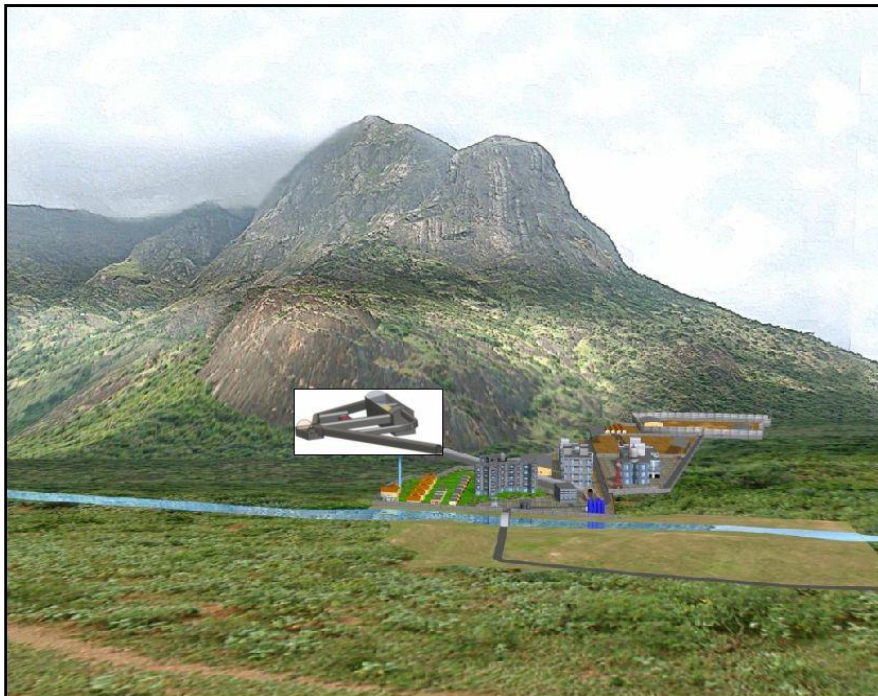




**CONCEPTUAL PLAN
INDIA-BASED NEUTRINO OBSERVATORY AT BODI
WEST HILLS, POTTIPURAM VILLAGE, THENI
DISTRICT, TAMILNADU**

India-Based Neutrino Observatory At Bodi West Hills,
Pottipuram Village, Tal.Uthamapalayam, Dist. Theni,
Tamilnadu



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1.0 INTRODUCTION

What are Neutrinos?

We know that atoms contain electrons that revolve around a central nucleus that contains protons and neutrons. While electrons are considered elementary or fundamental particles, protons and neutrons are not. This means that protons and neutrons can be broken up into smaller fundamental or elementary sub-structures called quarks and gluons.

Since this discovery more than 50 years ago, several other fundamental or elementary particles have been discovered, none of which are a part of the atom or its nucleus. It is not known whether all fundamental particles have been found so far; the most recently discovered particle is the Higgs boson which was discovered about 2 years ago in CERN, Geneva, and was popularised in the press as the God Particle.

Neutrinos are yet another type of the fundamental particles which make up the universe. Their abundance is only next to particles of light that is photons. In spite of this they are also the least understood. Here are some facts and open problems about neutrinos:

- ❖ Neutrinos are charge neutral. They seem to have a very small mass, a million or more times smaller than that of the electron. But we do not know the precise value of the mass.
- ❖ They were predicted by theorist Wolfgang Pauli in 1931, but only discovered in 1956 because they interact very rarely.
- ❖ They interact very feebly with matter in comparison to photons (light quanta) and electrons, their interaction being weaker by a factor of a million or more. Hence they are also the most difficult to detect.
- ❖ We know that there are three types of neutrinos, electron-neutrino, muon-neutrino and tau-neutrino which are partners of the corresponding charged particles, electron, muon and tau (these are heavier versions of the electron). We call them flavours. However, we do not know which of these types is heavier and which is lighter.
- ❖ During their propagation through vacuum or matter these neutrinos tend to oscillate or change flavours. What is the mechanism that drives neutrinos to play hide and seek is yet another open problem.
- ❖ There is a Standard Model of Particle Physics which is a successful synthesis of our knowledge of elementary particles. Though extremely successful, the neutrinos have zero mass in this model. Hence neutrino mass being non-zero opens up a new window into science beyond the Standard Model.

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- ❖ Neutrinos may ultimately hold the key to the intriguing fact that the Universe as we know is mainly made up of matter with no evidence of substantial structures with antimatter. This is intriguing because scientists believe that when the Universe began there was an equal amount of matter and antimatter produced by radiation. There are good reasons to believe that Neutrinos hold the key to this cosmological question.
- ❖ Another intriguing fact about the universe is that the matter as we see in planets, galaxies, etc. constitutes only about 4 percent of all the matter and energy in the Universe. Nearly 25 percent seems to be in the form of so called Dark Matter of which we know very little except that it is there. Because of their mass, neutrinos may constitute a part of this Dark Matter and may also hold the key to further understanding of the nature of Dark Matter.
- ❖ Because of their extremely feeble interaction, Neutrinos are very difficult to observe. Hence all the laboratories are situated deep underground to cut down the background of naturally occurring cosmic radiation on the surface of the earth. Furthermore, the detector have to be very large (1000's tons) in order to increase the probability of neutrino interactions.

The India-Based Neutrino Observatory (INO) is a pure science underground laboratory. Its primary goal is to study the properties and interactions of weakly interacting, naturally occurring particle called neutrino. There is world-wide interest in this field, due to its implications for several diverse and allied areas such as particle physics, cosmology and the origin of the Universe, energy production mechanisms in the Sun and other stars, etc.

The current study focuses on neutrino detection with static detectors, to be placed deep underground. It is envisaged that such an underground facility will develop into a centre for other studies as well in physics, biology, geology etc., all of which will make use of the special conditions that exist deep underground. Apart from the scientific goals, INO will greatly enhance the development of detector technology and its varied applications.

The INO Project received its financial approval of Rs. 1583 Cr. by Union Cabinet in Jan 2015 for INO. This project is a mega Science Project which is jointly funded by DAE-DST.

This project is based on completely in-house R&D with substantial industry interface and technology development. There are no strategic or defense applications of this project.

Its operation involves no radioactivity release or toxic emissions, hence there are less chances of major accidents. Overall there would be a Lab, comprising of one large and three small underground caverns to house detectors. Caverns will have an access tunnel to reach it.

2.0 HISTORY

Cosmic ray & neutrino physics technology has been developed decades ago. Research on penetrating cosmic rays at the Kolar Gold Fields concluded that the muon flux was low enough at the largest depths of 2km or more to permit measurements on atmospheric neutrinos. Indeed atmospheric neutrinos were first detected by the TIFR-Osaka-Durham collaboration at the Kolar Gold Fields in 1965. In addition the observation of the Kolar events suggested a decaying heavy particle and this was done using calorimeters consisting of up to 300 tons of iron and proportional counters. In view of the importance of this field, it was widely felt that neutrino physics experiments should be revived in India.

The possibility of locating a Neutrino Observatory in India was discussed as early as 1989. After a few meetings the INO collaboration was formed. In 2005, a document was presented to the Department of Atomic Energy (DAE), Government of India, which laid out an ambitious goal of establishing an India-Based Neutrino Observatory (INO) outlining the physics goal, possible choices for the detector and their physics reach. As a result of the support from various research institutes, Universities and scientific community, a Neutrino Collaboration Group (NCG) was established to study the possibility of building an India-Based Neutrino Observatory (INO).

3. SITE ALTERNATIVE

The proposed site of Pottipuram is a clear site from Forest & Environmental issues. The terrain is flat and there will not be any problem in transport of materials and disposal of excavated tunnel muck. The Reserved Forest is of open scrub variety and most of the mountain face is bald with patches of scrub forest. Good rock quality is available for the cavern formation. The cavern is to be set in massive Charnockite. One of the main advantages of the Pottipuram site is the steepness of the mountain which provides many possibilities for locating the portal depending on the overburden chosen and a relatively short tunnel length.

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Table 1 Site Alternative

Site features	Singara site	Suruliyar site	Pottipuram site	Kottagudi site
Cavern location	Under Reserved Forest (RF)	Under Wild life sanctuary (WLS)/estate	Under Reserved Forest (RF)	Under Reserved Forest (RF)
Rock type	Charnockite	Charnockite	Charnockite	Charnockite
Maximum Vertical cover	1299m	1264m	1279m	1400m
Portal location	TNEB camp	Inside Reserved Forest / Wild life sanctuary	Outside the Reserved Forest boundary	Outside the Reserved Forest boundary
Tunnel route	Partly under RF	Under WLS	Under RF	Partly under RF
Tunnel length	2100m	<3000m	1966m	<3000m
Access	From Masinagudi (crosses elephant corridor)	Road up to Portal	Katcha road (1km) to be strengthened	Katcha road up to Portal to be strengthened
Geo-tech data	Well studied-Good	Appears good	Good	Reasonable
Seismic risk	Zone-2	Zone-2	Zone-2	Zone-2
Environmental risk (lab)	Close to RF/WLS; under RF	Sanctuary edge/ under WLS	Under RF 4.62 ha only	Under RF (RF minimal)
Power	Available	Available	Not available (To be drawn from RasingapuramSS,10km)	
Water	Available	Available	Not available (To be drawn from Mullai Periyar,15km)	
Nearest town	Ooty	Theni	Theni	Theni
Nearest city	Coimbatore	Madurai	Madurai	Madurai

4.0 PROJECT DESCRIPTION

4.1 Need of Underground Laboratory:

Neutrinos have extremely weak interaction with matter hence it is very difficult to detect them in a laboratory. The background from cosmic rays (which interact much more readily than neutrinos) and natural radioactivity will make it almost impossible to detect them on the surface of the Earth. For these reasons it is necessary to locate neutrino observatories deep inside the Earth's surface.

The overburden provided by the Earth matter is transparent to neutrinos whereas most background noise from cosmic rays is substantially reduced due to their absorption by the Earth, the extent of reduction depends on the depth at which the detector is located.

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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

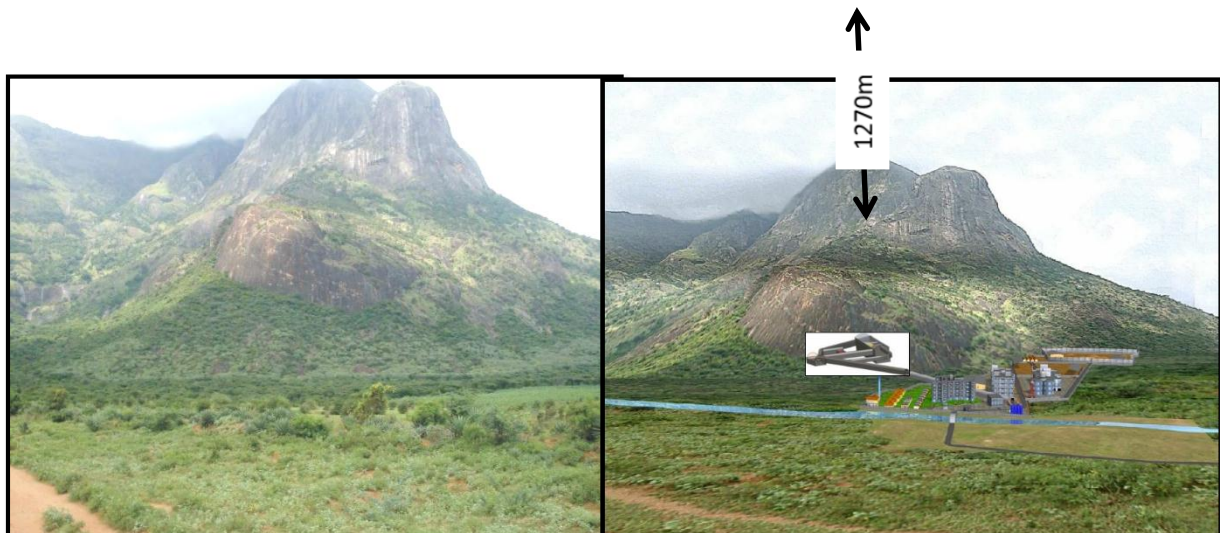
4.2 Site Location and Description:

The project is located geographically at $77^{\circ}17'5.32''$ E $9^{\circ}56'46.20''$ N Bodi West Hills, Pottipuram Village, Theni District, Tamil Nadu.



