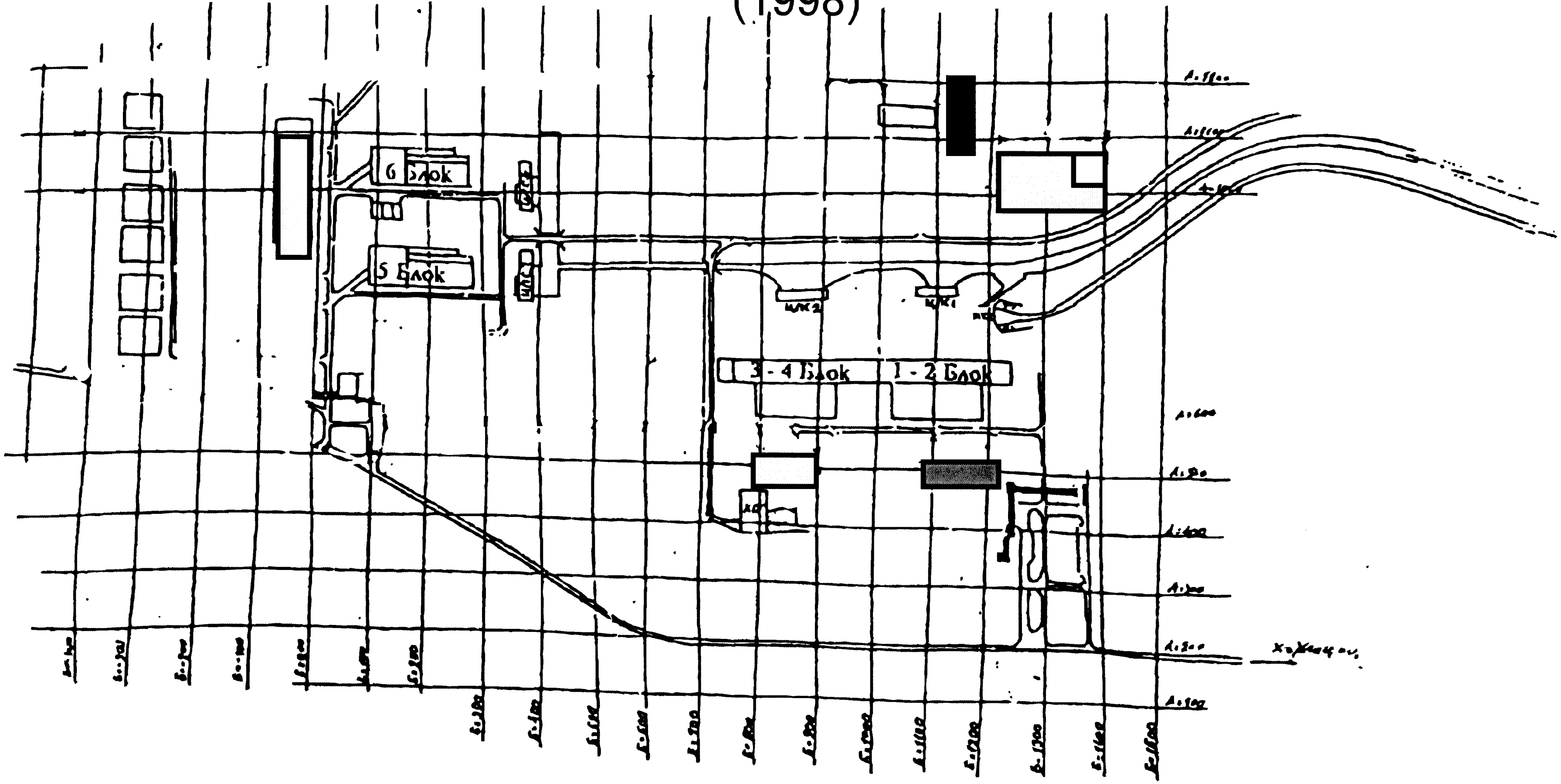
Storage facility for Containers with RAW - cross section



