Reconstruction and Modernisation of Novi Han Radioactive Waste Repository

Ivan G. Kolev

EQE Bulgaria AD, Sofia, Bulgaria

Contents

List of Figures

Abstract

The paper is an overview of the Feasibility Study for Reconstruction and Modernisation of Novi Han Radioactive Waste Repository (NHRWR), performed by EQE Bulgaria AD in 2000 for the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences.

The Study develops a concept for overall reconstruction and modernisation of NHRWR, including rehabilitation and partial reconstruction of existing facilities and planning of new facilities for conditioning and storage of various radioactive wastes and spent sealed sources.

The paper presents the general modernisation concept and outlines the proposed principle technical solutions for the existing and new facilities.

1 Introduction

The Feasibility Study for Reconstruction and Modernisation of Novi Han Radioactive Waste Repository (NHRWR) was contracted by INRNE at the end of 1999 to EQE Bulgaria AD. The initial results were reported in September 2000. This paper reflects the finalised results in the second issue of the study report [1], in January 2001 after the discussion of the first issue with NHRWR specialists.

1.1 Study Objectives

The objectives of the study were the development of conceptual solutions for reconstruction of existing and construction of new facilities at the NHRWR site, formulated in [2], as follows:

- A store for temporary storage of unconditioned high level sources;
- Temporary buildings over the existing radwaste storage vaults;
- A rainwater draining system;
- A plant for conditioning of high level spent sources;
- A plant for conditioning of low and medium level radwaste
- A 150 m^3 water reservoir for external fire extinguishing.

In addition, the study had to propose engineering solutions for conservation of the existing vault filled with high level spent sources (the gamma-well).

This paper briefly presents the most important issues of the feasibility study.

1.2 Study Scope

To meet the objectives of the study, the following tasks were performed:

- Review of the existing documentation of the facilities and previous studies, site walkdowns, review of regulatory recommendations for the NHRWR and of the current and planned activities of INRNE related to repair and modernisation of the site.
- Developing principle technical solutions for the facilities subject of the study, as well as for all interface, support and infrastructure systems required for the modernisation of the NHRWR.
- Planning of additional surveys and investigations for providing the required additional input data for the reconstruction and modernisation design.
- Developing of draft "NHRWR Reconstruction and Modernisation Programme", as well as cost estimates and investment plan.

2 Current Status and General Objectives of the Reconstruction and Modernisation of NHRWR

2.1 Current Status of NHRWR

The NHRWR is in operation since early 60-s. There is no original design documentation. The main information currently available is in result of additional studies and site surveys during the last decade.

In 1991, a geological survey of the site has been performed, and in 1994 an additional study provided site general plan and mapping of existing structures, as well as an attempt to restore cross-sections of the main storage facilities by walkdowns and personnel interviews.

Within this study, new walkdowns of the NHRWR site were performed and the main findings are summarised below:

1. The site has two zones called “clean” and “contaminated” in accordance with Bulgarian Regulation 0-35. The sanitary pass area in the Decontamination Building is currently not used and its status makes doubtful its future use as sanitary and radiological control facility.
2. There are reports for water inside the Solid Radwaste. The source is not evident – the water penetrated either through the cover hatches or through the walls and the bottom of the facility.
3. There is no data on the site underground piping and communication lines. Additional measures for the site upgrading has been performed in the recent years without proper documentation, including many new buried electrical and instrumentation cables. A detailed underground cadastre of the site is required prior to any new design and construction activities.
4. There are 2 wells at the site, made for the geological survey in 1991 and currently used as monitoring wells. They are insufficient for radiation monitoring of all facilities at the site in accordance with current regulations. The existing radiation monitoring wells along the Solid Radwaste Trench are shallow and not adequate for the purposes of efficient radiation monitoring.
5. New bore holes are also required in order to define the depth of the phillite bedrock under the backfill soil layer in the areas proposed for construction of new facilities. An additional detailed geotechnical survey is required to provide information for the terms of reference for NHRWR reconstruction design.
6. The available geodesic mapping is good in showing the site vicinity, but the points of survey within the site are not sufficient for the existing difference in elevation. A detailed geodesic mapping of the site operational zone should be made before the new landscape design is performed.
7. There is no documentation on the water supply system and tanks.
8. The road in the restricted zone of the site is too narrow. The reconstruction should follow the recommended measures.

Generally, the NHRWR is 30 years old and does not satisfy (see, e.g., [3]) all current requirements to the design of such facilities (see, e.g., IAEA publications ref. from 5 to 18). The lack of original design documents and documents on the later modifications is a serious impediment for clear definition of the applicable design basis assumptions and margins of the existing facilities. Development of updated design documentation for the existing facilities and a proper site survey should be a priority task in the future activities for modernisation of NHRWR.

2.2 Objectives of NHRWR Modernisation

The analysis of the reviewed documentation on the history of NHRWR, the regulatory requirements and the proposed development of the repository [2] in compliance with the “National Radwaste Strategy” [19] leads to the following strategic objectives for the site reconstruction and modernisation:

- Partial conservation of existing facilities in a way that would not preclude any future decisions regarding their status and would keep them operational. In particular, the option for retrieval of the stored radwaste should not be limited These activities should include sufficient radiation control and infrastructure measures at the site to ensure medium-term safe operation of the facilities. It is assumed that final decision on their future can thus be delayed.
- Change in the functions of NHRWR as a repository and planning and construction of new facilities for conditioning of wide range of various radwaste, including spent sources and low-level solid and liquid waste.
- The site should also provide for intermediate storage of the conditioned waste for the period before the construction of a new national radwaste repository.

The new NHRWR configuration should assume sufficiently modern conditioning technologies but relatively low volumes of wastes. Thus, sufficiently simple and efficient technologies should be chosen in order to limit the costs.

3 Proposed Engineering Solutions for the Existing Facilities

3.1 New buildings over the existing storage facilities

Temporary building structures over the existing storage are proposed for physical and rain protection of the following facilities:

- Solid radwaste vault;
- Biological radwaste vault;
- Solid radwaste trench.

Long-term storage of liquid radwaste is not allowed by the regulations, thus the existing liquid radwaste tanks, if in good condition, can be reconstructed for use within the new contaminated drainage system, or, alternatively, should be dismantled.

The temporary buildings are foreseen to be light steel structures appropriate to provide future possible dismantling, in case of facility closure, or in case of its decommissioning after the stored radwaste have been retrieved and conditioned.

The temporary building structures do not need heating and other passive or active systems, required for operation. The light structure will not endanger the reinforced concrete vault during an earthquake thus their design should meet the civil code requirements for seismic stability.

Building drainage is provided by drain channels in the floor leading to the restricted zone's rainwater drainage system.

Natural ventilation is foreseen for the structures. Power supply and security and access control instrumentation provisions are optional, but radiation monitoring instrumentation and telephone and/or loudspeaker outlet are recommended.

- Permanently closed windows, located over the metal doors on the North side of the building are recommended.

New equipment is required for mechanical lifting of vault hatches and respective principal solution is proposed. As its usage will be rare, this equipment may be manually operated.

3.2 Partial conservation of the Spent Sources Vault

The Spent Sources Vault (the “gamma well”) is presently considered full. Its design does not provide for retrieval of the sources so this facility has not been design as an interim store. However, there is currently inside it a considerable amount of long-life isotopes in contradiction to the requirements for a surface storage. This conclusion was made by a PHARE study [3], recommending retrieval, sorting and conditioning of the sources and decommissioning of the facility. The retrieval of spent sources from the storage is the best variant from the point of view of ecological and population protection in the long run. But it will cost much and the radiation doses of the operation personnel, performing dangerous operations, will be high.