Figure 1: Project Location

Figure 2: Proposed underground laboratory INO under mountain at Bodi West Hills in Theni District of Tamil Nadu



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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

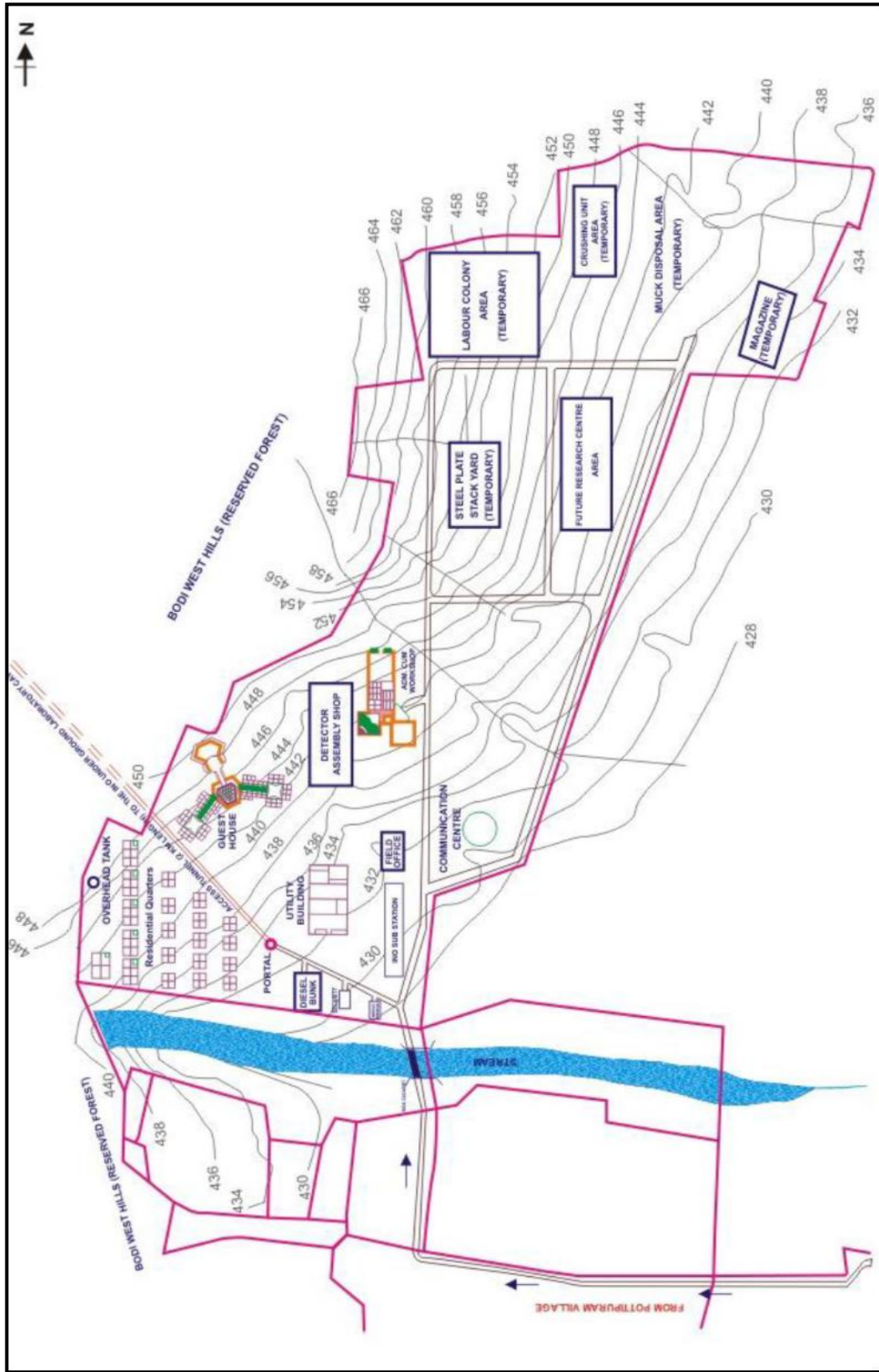


Figure 3: Surface Facility Layout

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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

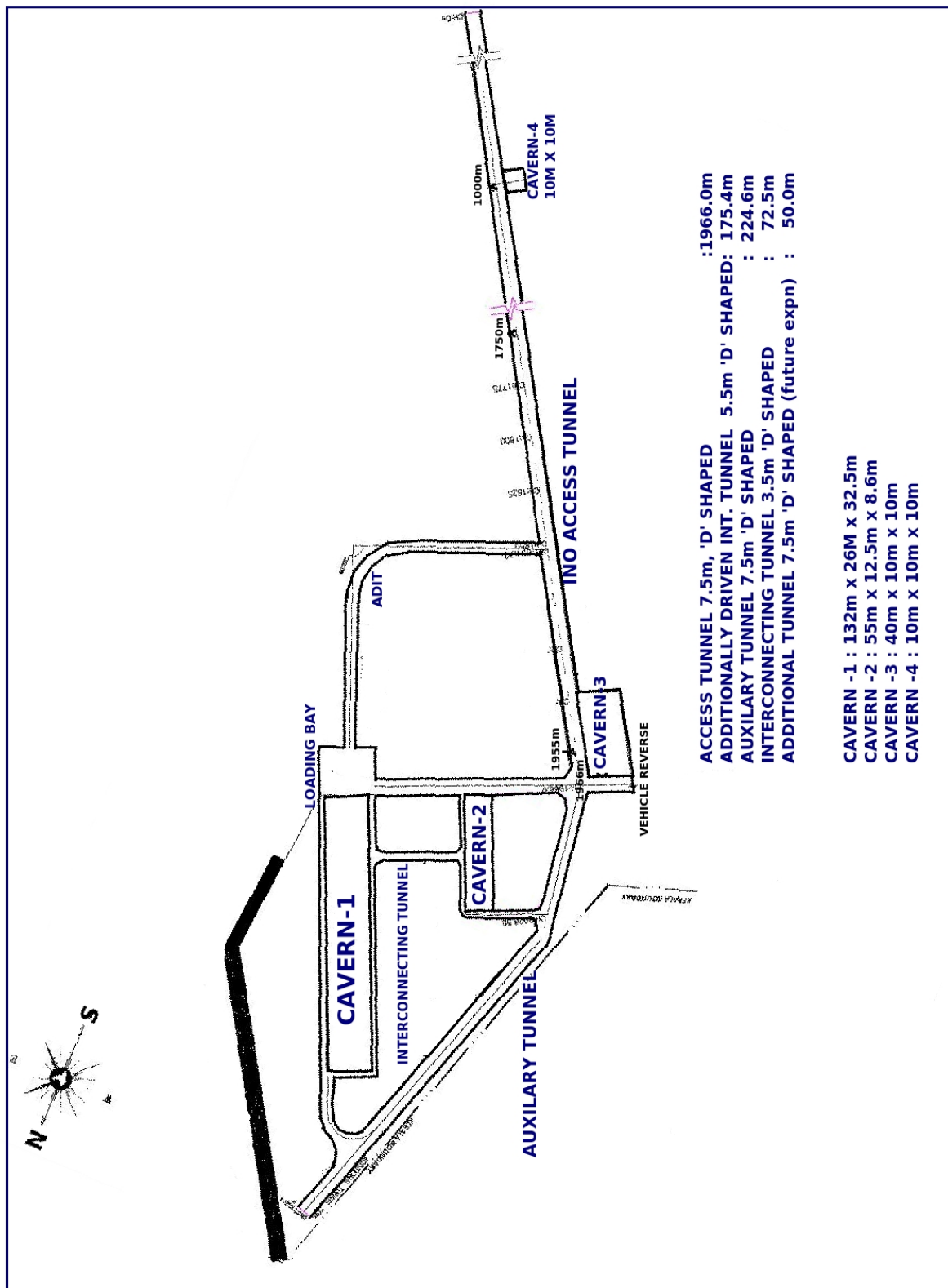


Figure 4: Underground Laboratory Layout

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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

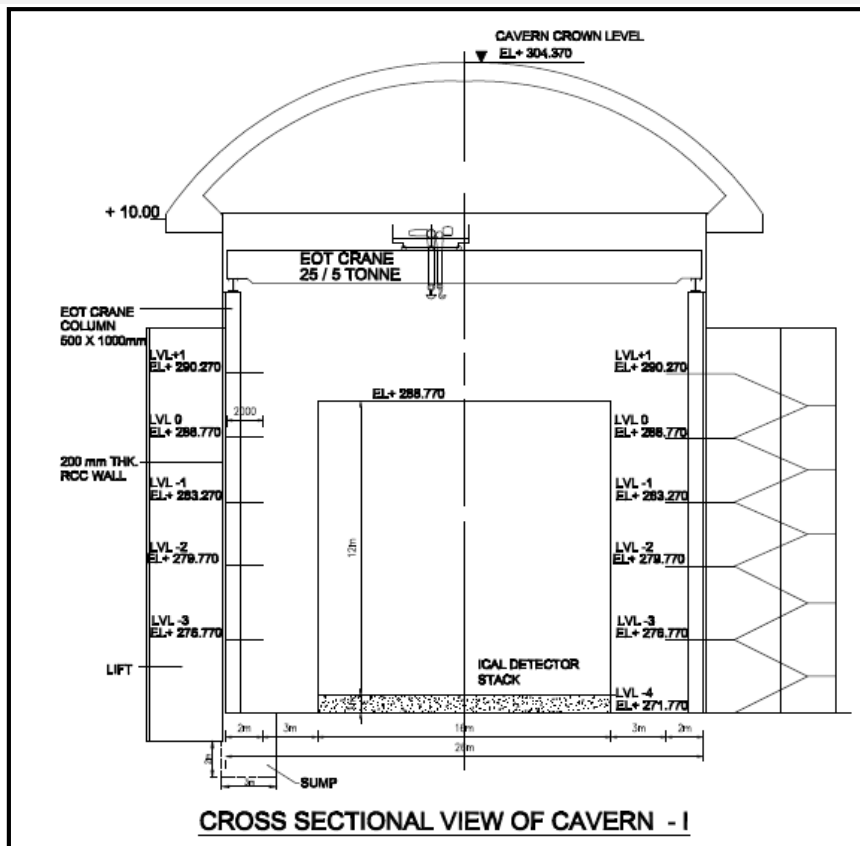


Figure 5: Cross Sectional View of Cavern – I

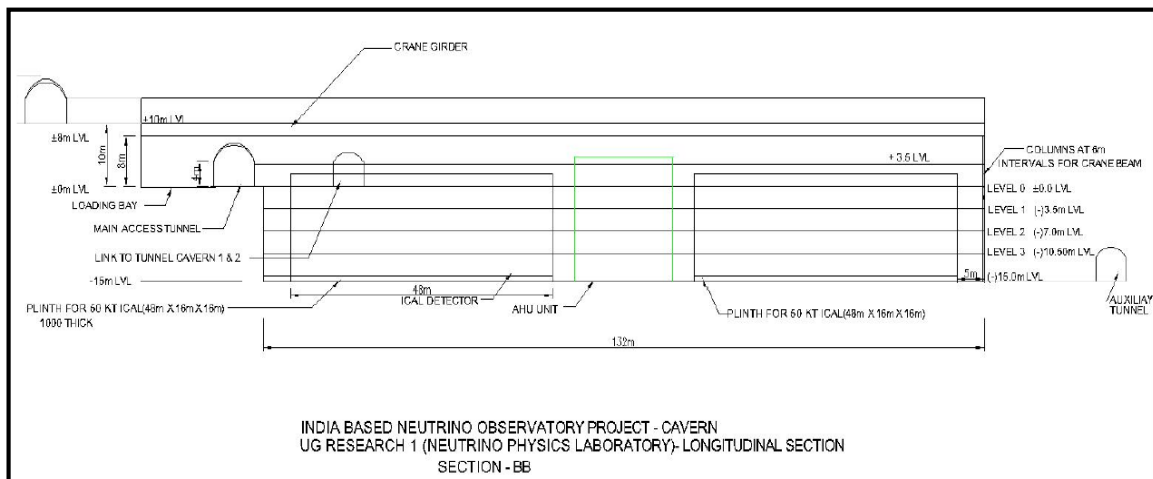


Figure 6: Section of Neutrino Physics Lab

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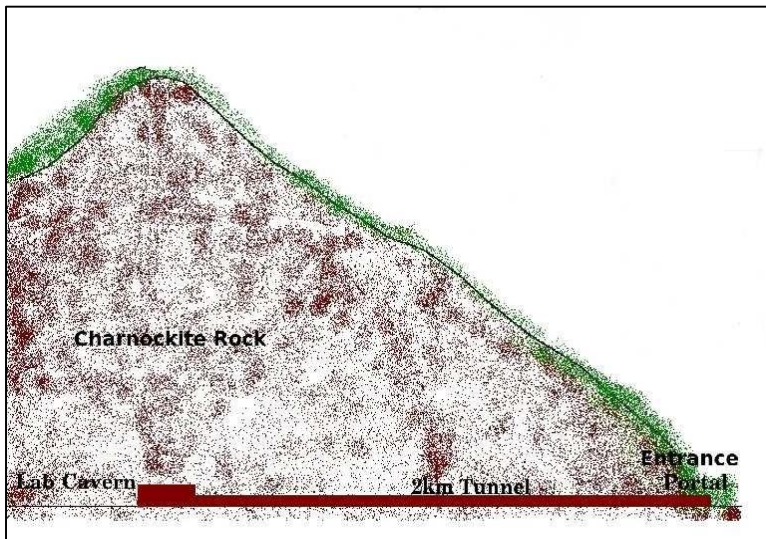