Storage Facility for Containers with RAW - chart

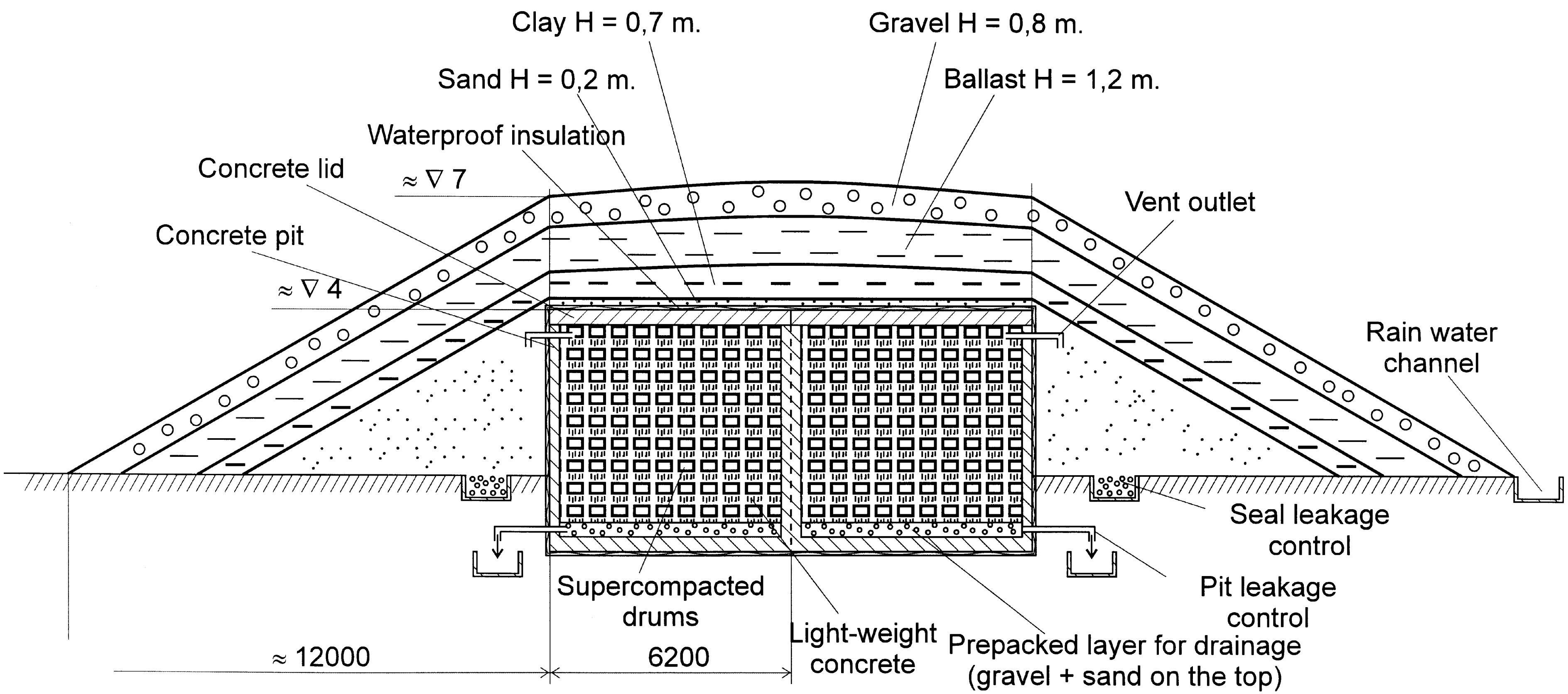


Solid RAW Storages at Kozloduy NPP (1998)

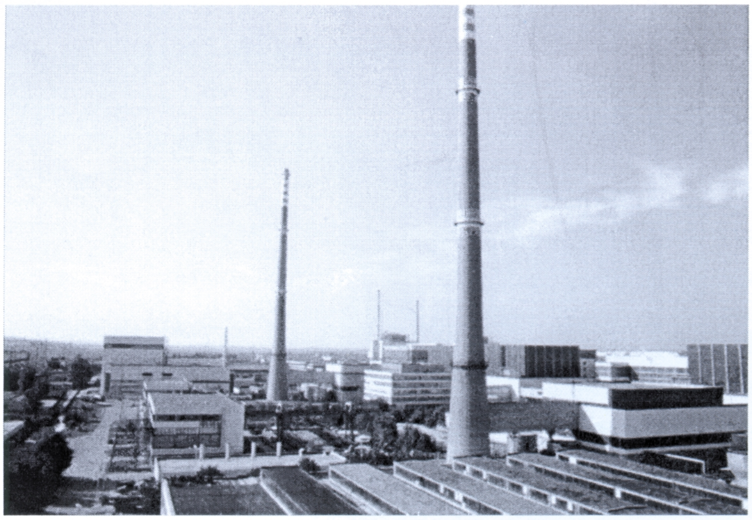


- Non Treated RAW
- Treated RAW
- Free of RAW

IAEA Disposal Facility Concept, adapted for Kozloduy NPP (TECDOC - 776 / 1994)



- Kozloduy NPP is in operation since 1974
- It has generated over 263 billion kW·h by now
- 6 units in operation - 4 WWER 440 & 2 WWER 1000



- No national RAW disposal facility for NPP generated waste
- Site storage necessity of generated RAW for 30-50 years period
- KNPP - adopted concept for RAW conditioning to stable form and package