The proposed solution is to provide partial intermediate term conservation, until available funding or new technologies will make possible decommissioning of the facility.

In compliance with the available information, the study of EQE Bulgaria recommends the following measures as necessary and adequate:

- Creating horizontal filter screens under the storage facilities by drilling sloping bore holes and vertical holes and injecting under pressure double-component polyurethane clays. Clays will fill in all soil pores and will perform as a waterproof barrier. Once the filter screens are created, the vertical drilling holes may be used for storage status remote control.
- Creating vertical filter screens surrounding the facility by reinforced concrete walls.
- Creating a waterproof reinforced concrete plate around the vault aboveground part that would drain surface water away from the area within the waterproof screens.

Additional conservation measures can be proposed only following the results of the currently developed INRNE programme for detailed investigation of the facility that is assumed to provide additional data on the inventory and current status of the radioactive material inside the vault.

3.3 Infrastructure measures for existing facilities

The NHRWR can not be operated without a clear distinction between the two operational areas and a modern sanitary pass between them with dosimetry equipment. The existing provisions in the Decontamination Building can not answer modern requirements and the building is not seismically qualified.

There should be on-site laboratories for radioactive material testing as well as for radiation monitoring of samples. Existing rooms are not suitable for modern laboratories, the buildings are not seismically qualified and there are no provisions for storage of small inventories of radioactive material.

Considering the observations above, a new building is proposed between the two zones at the site to host new laboratories, sanitary pass with dosimetry checkpoint, contaminated work clothes store and washing, etc. The building should have separate zones and separate drainage systems as well as general and special ventilation systems in accordance with the requirements for the respective laboratories.

Another important site modernisation activity is related to the new vertical levelling of the restricted zone, special provisions to limit the rainwater intake to the restricted zone and a special system for collection, storage and control of rainwater from the restricted zone. The study provides adequate technical solutions for this system in order to guarantee low water influence on the existing facilities (with unknown status of water insulation) and preclude any uncontrolled release of possibly contaminated waters to the environment.

If contaminated waters would be collected in any of the above systems and buildings, there should be a general site system for contaminated drainage collection and conditioning. Existing liquid radwaste tanks facility can be integrated into such system, if found to be in good shape. The study proposes that buffer tanks are provided for every source of possibly contaminated water and only actually contaminated water is transferred to the special drainage system tanks. The chemical conditioning of the contaminated water is proposed within the new facilities planned to be built at the site.

Contaminated water tanks and piping should be seismically resistant according to [18].

4 Engineering Solutions for the New Facilities in NHRWR

4.1 Site plan concept

Currently the administration building in the "clean" zone is supposed to host some of the site laboratories, which may perform operations with radioactive material. The checkpoint for personnel access to the "contaminated zone" is supposed to be in the "Decontamination" building, but actually the dosimetry checkpoint is organised at the main entrance to the NHRWR.

The concept for modernisation of NHRWR assumes clear division between the general administration zone and the restricted zone. The first is proposed to be relieved from any activities with radionuclides, while the access check-point and dosimetry control would be organised at the border with the restricted zone. The proposed new building in this area would be internally divided into general and restricted zones, with laboratories and personnel decontamination facilities situated in the restricted part. The general part would host administrative functions, radiation monitoring centre, eventually the servers of the information system, etc.

Within this concept, the existing administration building will be used only for administrative purposes, while the existing "Decontamination" building will retain its functions for decontamination of vehicles and may also host experimental installations.

In order to place all required new facilities, significant widening of the levelled part of the site is required. This is also required in order to organise reliable rainwater collection from the restricted zone. Despite this, the site offers little flexibility for placing new buildings.

The following other criteria apply to the placing of the new facilities at the site:

- Facilities communications should correspond to the technological integrity of processes and activities.
- Facilities within the restricted zone, requiring frequent personnel presence, should be located as near as possible to the entrance checkpoint in order to diminishing the time of personnel presence within the restricted zone.

- Places for loading and unloading operations with vehicles should be located as near as possible to the entrance checkpoint in order to reduce the hazard of contamination and the need for consequent decontamination activities.

The finally arranged proposed new general plan of NHRWR after the modernisation is shown in Fig. 1. It assumes a new laboratory and personnel checkpoint building and 3 new operations buildings for the new site functions, as follows:

- High Level Sources Plant with a store for temporary storing of sealed sources in transport containers and a special vaults facility for intermediate storage of high level sources.
- Low Level RW Conditioning Plant.
- Conditioned RW Store.

The plan also shows proposed temporary protective buildings over the existing facilities and the new proposed site vertical levelling as well as other new infrastructure facilities.

All major new facilities discussed below in this section should be designed to the highest seismic requirements according to [18].

4.2 High Level Sources Plant

The High Level Sources Plant should be able to process small quantities of various spent sealed sources used in the industry, medicine, agriculture and research. Since some of the sources can quite powerful, the plant should be equipped with lifting equipment able to process heavy transport containers. The plant (see Fig. 2 and 3) is planned to consist of the following main areas:

- Transport operations and incoming control area, which allows for vehicle loading/unloading operations and the personnel room for incoming control and logging into the database. The area also hosts some common building services, like electrical switchboard room and ventilation equipment rooms. Accumulator-driven forklift is proposed for in-building transport operations.
- Store for transport packages. This area is planned for temporary storage of spent sources in their respective transport containers prior to any conditioning operations.
- Conditioning area, which hosts a hot cell with mechanical manipulators for processing powerful sources. The cell should have sufficient geometry to allow for forklift entering and placement inside the cell of equipment for loading/unloading transport containers, as well as for re-packing of failed sources into stainless steel capsules by argon welding. Source capsules integrity testing equipment should also be provided. In separate room, a laboratory fume glove box is planned for manual handling of low level sources. In addition, a decontamination room is planned, as well as the control room for remote operation of the vault facility crane.
- Vaults facility. This area is planned for intermediate storage of various sources in special containers in stainless steel vaults with lead caps in a high-density concrete radiation shielding (see Fig. 3). A universal lead container concept is proposed that can be used for different number of sources depending on their activity. The concept container accounts for the size and geometry of the most widely used sources. For powerful sources, the container shall be loaded in the hot cell and its transport from the cell to the vault facility shall be done in an intermediate transport container. All crane operations in the vault facility shall be performed by remote control.

The building should be equipped with at least three separate trains of special contaminated sewerage system: one for the floor sewerage inlets, one for the hot cell, fume box and decontamination room, and one for the drainage of the vault facility. Special security, access control, communications and radiation monitoring systems are envisaged.

The low level sources which can be conditioned by cementation into drums) together with their casks (see e.g. [14]), after control in the above-described facilities will be transferred to the Low Level RW Conditioning Plant for cementation into standard 200 l drums.

4.3 Low Level RW Conditioning Plant

The Low Level RW Conditioning Plant should be able to process small quantities of various solid, biological and liquid radioactive wastes from the industry, medicine, agriculture and research. The basic envisaged conditioning principle is cementation into standard 200 l. steel drums, which in special cases can be provided with internal concrete shielding layers. All in-plant transport operations are planned by manual hydraulic or accumulator-driven forklifts.