Figure 7: Schematic of INO Underground Lab

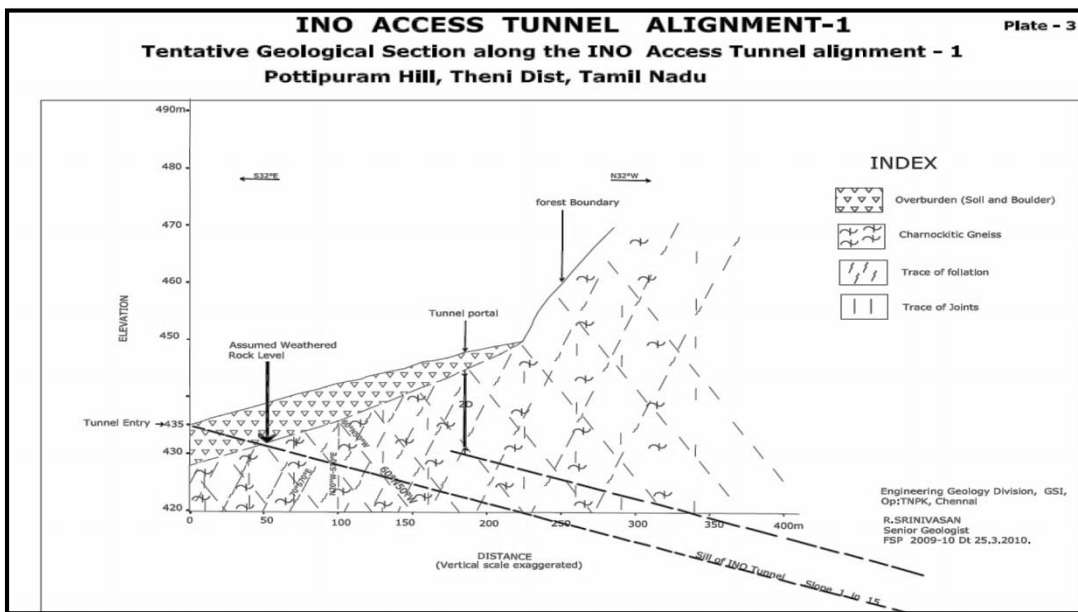


Figure 8: Geological Section along the INO Access Tunnel alignment-1

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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

4.3 Land Requirement and Area Statement:

Total Plot Area:

- Over ground 26.825 ha.
- Under ground 4.62 ha.

Built Up Area:

- Underground facility: 20,552 sq.m. (Laboratory caverns and tunnels)
- Over ground facility: 10762 sq.m. (Utility Building, Administrative building,
- Surface laboratory, Detector Assembly area, Guest House/Hostel and
- Housing up to 1+2 floors.

Poromboke land:

- Over ground facilities: 26.825 ha

Forest Land:

- Underground Tunnels & Caverns: 4.62 ha
- Over ground components: No Forest Land Required

Land component from private sources:

- Over ground components for connecting to the road near portal: 0.13 ha

4.3 Logistics and Material Requirements

Resource reqd.	Construction phase	Operations phase
Electrical Power	1 MW	3 MW (Rev. 4MW)
Materials: Cement Steel Aluminum/Copper Gas (R134a; isobutane, SF6) Fuel (petrol /diesel/LPG) PVC Blasting Gelatine Detonators	7500 tons 50000 tons (ICAL) 110/60 tons 200 m ³ (95:4.5:0.5) 45 tons and 5litres/day 40 tons 450 tons 360,000 nos	Diesel for DG Set: 5 litres/ hr in case of Power Failure

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4.4 Water Sources and Management

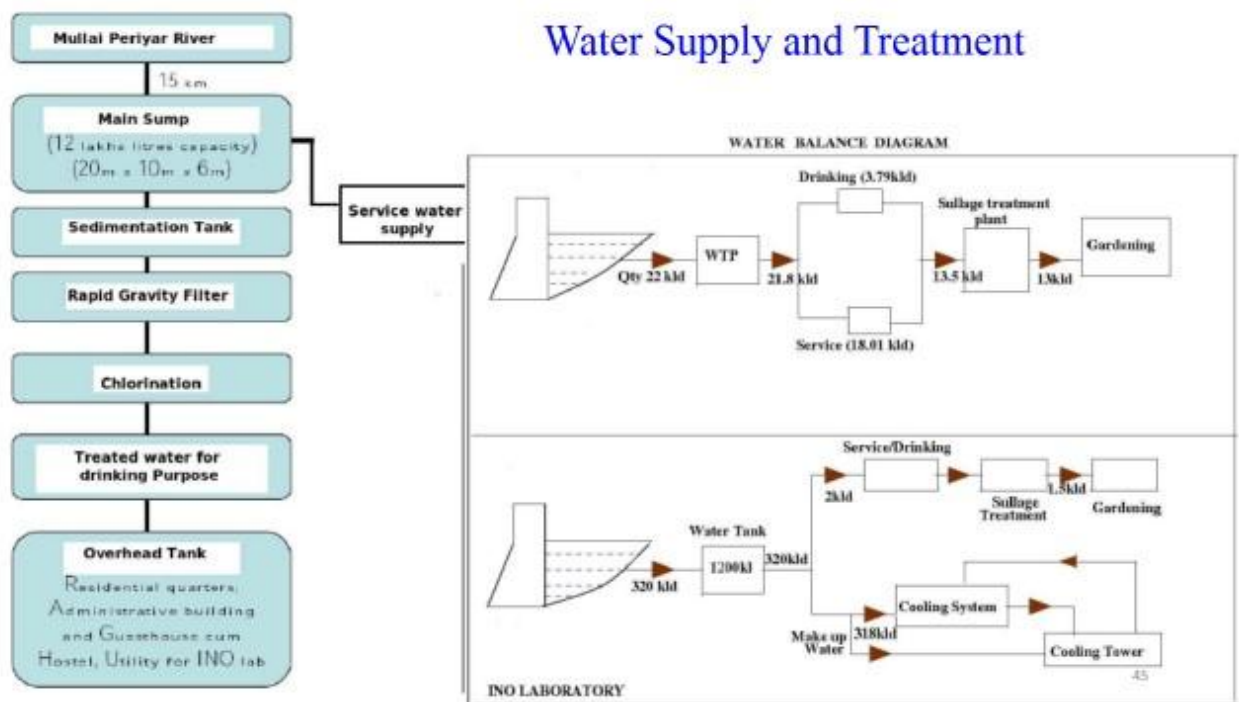
Construction: 50 m³/d

Source: water tanker

Operation: 340 m³/d

Source of water supply during operational phase is Tamil Nadu Water Supply and Drainage Board (TWAD) from Mullaperiyar River.

Figure 9: Water Balance Diagram



4.4 Proposed Facilities:

Table 2: Proposed Facilities

Underground Facilities	Surface Facilities	Temporary Facilities
Access tunnel portal	Utility service building	Tunnel muck transit yard
Access tunnel	Detector assembly building & surface Lab	Magazine to stack explosives
Auxiliary tunnel	Residential quarters	Diesel bunk
Interconnecting tunnel	Visitors hostel cum Guest house	Steel plates stack area
Additionally Driven	Administrative building cum workshop	Labour quarters
Intermediate Tunnel	Approach roads from the State Highways	Crushing unit for BG metal

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Underground Facilities	Surface Facilities	Temporary Facilities
Cavern-1	Future research center	Field office cum Guest house
Cavern-2	Main underground sump	Detector assembly shop
Cavern-3	Overhead tank	Weigh bridge
Cavern-4 (Intermediate)	Security building	
	Dedicated 110/11 KV Sub-station	
	Compound wall construction	
	Horticulture & Landscaping	
	Storm water drain	
	Internal roads in project complex	

4.5 Environment Setting:

Table 3: Environment Setting

Sr. No.	Particulars	Details
1.	National Park/ Wild Life Sanctuary in 10 km radius area	Mathikettan Shola National Park in Idukki District, Kerala – Within 5 Km from the proposed project site
2.	Eco-Sensitive Zone in 10 km radius area	Mathikettan Shola National Park in Idukki District, Kerala – Within 5 Km from the proposed project site
3.	Details of Forest land involved, if any	4.62 ha (notional). No over ground intrusion/ construction/occupation of forest land. Caverns and tunnels be will be deep underground.

5 PHYSIOGRAPHY OF THE STUDY AREA:

The proposed INO site is located in the eastern aspect of the southern Western Ghats. The Kodaikanal and Palni hills (~2000 m above MSL) are located to the north eastern part of the study site.

Climate	: Semi-arid
Average Temperature	: 18 ⁰ C to 35 ⁰ C
Average Annual Rainfall	: 800 mm to 1000 mm
Ecology & Biodiversity	: Dry deciduous vegetation
Plant	: 517 species
Endemic	: 34 Species of Plant
IUCN Red-listed medicinal plants	: 09 Species of Plant

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Endemic & New record for TN	: 01 Species of Plant
Rare, endemic and endangered	: 2 Species of Plant
Amphibians	: 14 Species (All LC)
Reptiles	: 27 Species (EN: 01)
Birds	: 137 Species (NT: 11, EN: 2, CE: 2)
Mammals	: 54 Species (EN: 7, NT: 7)
Butterflies	: 59 Species (Endemic: 3)

6 GEOLOGY

- ❖ The proposed site is located on the eastern fringe of the linear Western Ghat hills and is close to the Kerala - Tamil Nadu State boundary.
- ❖ The hill slope is rocky from peak to plain and is cover with sparse forest vegetation in patches.
- ❖ The rock mass characteristics of the hill appear to be homogeneous all around the hill and no sharp variation is seen in the geological conditions along the hill slopes of eastern side.
- ❖ No major adverse geological features are seen.
- ❖ Tunneling media (Charnockitic gneiss) is hard, fresh and with 3 to 4 sets of joints
- ❖ Rock mass quality is related to be 'Good' and tunneling is prognosticated to be smooth with some light support like Rock bolt, shot Crete, etc. in the low cover reaches

7 PROJECT COST:

Civil and Infrastructure	: 300 Crores
ICAL-Detector set-up	: 845 Crores
IICHEP Madurai	: 45 Crores

8 WASTE GENERATION:

Table 4: Waste Generation

Sr. No.	Sector	During Construction	During Operation
1.	Solid Waste	Muck from Excavation (Total 2.30 lakh cu.m)	Domestic and lab waste (36 kg/day)

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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

		Sewage/sullage products	Biodegradable waste (21.6 kg/day will be processed in OWC
		Construction scrap	Non-biodegradable waste generated 14.4 kg/day to authorized local vendor.
2.	Air Environment	Transport of loose material/debris	Domestic fuel
		Vehicle/equipment from blasting	Dust DG sets exhaust
		Dust from crushers	RPC gas mixture
		Domestic fuel	
3.	Noise and Vibration	Noise generated during excavation, loading, unloading and transportation of material.	Max. noise level : 40-45 dB (A)
4.	Water	Water requirement : 50 CMD	Water requirement : 340 CMD (Domestic & Misc. 20 and Cooling water 320 CMD)
		Sewage generation: around 5CMD	Sewage generation: 15 CMD
		Runoff of muck/debris	Water requirement: 340 CMD (Domestic & Misc. 20 and Cooling water 320 CMD)
		Seepage/wash water from tunneling/construction	Sewage generation: 15 CMD

8.1 Waste Disposal Facility

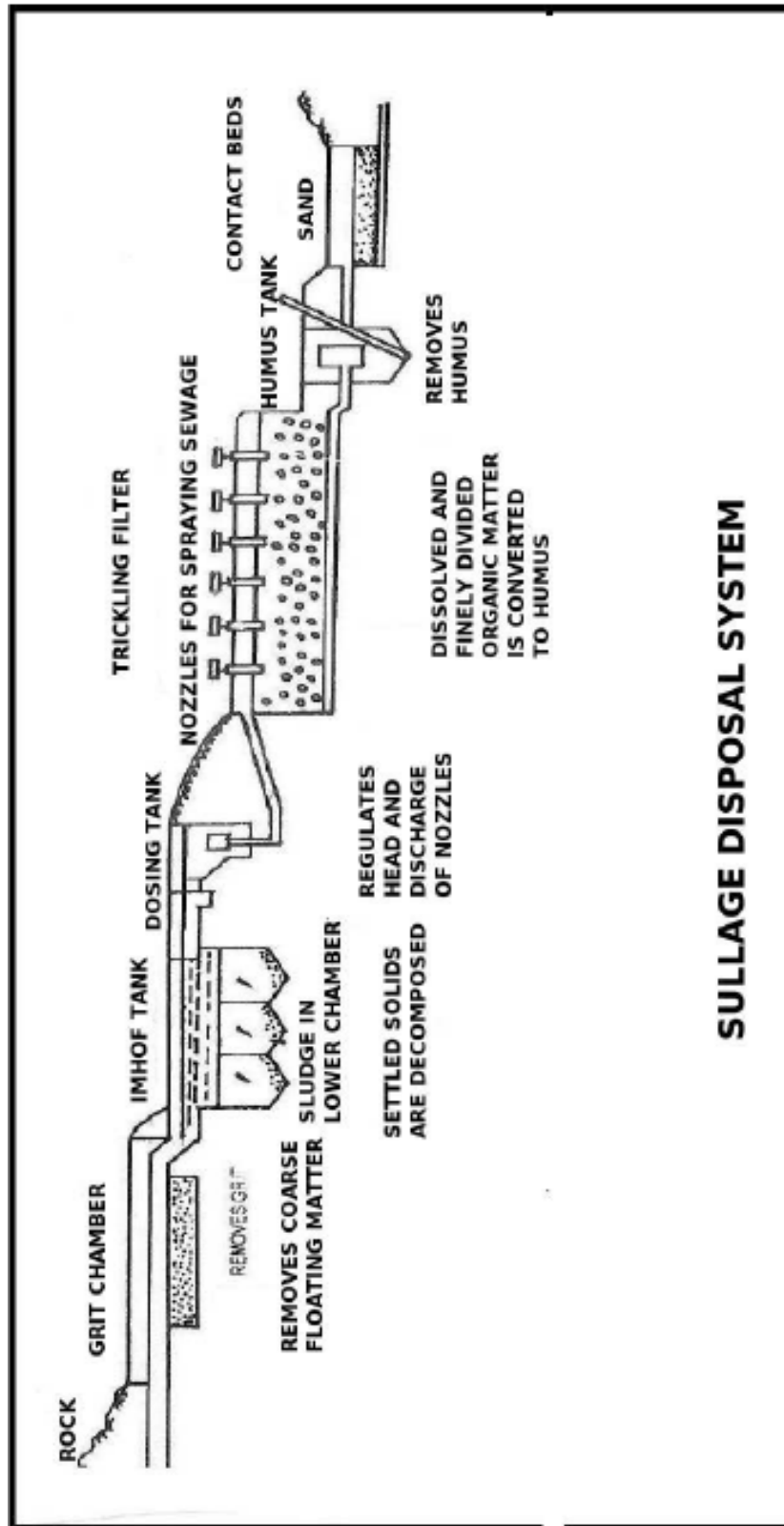


Figure 10: Sullage Treatment Plant

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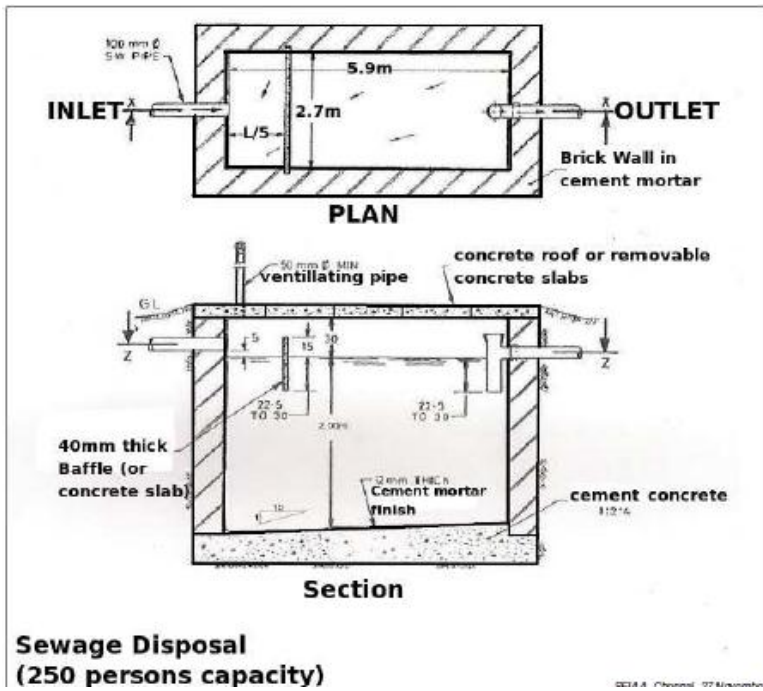


Figure 11: Sewage Disposal System

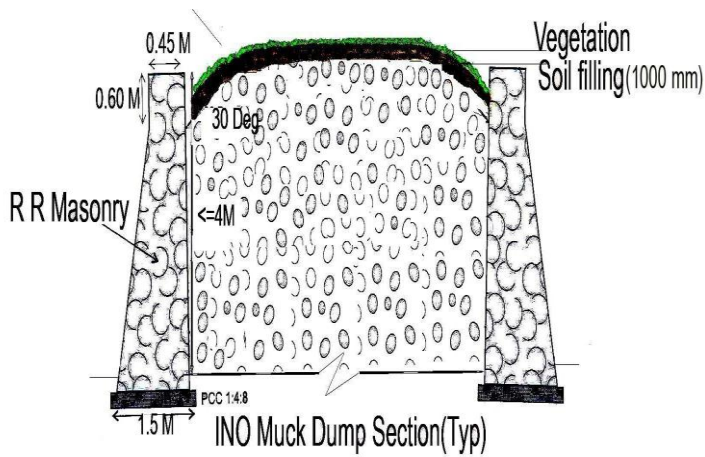


Figure 12 : Muck Storage Yard

9 MITIGATION MEASURES:

Table 5: Mitigation Measures

Aspects	Mitigation measures	
	During Construction	During Operation
Land Environment & Solid waste generation	<ul style="list-style-type: none"> • Rainy season will be avoided for cutting and filling of earthwork. • The use of explosives for controlled blasting will be limited. The major excavation will be by earth moving equipments. • A portion of muck will be utilized for the project construction work. • Tunnel muck area of 2 ha will be made into 2 segments each to facilitate simultaneous loading and lifting of tunnel muck • Rest Muck will be preferably dispose off daily with the help of District Revenue authorities 	<ul style="list-style-type: none"> • Biodegradable waste (21.6 kg/day) will be processed in OWC • Non- biodegradable waste generated 14.4 kg/day to authorized local vendor.
Air Environment	<ul style="list-style-type: none"> • Use covered vehicles wetting while unloading • New efficient vehicles/Equipment • Tunnels properly ventilated • The broken material will be wetted uniformly. • Water spraying to capture airborne dust • LPG will be provided • Providing dust collectors for dust sucking • Retaining walls will be constructed upto 4 m height. GCI sheet will be provided to prevent the flying of dust. 	<ul style="list-style-type: none"> • LPG will be used • DG set will be in power failure only • RPC is Non-flammable, non toxic
Noise & Vibration	<ul style="list-style-type: none"> • Provision of acoustics hoods wherever possible on the construction equipment and regular maintenance of the equipment. 	<ul style="list-style-type: none"> • Max. noise level will be 40-45 dB (A)

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	<ul style="list-style-type: none"> • Recommend light and sound barriers to proposed activities/working areas. • The construction workers will be provided with the personal protective equipment like ear muffler, hand gloves etc. • Noise generating activities shall be restricted during day time only • Controlled blasting will be limited, as the major excavation will be by earth moving equipments. • The vibration due to the control blasting in the initial reaches of access tunnel will be negligible and it cannot be felt in the nearby habitat (i.e.) T.Pudukottai village which is at 1.2 km from the Tunnel portal. 	
Water	<ul style="list-style-type: none"> • No use of ground water for construction activities. Water supply through tanker. • Modular STP/Portable sanitation, treatment and disposal facility shall be provided at construction site. • Construction activities shall be restricted to non-rainy days only. • Treated water will be reused for plantation • Retaining walls around yard will be placed for runoff 	<ul style="list-style-type: none"> • Sewage will be treated in Sewage Treatment Plant • Cooling water will be recycled • Treated water will be reuse in flushing and gardening
Ecology & Biodiversity	<ul style="list-style-type: none"> • Forest land 4.62 ha for underground Tunnels & Caverns, no over ground intrusion/ construction/occupation of forest land. Caverns and tunnels be will be deep underground. • For all affected trees 1:3 compensatory afforestation will be done at designated plantation area • Construction material will be dumped on designated area. • Movement of vehicle will be monitored and blowing excessive horn will be prevented. • Restriction of construction activity 	<ul style="list-style-type: none"> • No negative impacts envisaged

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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

	<p>from dawn to dusk.</p> <ul style="list-style-type: none"> • Plantation of indigenous plant species to attract fauna like insect/ butterfly, bird etc. • Care should be taken not to disturb wildlife habitat. • Workers should be briefed about do's and don'ts like No hunting/poaching, vegetation burning, no collection of eggs, not to disturb any habitat within and outside the project area, off-road driving, speeding etc. • Training cum awareness program shall be conducted. 	
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10 ENVIRONMENT MANAGEMENT CELL:

All the environmental practices will be monitored by the project proponent. An organizational set up will be formed to ensure the effective implementation of mitigation measures.

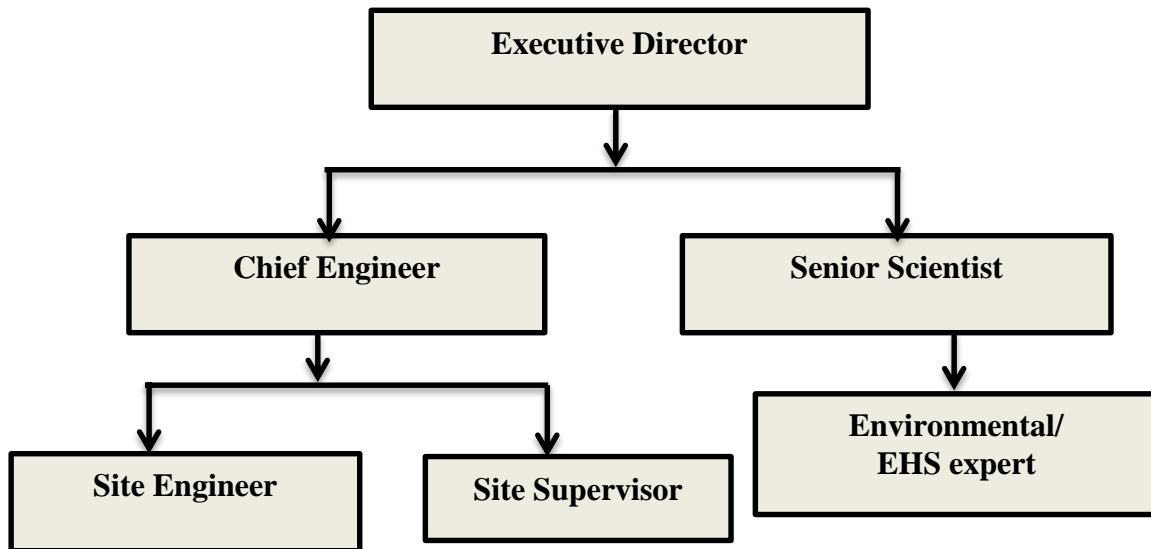


Figure 13: Environment Management Cell

11 RISK ASSESSMENT & SAFETY :

- The following areas are covered under risk assessment:
- Excavation & ground support
- Compressed air working
- Fire and smoke
- Firefighting and rescue
- Ventilation
- Dust
- Underground and surface illumination
- Operating communications
- Noise & vibration
- Lifting equipment
- Access
- Transport & loading
- Tunnel plant
- Electrical failure
- Maintenance & Repair

11.1 FIRE FIGHTING:

➤ **FM 200 system**

Control room in the cavern-2 being a manned area, it is proposed to provide clean agent system (FM 200)

➤ **Inert Gas Argon IG-01 system**

To avoid suffocation at the time of fire. Since the activity in Cavern-1 is sensitive to moisture, inert gas fire protection system is proposed. Two sets of cylinder bank arrangement (one set main and one set standby) using directional valve is proposed. Gas discharge is proposed to be done manually after verifying the real fire condition and by operating the respective manual gas discharge station.

➤ **Portable Fire Extinguishers**

Portable fire extinguishers Class-A, B & C have been proposed in utility building, Assembly shop, surface facilities etc., so as to fight fire in such areas.