The plant (see Fig. 4 and 5) is planned to consist of the following main areas:

- Materials store. This area is planned for storing dry materials for the cementation, reinforcement metals, etc., as well as the forklift accumulator charging station.
- Incoming RW store and control. This area also hosts refrigerator for biological wastes and is situated next to the sampling laboratory with fume boxes.
- Solid RW sorting area, which hosts a special fume glove-box with built-in compactor for sorting and compacting of solid RW, similar to the one proposed in the IAEA Reference Design [15]. In separate room a fume glove box is installed for handling alpha-isotope-containing waste.
- A special chemical treatment installation is provided in separate room for conditioning of liquid radwaste (it is expected that most of liquids will arise from decontamination activities within the NHRWR). The installation follows the recommendations of IAEA Reference Design. The sludge is transferred to the mixer for cementation.
- The cementation area hosts equipment for mixing semi-liquid substances with cement (sludge from conditioning of liquids, resins, etc.) and concrete mixer for cementation of solids. The outgoing control area hosts also the drum-closing machine. There is an outgoing store for temporary storage of conditioned waste in drums prior to transfer to the Intermediate Store.

The building should be equipped with decontamination room, special ventilation systems, at least two separate trains of special contaminated sewerage system: one for the floor sewerage inlets and one for the glove boxes and decontamination room. Also the services should be provided: personnel room, electrical equipment room, steel workshop for the reinforcement, room for contaminated water tanks, etc. Special security, access control, communications and radiation monitoring systems are envisaged.

4.4 Intermediate Store for Conditioned Waste

The Storehouse (see Fig. 6) is planned for intermediate storage of conditioned waste in steel drums for the period until its transfer to the new National Repository or, for short-living isotopes, until their activity would allow their disposal as conventional waste.

The facility is a large concrete building without any active technology systems. Electric forklifts are envisaged for transport of drums from the LLRWCP. Natural ventilation is provided by use of special roof deflectors. The building should be connected to the radiation monitoring and security systems, while telephone/loudspeaker and access control systems are optional.

4.5 Common Site Systems

In above sections, the following activities and systems were mentioned as required or recommended for the modernisation of NHRWR:

- New site vertical levelling and new rainwater system for the restricted zone with drain channels, control tanks and pump for connection to the contaminated drainage system (see Fig. 7).
- New site-wide contaminated drainage system (see Fig. 8), consisting of in-buildings parts (drainage trains with control reservoirs and pumps, where required), common contaminated drainage stainless steel pipeline in concrete tunnel; common contaminated drainage tanks with valve chamber, pumps and connection to the input tank of the liquid radwaste processing installation in LLRWCP.
- Electrical Power Supply system should be reconstructed into two trains for preferred and emergency power supply with automatic switching in each building for safety, security and radiation protection equipment only.
- New system for internal and external communications with central automatic phone switchboard, phone outlets in all habitable buildings/areas (recommended outlets for stores as well) and emergency annunciation network (loudspeakers).
- Reconstruction and extension of the radiation monitoring system from external measurements only to coverage of all buildings/areas and construction of a central recording and control unit.
- Extension of the security systems and access control systems with several levels of access permission to various buildings and site areas as well as to different areas within operations buildings.
- Information system with central database and terminals in the two operations buildings for logging of radwaste inventories and processing details.
- Special attention should be paid to the Fire Protection Facilities at the site. The NHRWR should be provided in any case with water reservoir to ensure sufficient water quantities for external fire extinguishing of existing buildings. A 150 m^3 underground concrete tank is proposed in the study (see Fig. 1). The tank should be used by fire vehicle. The need for additional fire system with pumps and hydrants should be evaluated in the design. All new facilities will also need internal fire alarm and fire extinguishing systems. Thus it is planned to install a complete new centralised fire alarm system for all site facilities with central station in the security personnel building. The need for automatic fire extinguishing systems in the production areas should be evaluated in the design. At this stage, no automatic water sprinklers are envisaged due to the risks of contaminated water flows in case of fire. Rather, CO_2 and powder extinguishers seem feasible.

5 NHRWR Reconstruction and Modernisation Programme

The Feasibility Study has defined the principle technical solutions for each of the existing and new proposed facilities. It has also identified the required new facilities and general site infrastructure systems, which were not requested by INRNE but are required or recommended in accordance with current safety and radiation protection requirements.

In addition, the Study also identified areas, where the currently available data and information is insufficient for contracting the Technical Design for the reconstruction and additional investigations are required. Identified were also the administrative and regulatory problems of the reconstruction, which may influence the time schedule.

The NHRWR Reconstruction and Modernisation Programme, developed at the end of the study, assumes all above factors in order to present a realistic time frame (see Fig. 9) for all investigations, design and licensing activities and construction works at the site. Currently the Programme assumes activities for NHRWR to continue till 2007, when all new facilities at the site can be commissioned.

A Cost Estimate (by activity and facility) and an Investment Plan complement the Programme.

The Study results have been discussed with INRNE in September - December 2000 and the Study report was re-issued in January 2001 to reflect the results of these discussions. It is expected to finalise the Feasibility Study phase before the summer of 2001, when some preliminary investigations of the site can be initiated.

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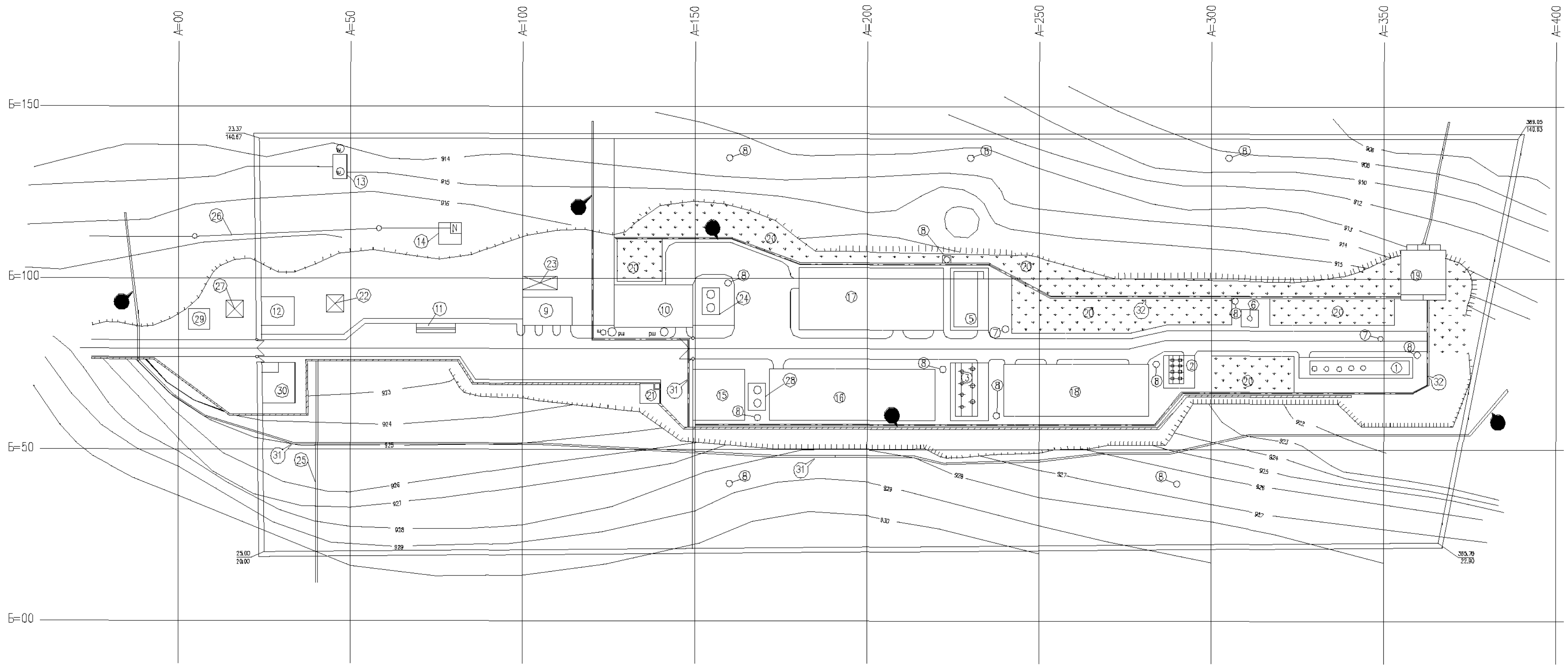


Figure 1 Proposed NHRWR General Layout Plan After the Modernisation

(1) Existing solid RW trench; (2) Existing biological RW vault; (3) Existing solid RW vault; (4) Not used: former isotopes store to be demolished and replaced by laboratory building; (5) Contaminated sewerage tanks and valve chamber; (6) Existing spent sources vault; (7) Existing wells; (8) Proposed new network of monitoring wells; (9) Garage; (10) Existing Decontamination building; (11) Vehicle maintenance channel; (12) Existing administration building; (13) Existing sewerage shaft; (14) Existing transformer substation; (15) Proposed new laboratory and dosimetry checkpoint building; (16) New high level sources plant with shielded vaults facility; (17) New low level RW conditioning plant; (18) New store for conditioned RW; (19) Rainwater tanks with valve chamber and pump; (20) Drained grass areas; (21) Fire water tank; (22) New DG building; (23) New general appliances store; (24) Control tanks for Decontamination building contaminated sewerage system; (25) Existing water supply pipeline route; (26) Existing power supply overhead line route; (27) Existing diesel oil tank for the heating installation; (28) Control tanks for laboratory and checkpoint building contaminated sewerage system; (29) Proposed new sewerage tank; (30) Existing security and checkpoint building; (31) New drain trenches and ditch for decreasing the rainwater flow into restricted area; (32) Drain ditches of the Restricted Area rainwater collection system.

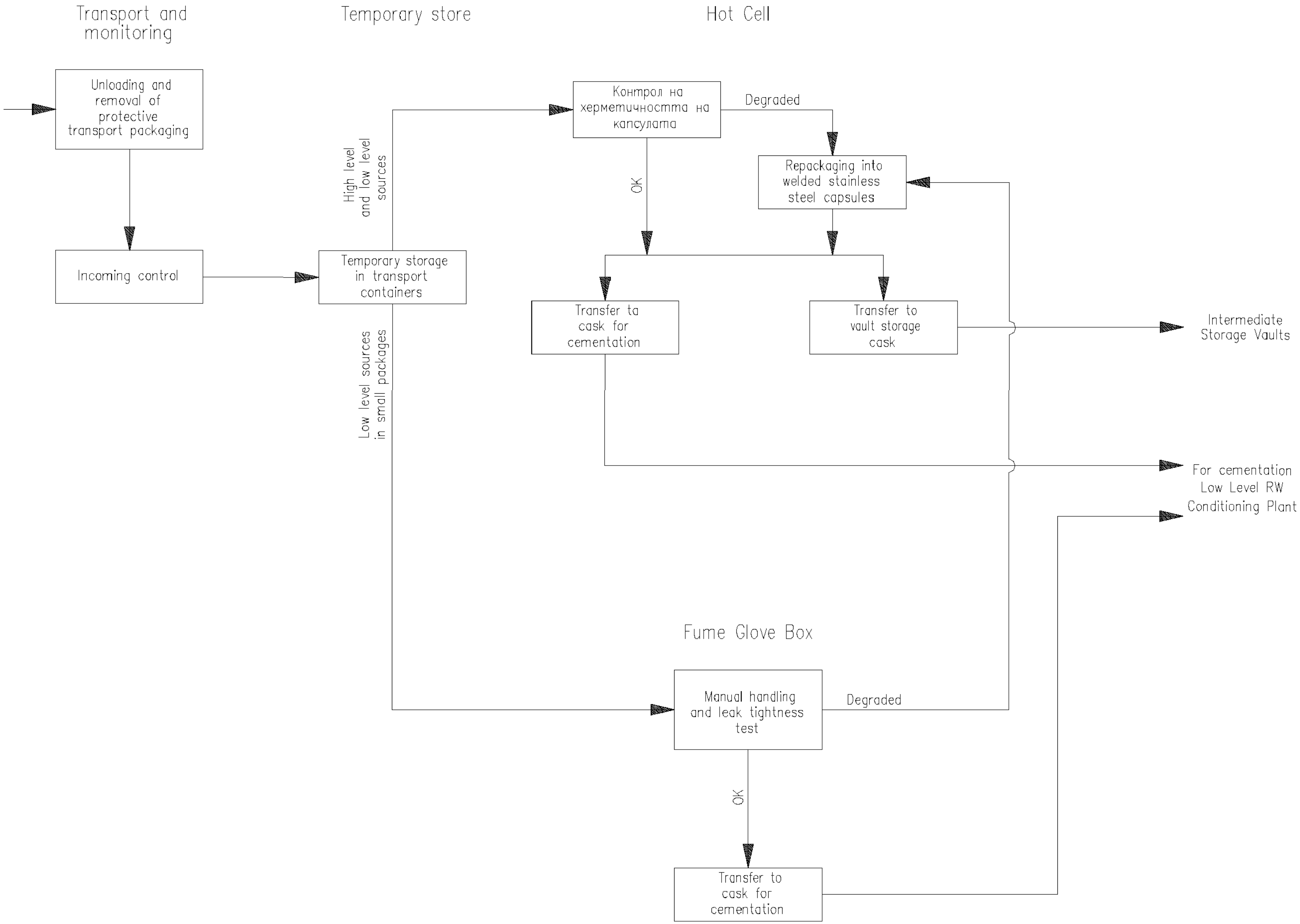
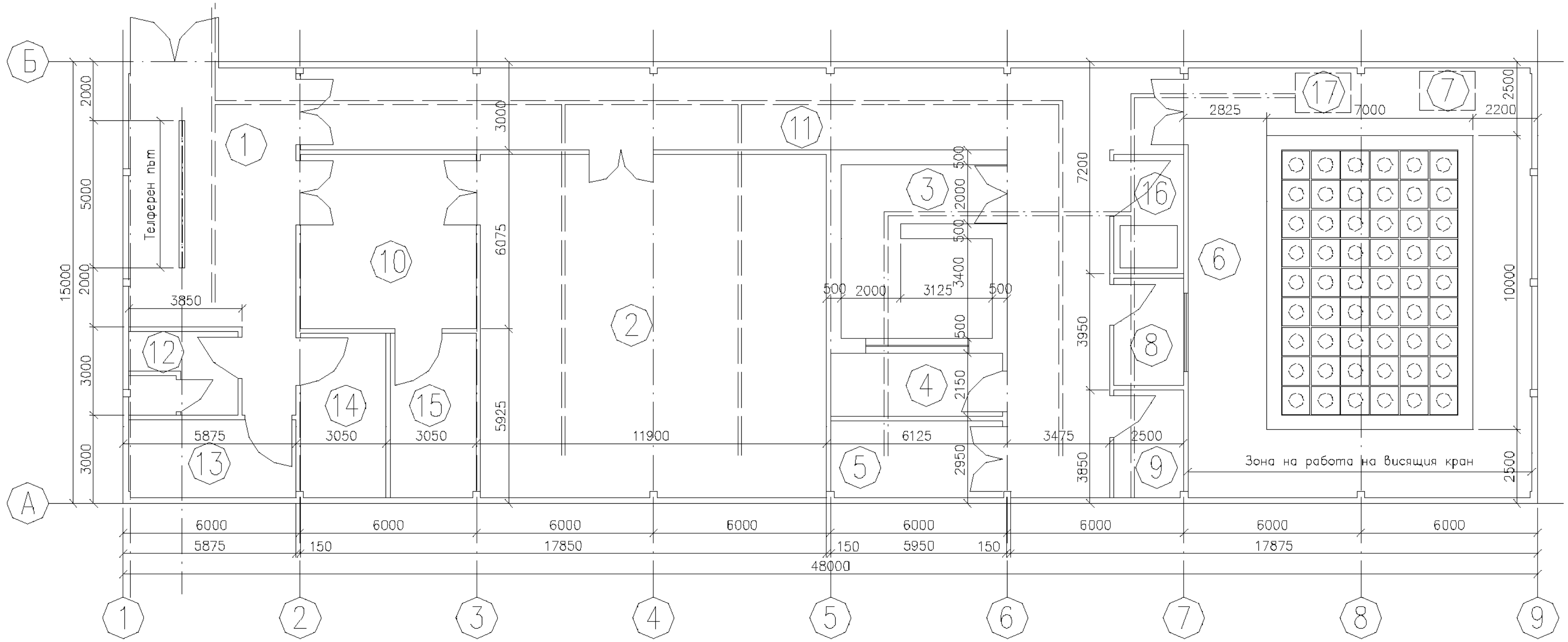
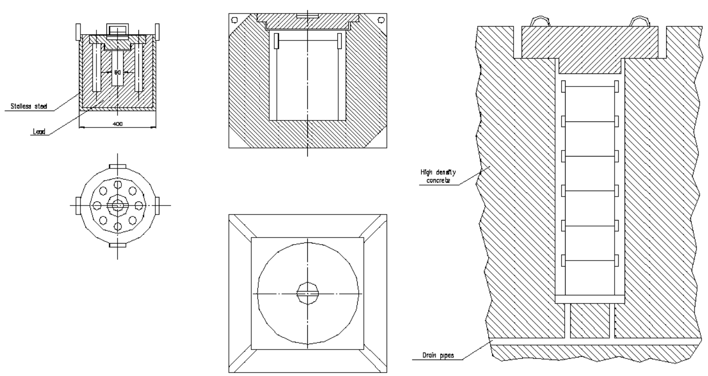