11.2 SAFETY EQUIPMENTS:

- Canister gas mask
- Chemical cartridge type gas mask
- Self-rescue type gas filters
- Mechanical filters for dust nuisance
- Resuscitators
- Fire proximity suits
- Safety Helmets
- Face Shields
- Gas tight rubber goggles
- Torches
- Axes/Hand Saw
- Fire Blankets
- Gloves
- Ropes
- Ladders
- Safety belt

12 DISASTER MANAGEMENT PLAN:

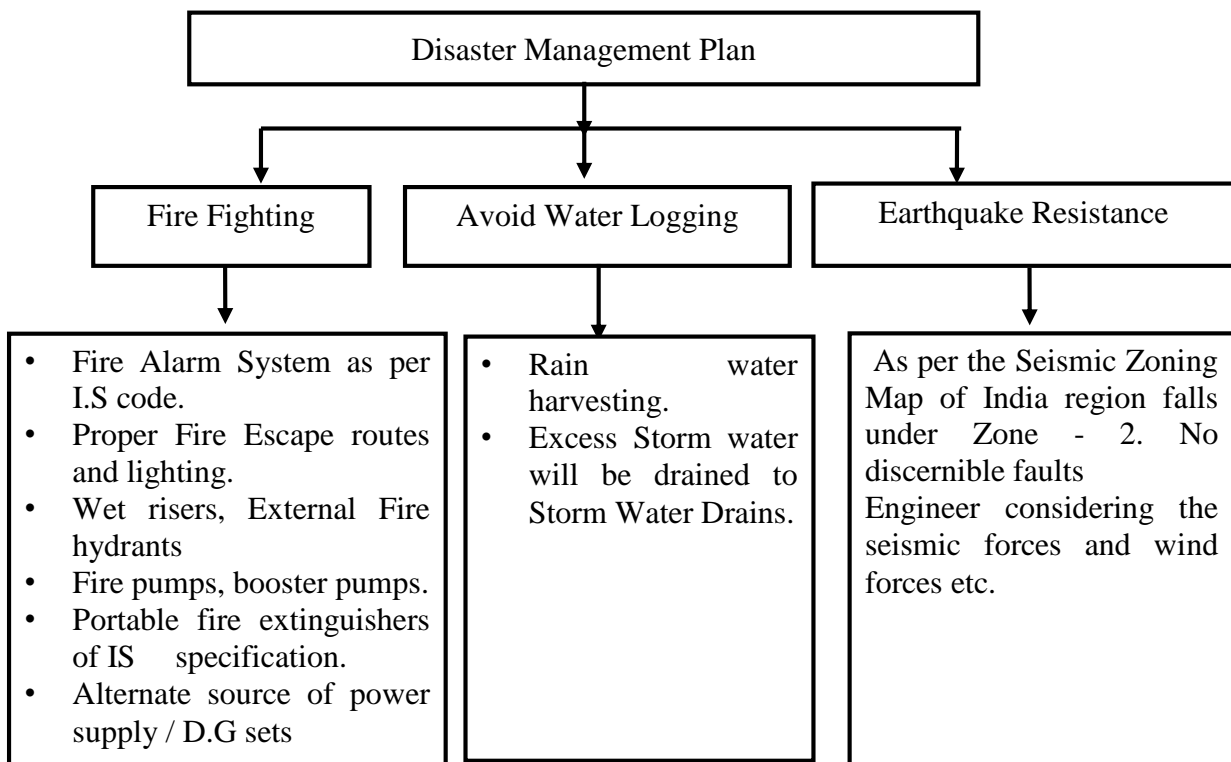


Figure 14: Disaster Management Plan

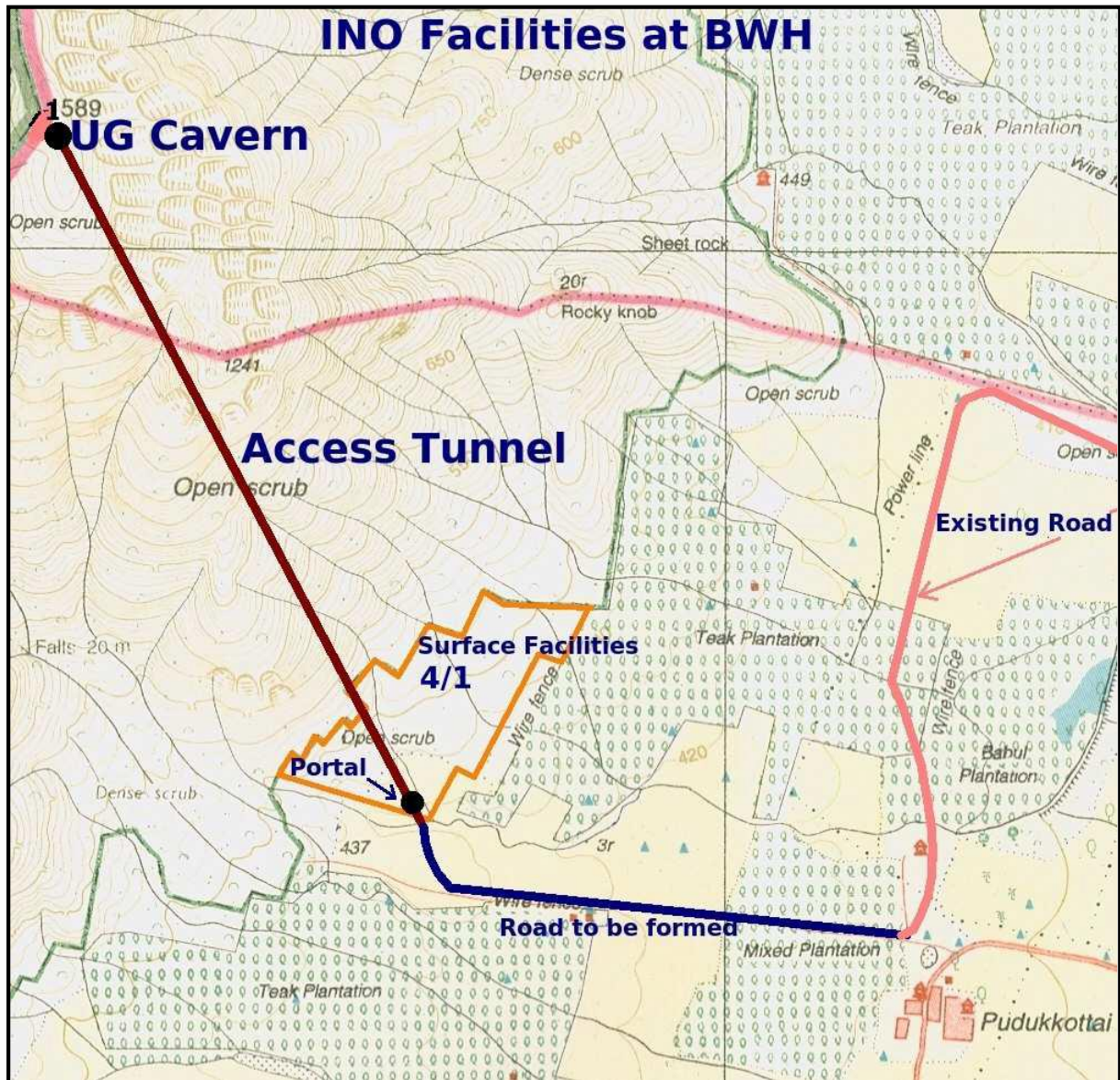
Annexure :

**Plan layout of residential and
office buildings on the surface**

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India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

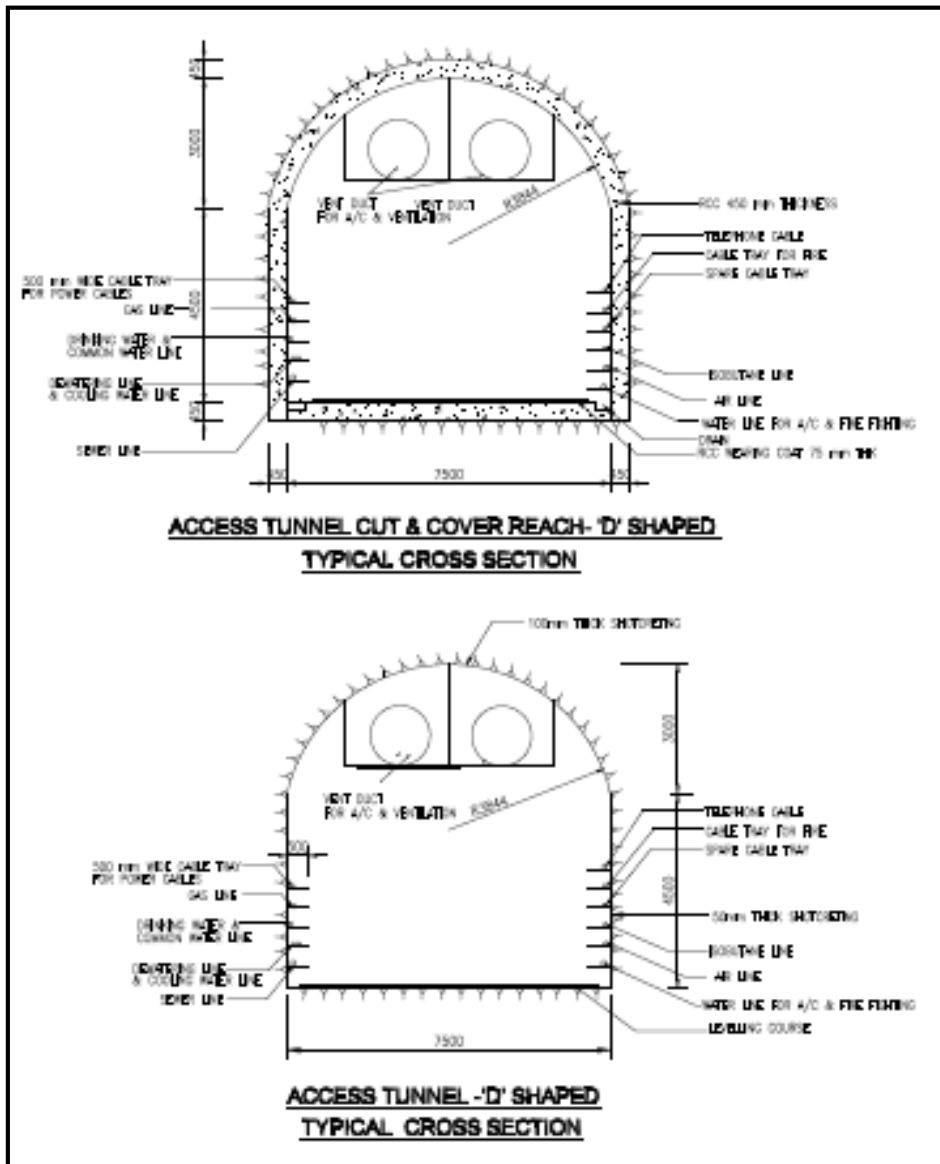
Annexure I INO Facilities at Bodi West Hill



CONCEPTUAL PLAN

India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

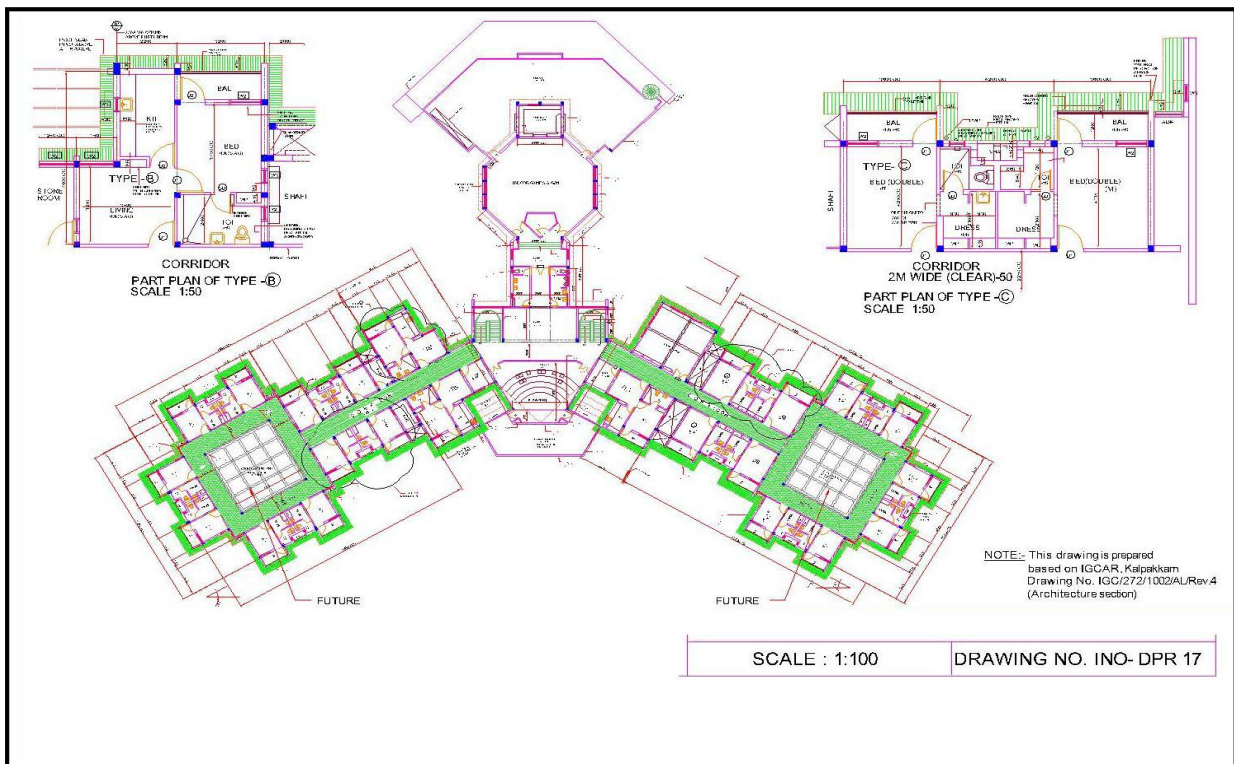
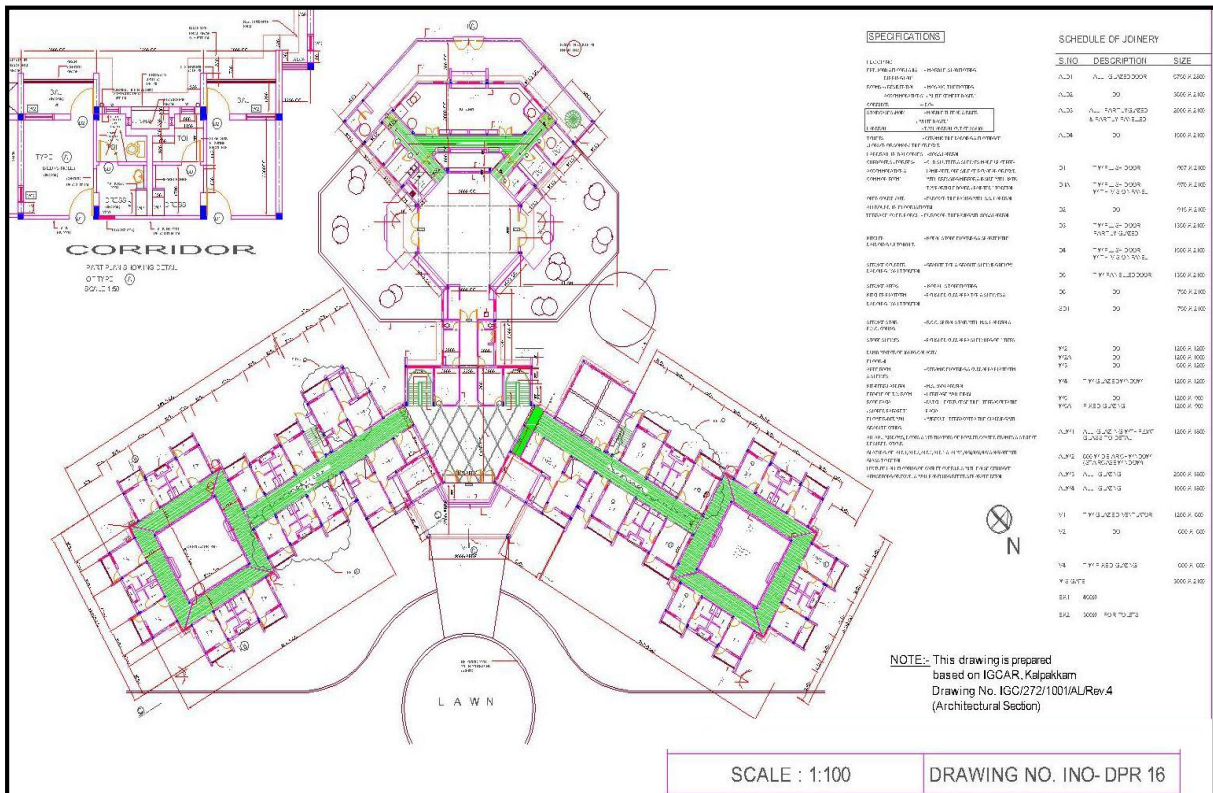
Annexure II Access Tunnel Layout



CONCEPTUAL PLAN

India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

Annexure III Hostel Layout

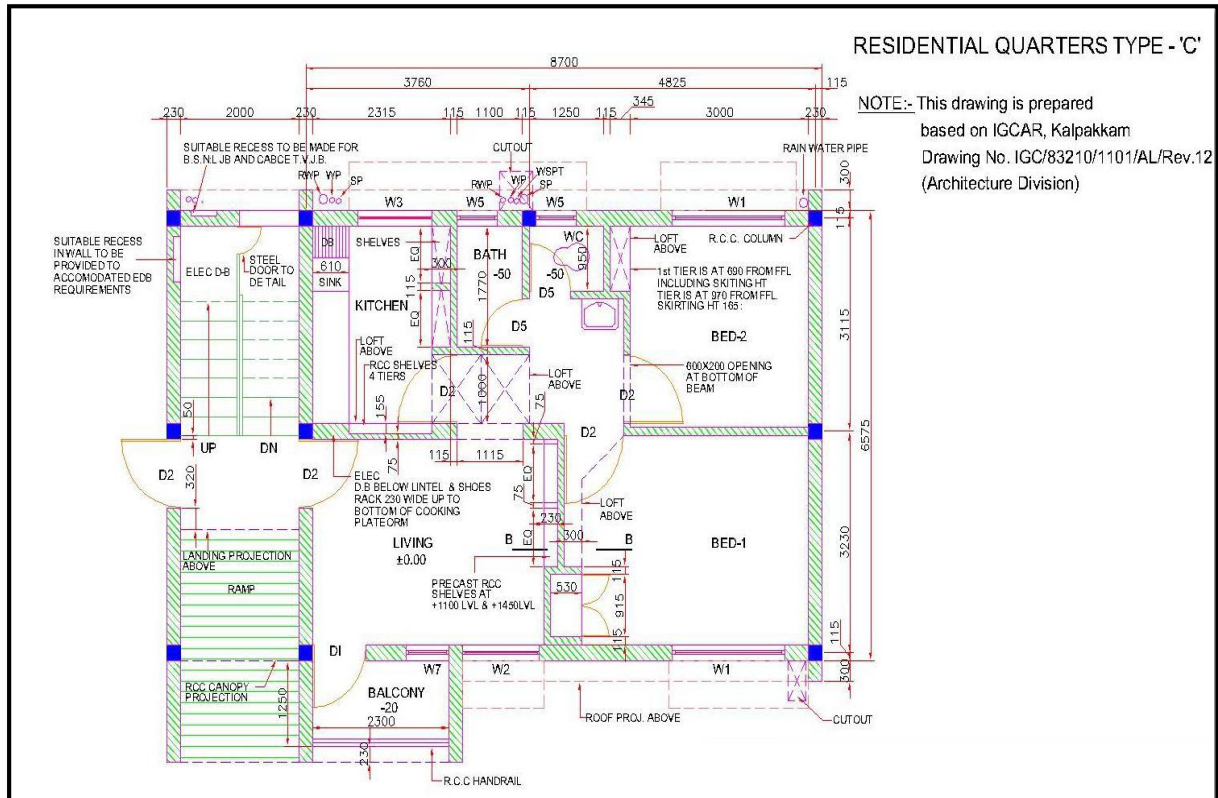
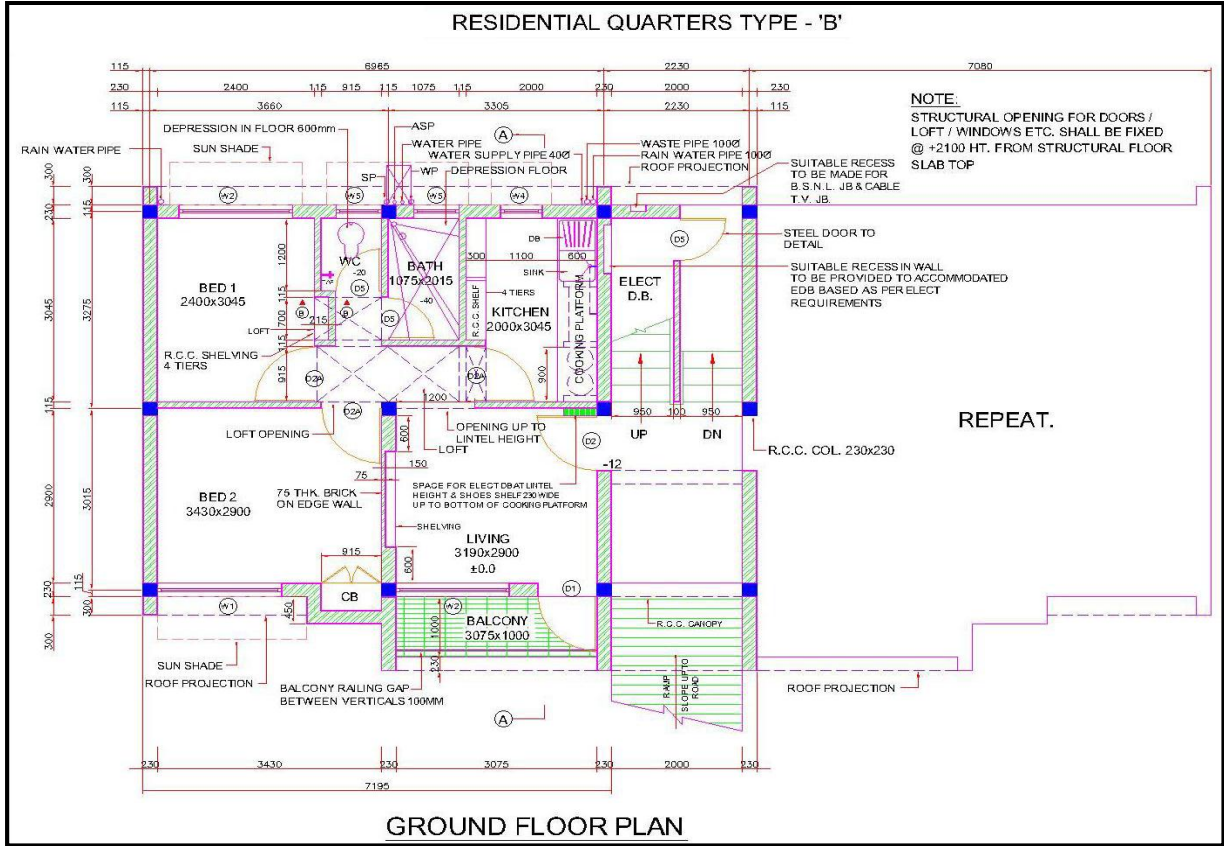


First Floor

CONCEPTUAL PLAN

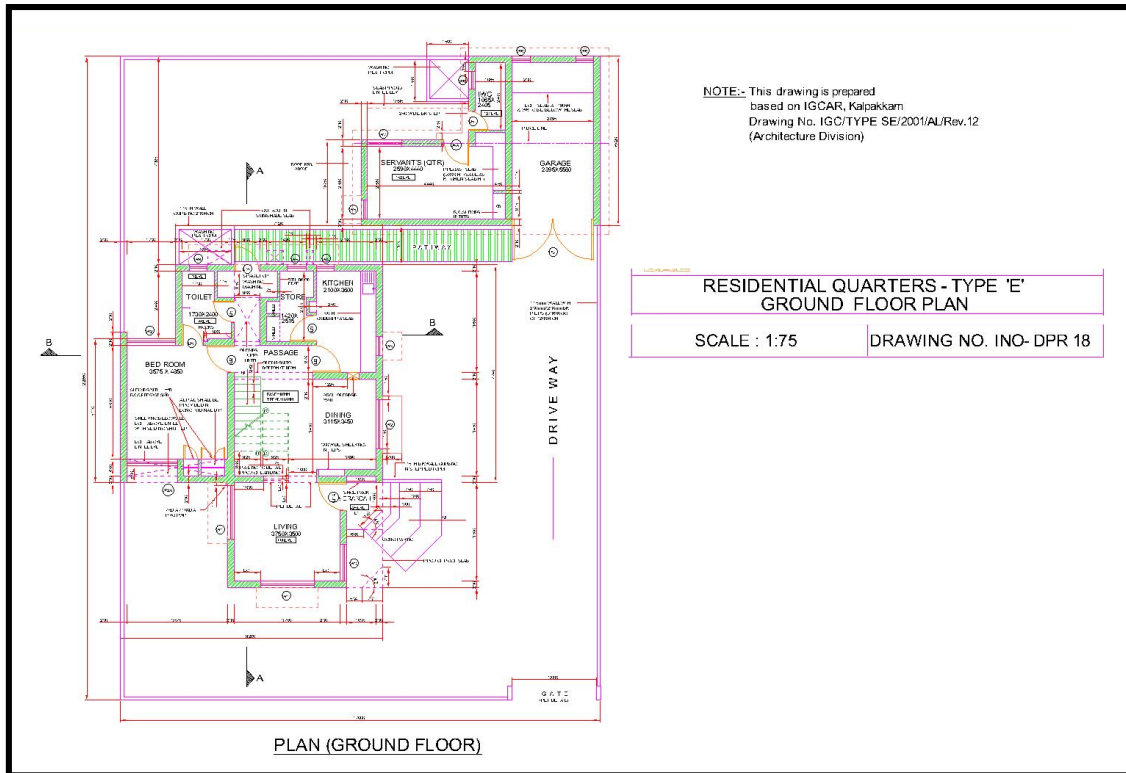
India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