Figure 2 Process Flowchart of the Proposed New High Level Sources Plant at NHRWR Site



High Level Sources Storage and Transfer Casks



High Level Sources Vaults

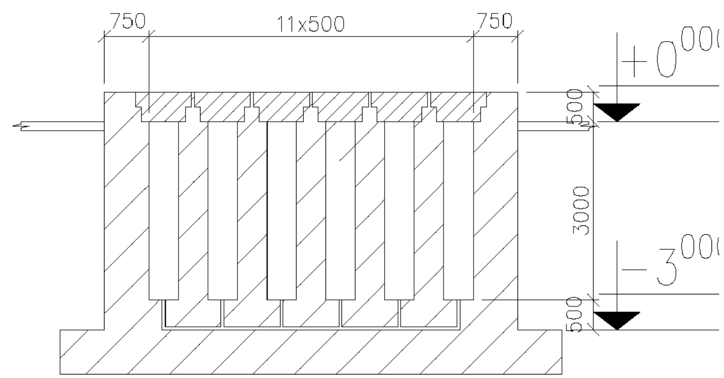


Figure 3 Layout of the Proposed New High Level Sources Plant at NHRWR Site

(1) Transport operations room; (2) Temporary incoming store; (3) Hot cell; (4) Hot cell operator room; (5) Decontamination room; (6) High level sources vaults facility; (7) Vaults drainage tank and pump; (8) Crane remote control room; (9) Contaminated washroom; (10) Incoming control room; (11) Transport corridor; (12) Clean washroom; (13) Electrical equipment room; (14) Fresh air vent centre; (15) Suction vent centre; (16) Room for fume glove box; (17) Contaminated water drain tank and pump.