Annexure IV Residential Quarters Layout Type B, C, D, E



CONCEPTUAL PLAN

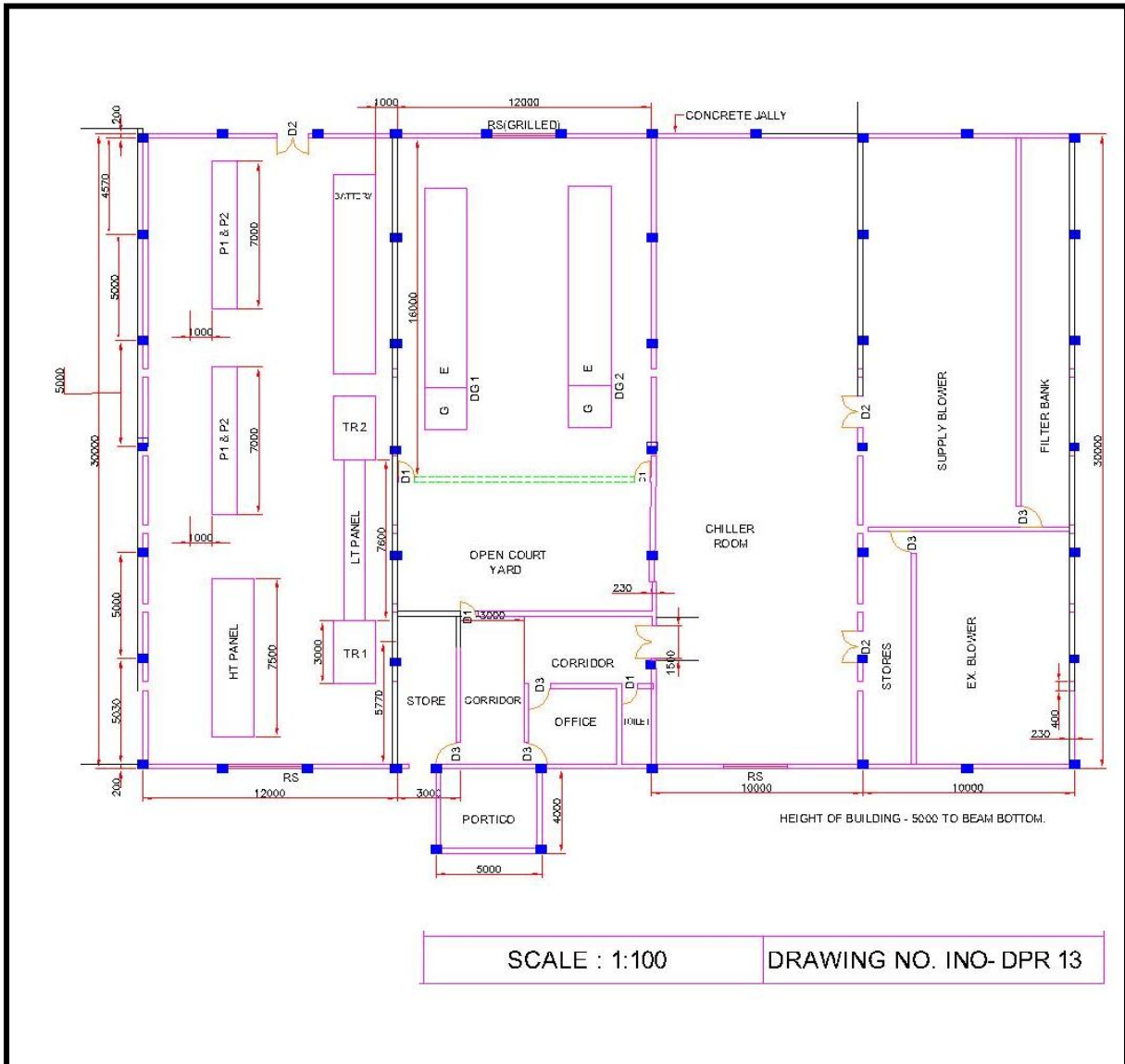
India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu



CONCEPTUAL PLAN

India-Based Neutrino Observatory at Bodi West Hills, Pottipuram Village, Theni District, Tamilnadu

Annexure V Utility Building Layout



**RISK ASSESSMENT
DISASTER MANAGEMENT
&
ENVIRONMENT MANAGEMENT PLAN**

India-Based Neutrino Observatory

At Bodi West Hills, Pottipuram Village, Tal.Uthamapalayam, Dist.
Theni, Tamilnadu

Tata Institute of Fundamental Research

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Preamble

A brief History of INO Project

INO collaboration emerged out of a grass root movement in Science with scientists coming together to build a world class observatory in India. The idea was mooted during a Workshop on High Energy Physics and Phenomenology in the year 2000. The INO collaboration was formed afterwards. It took many years to shape the scientific aims and objectives of INO. In particular every component of the detectors have been designed and developed indigenously.

Indian scientists were pioneers in Cosmic Ray and Neutrino Physics. KGF underground laboratory was one of the first such labs established in the world. INO is an attempt to revive this pioneering spirit. In particular, INO hopes to galvanise interest in science and science research in and around Theni and Madurai and in the whole of India as well. It is an opportunity for students to do cutting edge research, while being located in India, and for local students in colleges to understand the thrill and processes of doing basic sciences research.

Any such large basic sciences project has immense technological implications which will serve the larger interests of the society. The electronics and detector R & D done for INO has already generated an entire industrial interface with INO. This will have a cascading benefit over time.

It is reiterated that this is a basic sciences research project which is green project in every respect, with the primary goal of setting of a world class observatory where students and researchers have an opportunity to work on cutting edge of technology and science.

1. RISK ASSESSMENT & MITIGATION MEASURES

Risk Assessment & Mitigation Measures

Risk assessment of any given site normally done through five steps such as identifying hazards, to arrive at a decision as to who will be harmed and how, robust analysis of risks leading to risk assessment and taking corrective and control measures and documenting them. The hazards that one may face in any such project can be broadly categorized as falling under natural hazards or man-made hazards leading to disasters. At the proposed INO site the natural hazards identified are Subsidence, Flooding, and occurrence of earthquake while those associated with construction activities are also listed under this chapter.

1.1 Key Risks Identification & Mitigation Measures

Natural hazards

- Land subsidence
- Flooding
- Earthquake

Hazards identified & mitigation measures

Risks during Mining or Tunneling

- Falling of objects from heights
- Shotcreting/Lining of the tunnel
- Flooding inside the tunnel
- Lighting
- Risks due to Electrical equipment and installations - Fire
- Air pollution and ventilation
- Communication
- Traffic Risk
- Other Fire Hazards
- Constructional Risk
- Operational and Maintenance Risk
- Material & Manual Handling
- Impact on Wildlife Movement and Mortality

1.1.1 Natural Hazards

Landslide and Subsidence

The site is located in an area with a very gentle toe slope and from mid-slope to Crown of the hill is up of very massive rocks Slope forming material constitutes a thin veneer of soil, weathered rock and fresh rock. The vegetation is barren to supporting shrubs. The proposed Access tunnel will be driven through very good to good category of rock mass and the rock cover gradually rises to unlimited. The tunnel will be excavated by drilling and blasting method. The initial reaches will be through open excavation and therefore impact due to blasting will be at the very minimum and in view of the slope mass characteristics, no subsidence will occur. As the ground water is very deep and it is not proposed to draw huge quantity of ground water sudden subsidence will not occur. The open excavation will be a designed excavation based on the cohesion and angle of internal friction after a detailed stability analysis with required Factor of Safety and therefore landslide hazard is of a very low probability. Regionally no landslides are also reported.

During tunneling initially heading and benching will be adopted with suitable rock bolt and shot-crating making the mass as monolithic and therefore subsidence during tunneling with the available data is ruled out.

In addition to what is stated above, survey pillars constructed for the tunnel alignment purposes will be used for monitoring settlement and horizontal movement if any.

Flooding

The project area falls in a rain shadow area and experiences a low rain fall. There are no perennial streams crossing across the tunnel alignment. During construction of proposed access roads, improvements will be made to the existing cross drainage structures such as culverts etc. based on the maximum discharges of the ephemeral streams and wherever additional or new ones are required the same will be constructed. There will be training work for channelizing the flow which will completely prevent flooding in the area. Also, as the area is in the toe slopes of hills, the run-off will be for shorter duration and rapid.

Earthquake

The project area falls in the lowest Seismic zone of the country i.e. Zone II (BIS code 2000) and the major earthquake that has taken place in the area is the Coimbatore Earthquake of Magnitude 6 (1900) and the Nedumkantam Earthquake of 1988 of Magnitude 4.5. As the area falls in Stable Cratonic Region, the recurrence intervals of major events are too large. More over the project structures will be at a depth of more than 50m where the acceleration will be reduced to half of surface acceleration. All the over-ground structures will be designed to withstand the seismic forces appropriate to Seismic Zone 2 classification. The large cavern ceiling will be RCC lined. The access tunnel will be strengthened with RCC lining, wherever weak rocks are encountered. Shotcreting, rock bolting will be done for the main access tunnels.

For determination of stress conditions continuous Micro earthquake monitoring is intended to be carried out by a network of minimum 3 stations and the data gathered will be analyzed for the impending danger if any. From seismic considerations this is one of the most stable places of the country.

1.1.2 Man Made Hazards identified & mitigation measures

Falling of objects from heights

Rock falls occur during tunneling. They can be occasional, intermittent or continuous. Rock mass of the project tunnel as stated elsewhere in the report falls in category I and II which means good to very good category and therefore rock fall will be very rare. As a routine procedure, immediately after de-fuming, scaling of the tunnel will be carried out by which loose rocks released due to blasting will be removed manually. This takes care of nearly 90% of the rock falls in the present case.

This can be fixed by spot bolts which will be ready at the site. In addition, the area will be covered with wire nets or chain-links of proper dimension and in case of heavy fall concurrent shot-creting will be resorted to. All these mitigation measures will be available at site.

Shotcreting/Lining of the tunnel

The following elements constitute the risk while shot-creting. 1) During shot-creting objects can fall from heights 2) Rebound and dust 3) chemical additives and 4) bursting of concrete hoses. In order to minimize rebound and dust generation, the face or wall will be less than 1.5m, wet mix will be used with alkali free additives and also shotcrete machines with robots. Protective gear includes overalls, gloves, respiratory protective mass and goggles. All the spares required will be in situ to prevent time delay.

Concrete lining of the tunnel will done in accordance involved with codal procedures and also bearing in mind the safety of workers as primordial importance. Cleaning of surfaces with air/water jets, preparing the surfaces for concreting, transporting concrete into the tunnel at select reaches, shuttering, curing etc. will be carried out with all precautions. Protective gear for the workers include hand gloves, goggles, overalls, hard hats, gum shoes/boots recommended for mining standards, hard hats flood lights and torch lights. Supervisors and workers will be trained to devise methods for communication and warnings amidst noise and heat generated. First aid kit will also be placed in the vicinity for easy access and use in case of accidents. No woman workers will be entrusted with such tasks.

Flooding inside the tunnel

There can be trapped water in the rock masses which when excavated for tunnel can give rise to flooding depending on the head and quantum of water trapped. This normally happens if water barriers are present during the course of tunneling. They are also manifest signs such as sweating of rock faces, a very low oozing of water etc. If found then immediately drilling is carried out for inserting drainage pipes to channelize the seepage and flooding is prevented. In cases where there are sudden bursts of water, drainage pipes are driven into the tunnel and water is drained into the lateral drains and led to the sump.

Lighting

In order to have better visibility, so as to avoid accidents and help in carrying out all tasks properly, the tunnel needs to be well lit. In order to achieve this, fluorescent lamps, of minimum 40 lux intensity, spaced at 50 m are required. Also, a requisite number of generator sets of suitable capacity are kept ready as standbys, in case of power failure. Insulated power-lines with proper circuit breakers/MCB with proper earthing is considered a must.

Air Pollution and Ventilation

In order to de-fume the tunnel of gases released due to blasting for environmental preservation and workers safety the tunnel will be well ventilated. A blower fan with suitable duct diameter will be used for throwing and sucking contaminated gases. Besides this, adits driven and several mandatory openings created for project purpose will also facilitate and augment ventilation.