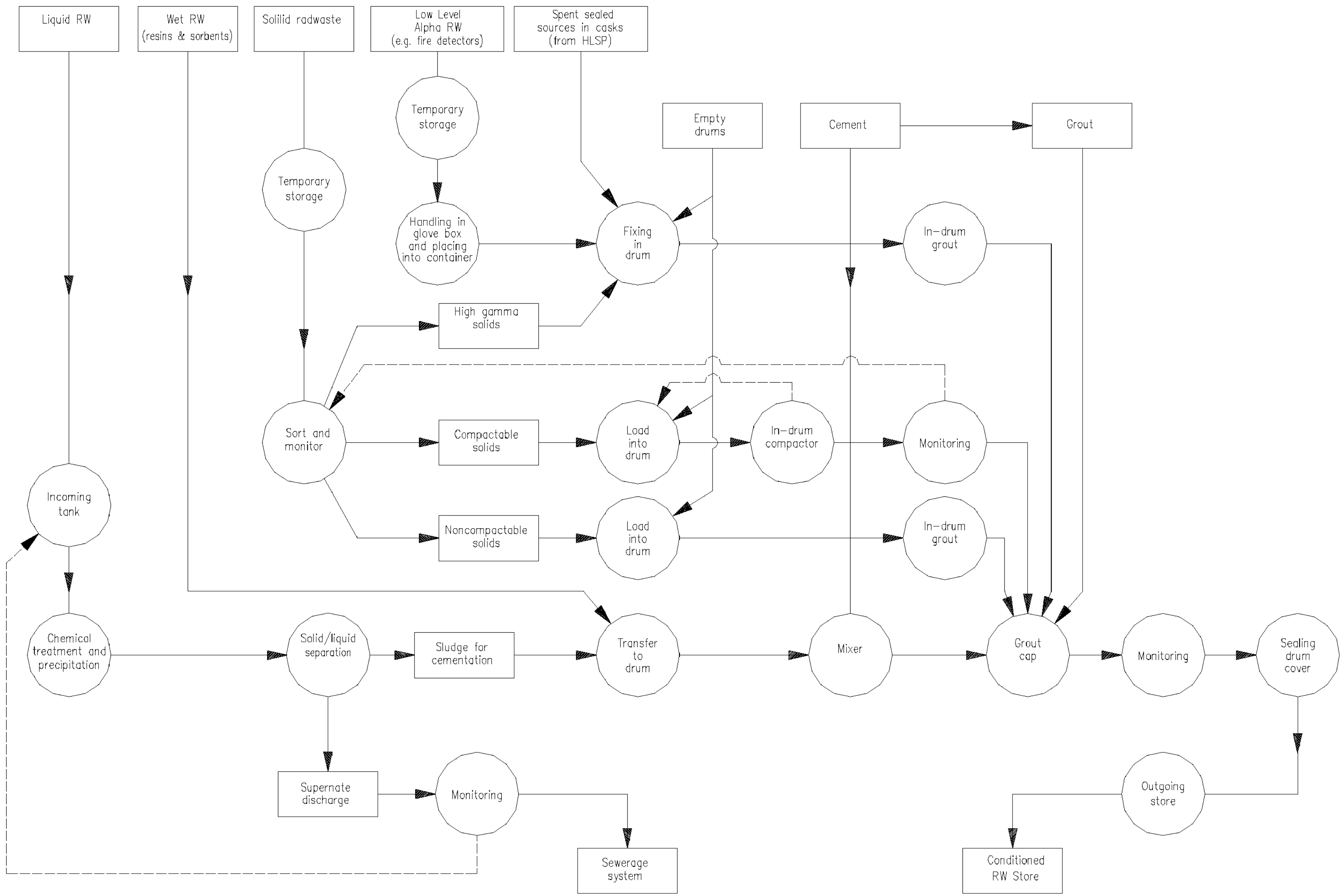


Figure 4 Process Flowchart of the Proposed New Low Level RW Conditioning Plant at NHRWR Site

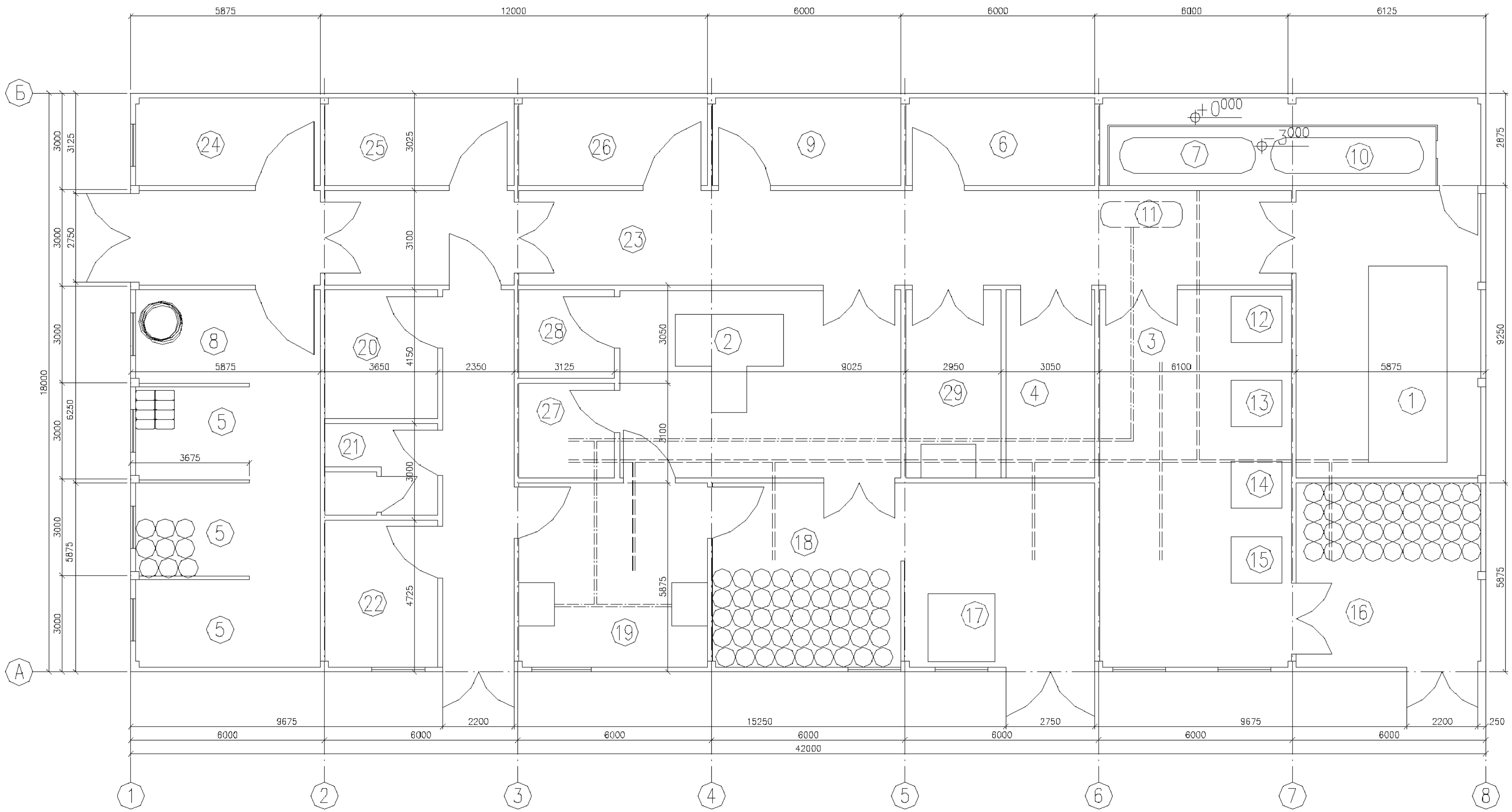


Figure 5 Layout of the Proposed New Low Level RW Conditioning Plant at NHRWR Site
(1) Liquid RW Installation; (2) Sorting glove box with built-in compactor; (3) Cementation room; (4) Decontamination room; (5) Materials store; (6) Chemical store; (7) Contaminated sewerage tank for floor siphons train; (8) Reinforcement steel workshop; (9) Storage room; (10) Liquid RW Installation incoming tank; (11) Contaminated sewerage tank for fume boxes and decontamination room train; (12) Liquid RW mixer; (13) Concrete mixer; (14) Drums outgoing monitoring; (15) Drums sealing machine; (16) Outgoing store; (17) Incoming monitoring; (18) Incoming store; (19) Laboratory with fume boxes; (20) Electrical equipment room; (21) Clean washroom; (22) Personnel room; (23) Transport corridor; (24) Forklift batteries charging room; (25) Fresh air vent centre; (26) Suction vent centre; (27) Contaminated washroom; (28) Information system computer room; (29) Alpha RW glove box room.

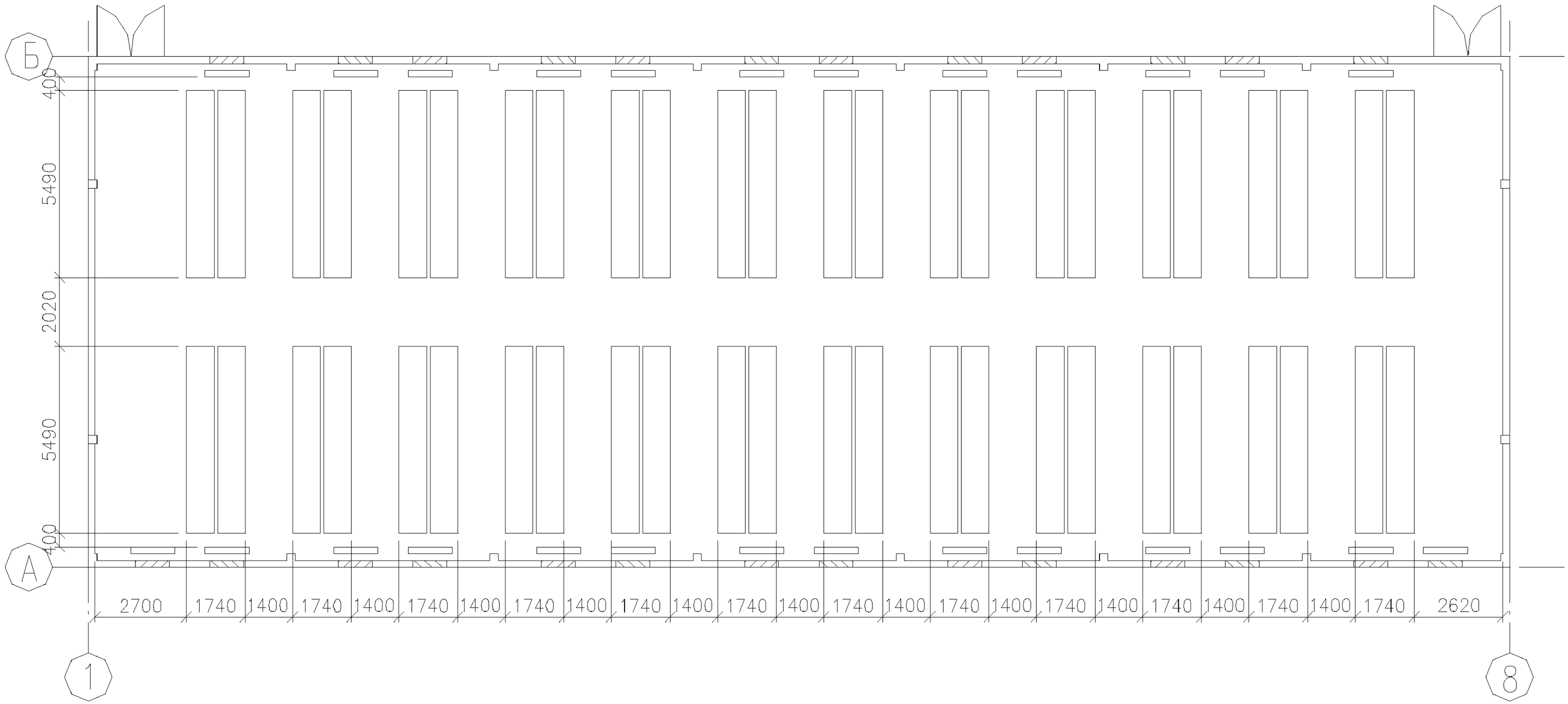


Figure 6 Layout of the Proposed New Intermediate Store for Conditioned RW in 200 l Drums.

Drums to be stored in horizontal position in 3 layer stacks. Floor drain channels are discharging to the site Contaminated Sewerage System header. Layout spacing allows for forklift transport operations with drums and monitoring access to any drum at any time. Natural ventilation ensured by side wall air inlets and roof deflectors or Johnson-type roof opening. Air inlets shielded by additional walls. Two entrances are provided for easier transport operations and for emergency access. Total capacity: 1152 drums.

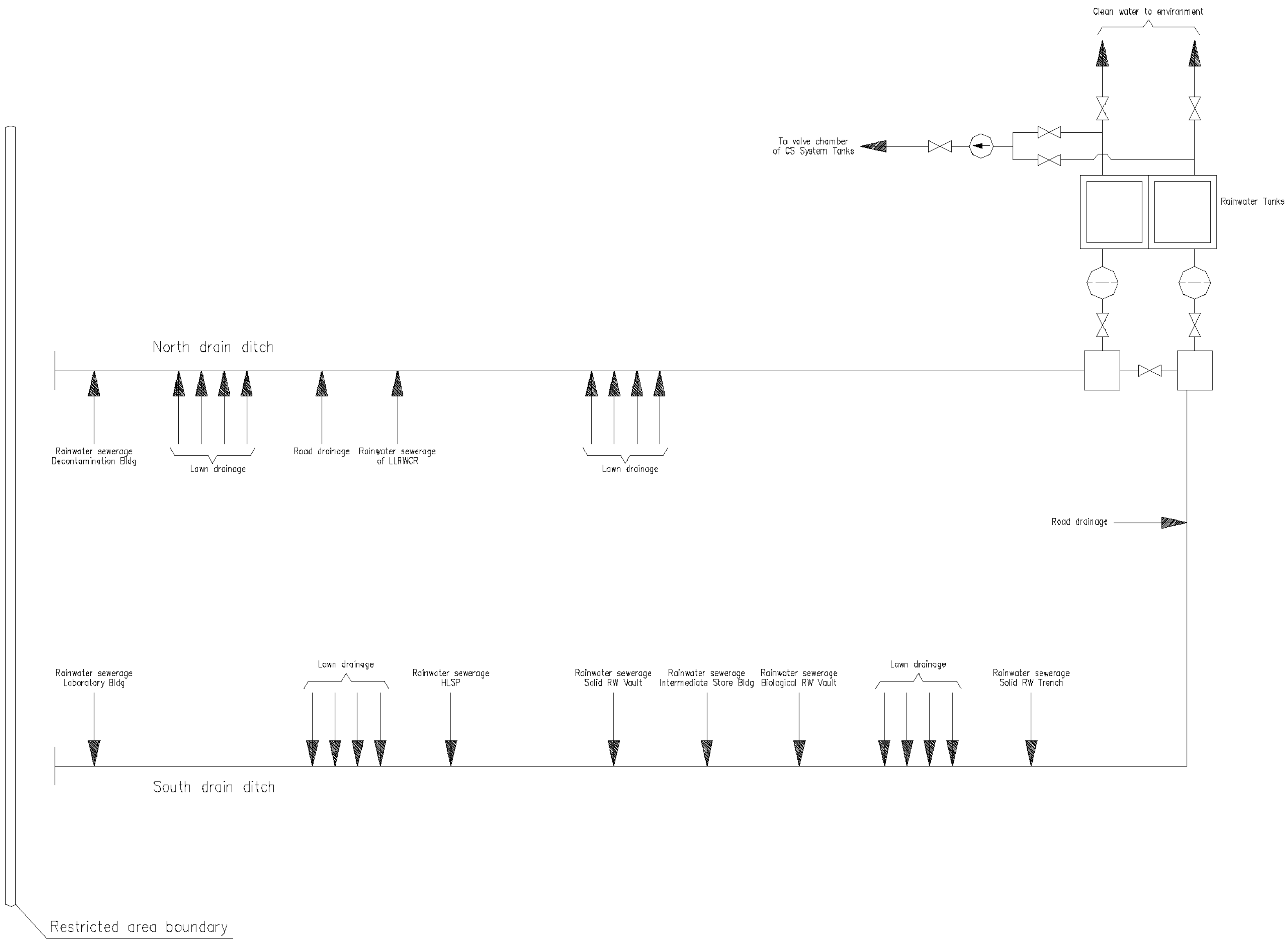


Figure 7 Flow Diagram of the Proposed New Rainwater System in the Restricted Area of NHRWR

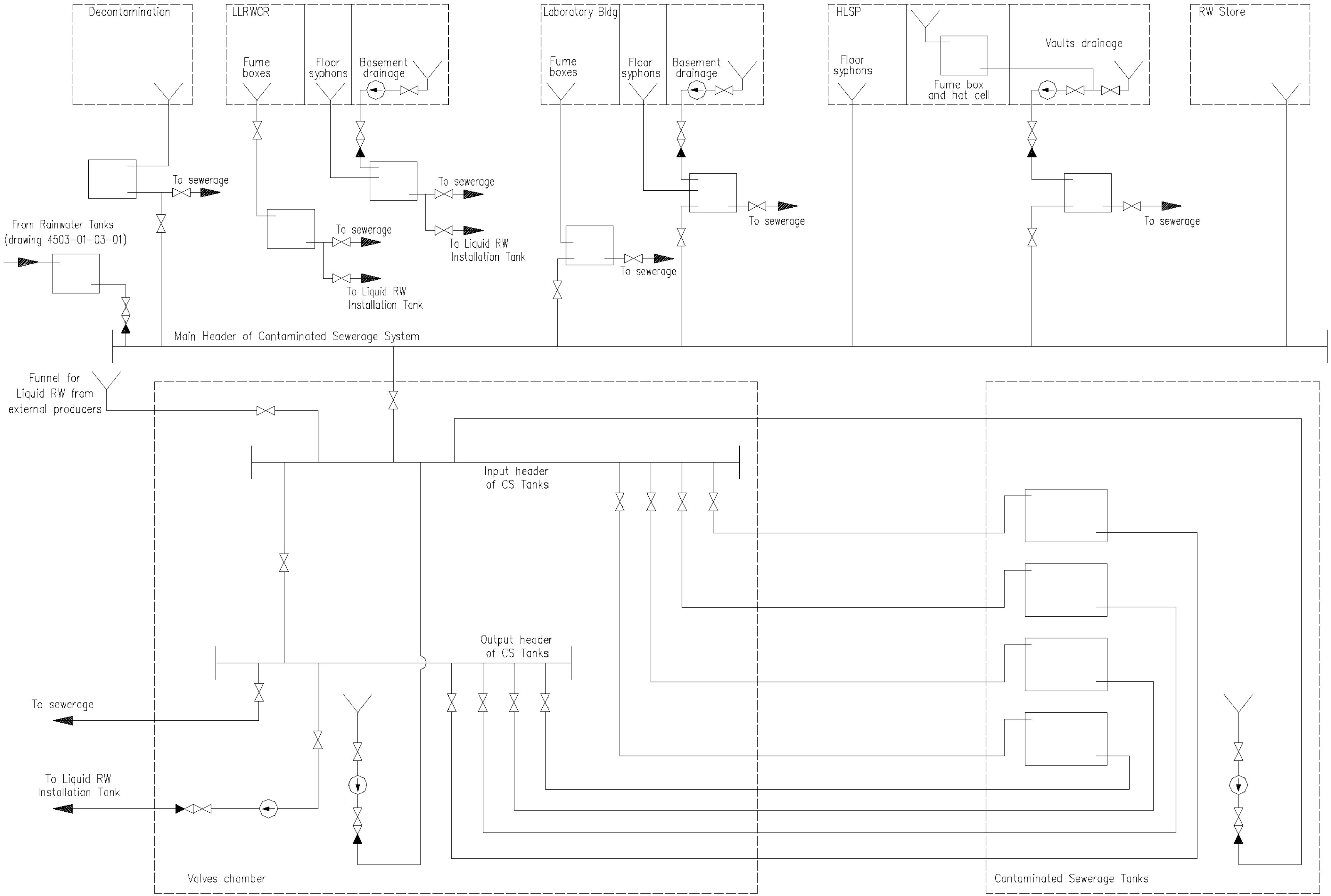


Figure 8 Flow Diagram of the Proposed New Site-wide Contaminated Sewerage System

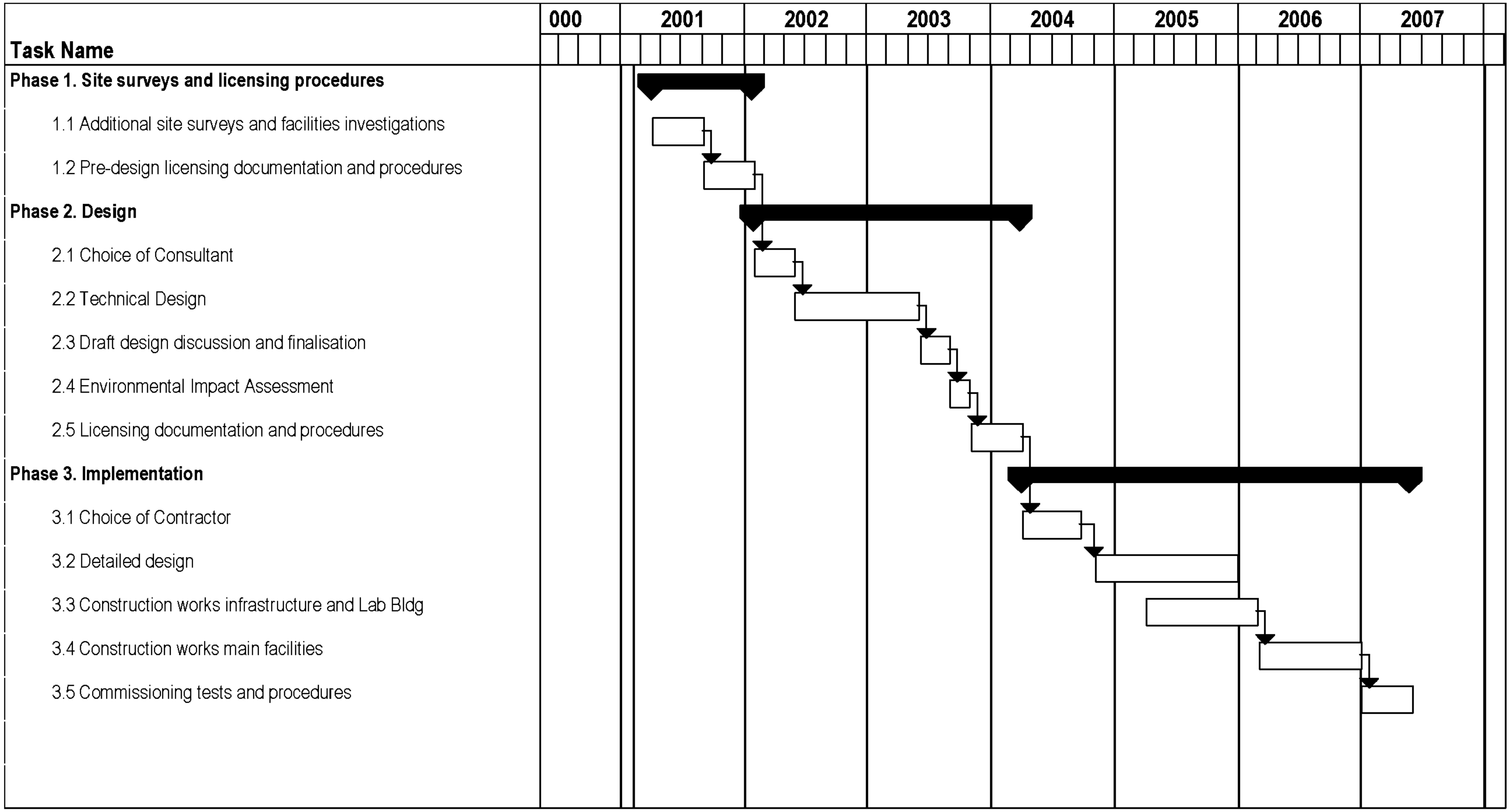


Figure 9 Milestones of the Proposed NHRWR Reconstruction and Modernisation Programme