Traffic

Traffic control aims to give adequate warning and clear information to motorists about the nature of works on site. This will translate into correct actions required in order to pass the work site safely. Other than the vehicles operating at site, there will not be any dense vehicular movement through the site as it is located on foothills and roads lead to no important town or city etc. Hence the probability of occurrence of traffic accident due to density is of a very low order and therefore no special corrective measures warranted although general traffic rules will be strictly adhered to.

Inside the tunnel, to avoid accidents during construction, adequate lighting will be provided with suitable vehicle pockets of proper sizes staggered on either walls for vehicles passing over each other smoothly and appropriate warning signals will be in place about the curves etc.

Fire

The contractor shall ensure that construction site is provided with fire extinguishing equipment sufficient to extinguish any probable fire at construction site besides fire alarms. Recharging of fire extinguishers and their proper maintenance will be carried out regularly. All drivers of vehicles, foreman, supervisors and managers shall be trained on operating the fire extinguishers and firefighting equipment. Necessary mock drills will be put in place.

Toxic gases

During operation phase, the Underground facilities will have forced ventilation (about 0.5 air changes per hour) even though there is no activity releasing toxic gases. Ventilation systems will have stand-by units. In case of Mains failure, DG power will be used to run the system in low speed to prevent air stagnation. The caverns will have re-circulatory air conditioning system with adequate fresh air intake from the ventilation system. The return air will pass through filters to trap any isobutene in the atmosphere around RPC detectors. The gas mixture will be purified and recycled.

Communication

All the workers and watch and ward and personnel involved with the project will be trained in communication in a professional manner. Training will also be imparted about coping with emergencies, accidents, evacuation and getting in touch with identified contact person/authority without panic or hesitancy. Periodical safety meetings will be held, assignments of responsibilities, changes will be duly communicated/updated. All the activities will be documented properly with the help of site registers.

A two way telephone system will be put in place at all working faces with communicated telephone numbers to all concerned.

In the operation phase, vehicles of capacity equal to the number of people working in the caverns at any given time will be positioned round-the-clock, just outside the caverns, to ensure quick exit. All personnel will be advised to get driving license. At any given time, (when persons are working in the caverns) at least one person with valid driving license will be available in the working crew

1.1.3 Constructional Risk

General precautions to be maintained by the Contractor: Ensure health, safety, and welfare of all workers while at work, including:

- A. Maintenance of safe systems and without risks to health
- B. Safe use, handling, storage and transportation
- C. Information, instruction, training and supervision for health and safety
- D. Safe working environment
- E. Provision of Safe articles for use and without risks to workers
- F. Necessary tests and examination for the use of articles before works
- G. Elimination/minimization of risks to health and safety wherever necessary
- H. Application of suitable methods for prevention and accumulation of dust and fumes

1.1.4 Operational and Maintenance Risk

Proper maintenance is essential for reliable and smooth operation of project in order to maintain its function as a key infrastructure that serve as network to the nation. Improper maintenance works would increase hazards that lead to accidents associated with human, damage of property and environment as well as boosting the operational cost.

The top five-workplace hazards that have been discovered by OSHA (2010) are (Ref. Occupational Safety & Health Administration, United States Department of Labor (OSHA) (2010) Hazards – Young Workers. Accessed from <https://www.osha.gov/youngworkers/hazards.htm> l)

Electricity – one of the greatest hazard for worker who expose to power line task at workplace

Excavation and trenching – the most recorded fatalities at site operation

Scaffolding – the most common accident during construction and maintenance work

Falls – the most dangerous accident that causes from slipping, tripping, falling objects and unstable work platforms

Heavy equipment – main accident cause of struck by, collision, overloading, overturning

Medical Aid

A primary health center , manned by a medical attendant, will be established at the INO campus to provide first aid and emergency care for the staff and residents.

The nearest Government hospital is located at Kuppanancheri, about 6 km from site. It has basic facilities to attend to the needs of INO personnel. Further medical care is available at Bodinaickanur (18 km away) and at Theni, (the district capital) about 35 km away where there is a government medical college and hospital.

1.1.4.1 Risk factors associated with detector components and physics issues

The detector is a static detector and observes naturally occurring particles called neutrinos. The major components of the magnetized iron calorimeter (ICAL) detector are magnetized iron plates and the active elements called resistive plate chambers (RPCs) with associated electronics where the signals are received. The detector that is proposed to be installed in INO is about 50 ktons, mainly iron sheets, interspersed with active detector elements called resistive plate chambers (RPCs). Iron comprises about 98% of the detector by weight. The entire detector is passive and will simply give an electronic pulse when a charged particle passes through. This is because the RPCs are at a high DC voltage and the gas inside the RPC discharges when a charged particle (such as an electron or muon) passes through it; this is registered as a pulse in the associated electronics.

1.1.4.2 Risk factors for RPCs

The RPCs are sealed chambers of 2X2 m² glass plates separated by a gap of 2 mm with gas mixture of R134a (95%), isobutane (4.5%) and SF6 (trace) flowing through them in a closed loop at just a little above atmospheric pressure and a total volume of 200 m³.

The gas mixture is non-toxic and non-inflammable. Since it is heavier than air, it can settle down to the bottom of the room. The main safety concern is therefore asphyxiation in the case of leakage of the gas: this will be monitored by gas leak monitors. Given the cavern dimensions of the cavern that will house ICAL (132 X 26 X 32.5 m³), even if the entire inventory of gas leaks out accidentally, this will form a layer about 6 cm thick at the floor level and hence the risk of asphyxiation is very low. The leaked gas can be safely mixed with air and taken out.

The main gas component, R134a, is a commonly used refrigerant. As per its Material Safety Data Sheet (MSDS), it is barely soluble in water (0.15% by weight) and so in the case of a simultaneous leak of water from the coil cooler and gas from the RPCs, a small fraction of the gas can dissolve in the water. There is no reaction; it just partially dissolves. R134a is non-flammable. While its ozone depleting potential is zero, its global warming potential is 1200. Potential health hazards include irritation of skin and eyes, while toxicity due to inhalation (unlikely due to its low boiling point -26 degrees) is low in animals. When oxygen levels in air are reduced to 12-14% by displacement, symptoms of asphyxiation, loss of coordination, increased pulse rate and deeper respiration can occur. Its autoignition point is greater than 750 degrees and so its fire risks are negligible. Isobutane is used in 4% concentration; it is a flammable gas which is also negligibly soluble in water with no adverse ecological effects expected. Its lower and upper flammable limits are 1.8% and 8.4%; hence when it is used in 4% concentration it is non-inflammable.

Mitigation:

The gas is circulated in closed loop form. In case of leakage, the gas is mixed with many times its volume of air due to relatively small amount of gas compared with volume of cavern and can be safely flushed out. In case of exposure of personnel, skin and eyes can be flushed with warm water and personnel can be moved to room with fresh air.

1.1.4.3 Risks associated with Magnet assembly and operation

The magnet comprises sets of copper tubes wound around the iron plates with high current passing through to form an electromagnet. The tubes are hollow and carry cooled water to dissipate the heat.

Magnet

A magnetic field of upto 1.5 Tesla exists in the iron plates, and the fringe magnetic fields in the gaps between layers has been studied through simulations and in a prototype to be about 0.05-0.1 T just outside the plate and rapidly decreases away from it. Hence the field outside ICAL is negligibly small so it is possible to safely stand just outside the detector with no effect of magnetic field. For comparison note that typical MRI machines have magnetic fields also at about 1.5 T, but can vary between 0.2 to 7T. The ICAL magnet can be demagnetized by just switching off the current.

Mitigation

Humans (as evidenced by MRI scans) are well able to withstand these magnetic fields. In contrast to MRI machines, since ICAL has very small fringe fields, people can work normally and safely around it, in fact, without even needing to remove their watches or metallic earrings, etc.

Water cooling for the magnet:

Low conductivity water (LCW) is used to cool the magnets. The LCW is part of a closed loop which through a heat exchanger is cooled by chilled water that dissipates heat through a cooling tower outside the tunnel. The latter is also used for the Air Conditioning of the cavern.

Mitigation

The copper conductor and rubber hose pipes used in the cooling process can withstand the pressure upto 20 bar. All the precautionary measures will be taken into consideration to reduce the chances of leakage. Even in case of any eventuality of water leakage, following are the ways to sense the leakage or pipe burst:

- a) Return line water flow will show no flow and thus Interlocks will be activated.
- b) In case of small leakage of water, the presence of water in container will be sensed with appropriate sensors.

In either case, as soon as the leakage is detected, the supply pump will be switched OFF with an audio alarm. The spilled water could then be either pumped out or reused. There is no hazard if spilled water accidentally enters the RPC; this can damage the RPC (actually just reduces its efficiency).

1.1.4.4 Radioactivity

There is none. ICAL at INO will be a passive magnet. Just like a telescope studies the sky passively in visible spectrum, ICAL will study the sky through neutrinos. It will study neutrinos that are already there from various sources, especially Earth's atmosphere.

Mitigation

None required.

There were concerns raised about INO being a possible nuclear waste storage site or about a possible neutrino beam from a neutrino factory from a distant site to INO. The first issue about nuclear waste storage site was never under consideration at any time and was a misinformation campaign. As to the latter issue, the key point to note is that neutrino beams (which exist, unlike neutrino factories that do not), are produced from high energy proton beams which require shielding. However, the radiation is localized to just several meters from the production point. After a distance of a few hundred meters there is no radiation risk. Since the production point is several thousand kilometers away (million meters away) there is no radioactivity in the neutrino beam, even if such a beam is built. As has been mentioned in the FAQ, there is no longer a physics motivation to build such a beam and the international neutrino physics community is not discussing such a possibility since 2012. In any case there is no radioactivity and hence no mitigation of risk required.

To reiterate, we are not creating any sources of neutrinos: just studying what is naturally there. Neutrinos themselves are harmless since they are so weakly interacting. Even neutrinos from neutrino factories that may be built much into the future (though it is not motivated by current physics knowledge) will not harm either the environment or humans. In fact, the radiation due to neutrinos from a typical future neutrino factory will amount to a miniscule 0.00000001 mSv to be compared to average exposure of 1 mSv per year from natural radioactivity. That means you have to expose yourself to the neutrino beam for crores of years before you accumulate the dosage the other natural radioactive sources give you in a year.

It must also be noted that the energies of all these particles are negligible compared to those experienced in daily life. Typical energies of detected neutrinos at INO will be 1--10 GeV. Note that $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$ and $1 \text{ GeV} = 10^9 \text{ eV}$. A flying mosquito has an (kinetic) energy of about 1000 GeV. The energy produced when a pencil falling from 1 cm height hits the ground is 1 crore times more than that of the neutrinos.

There has been much talk about neutrino weapons but this is, as of now, and for the foreseeable future, merely science fiction.

1.2 Disaster Management Plan- On-Site Emergency Plan

1.2.1 Scope & Objective

1. Preliminary Hazard Analysis of all the operations including handling of hazardous substances. This would indicate the scale of the worst impact of an emergency, which might take place and its Off-Site implication if any.
2. The fire/explosion/toxic and health characteristics of chemical/materials handled, processed and/or stored in the premises and various extinguishing agents, control measures and medicines/antidotes required reduce/eliminate the destruction and casualties which may result because of disaster involving such chemical/materials.
3. Liaison with outside authorities including emergency services.
4. Procedures of alarm raising and communicating the same both within and outside and works.
5. Appointment of key personnel, works incident controller and site main controllers and other key personnel and their responsibilities and duties towards controlling the emergency.
6. Setting up of Emergency control centre.
7. Action on Site.

1.2.2 The Objectives of the plan covers:

The primary objective of the emergency procedure is to safeguard the life of the personnel working in the premises, property, infrastructure, etc. and minimise business loss. The other objectives of On-site Emergency Plan are:

1. To control the emergency, localize it and if possible eliminate it.

2. To avoid confusion / panic and to handle the emergency if arises with clear instructions / guide lines.
3. To minimize the effects of the accident/ incident on people and property and also to minimize the damage to the environment in and around the premises.
4. Evacuation, Rescue operation and Head count of personnel.
5. Treatment to be given to injure & mobilization to the hospitals.
6. To Preserve records and take appropriate steps to prevent recurrence.
7. To minimise business loss by quickly restoring operations.

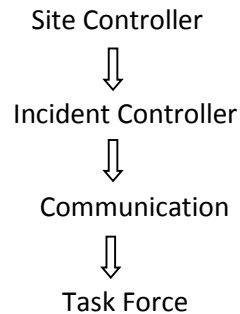


Figure 1: Organization Chart for On-Site Emergency Plan

Note-1. The Apex body for disaster and safety Management will be the Disaster and Safety Management Council. The Head of INO activities at Pottipuram/Controller will be the chairperson. He/She will be responsible for, Safety audits and getting mandatory approvals.

- Initial and refresher training of personnel in disaster and safety management.
- To ensure that all related systems and practices are in place and in working condition all the time.
- Coordination with district level authorities for mutual benefit.

All the other employees will assemble at the emergency assembly points. In case of the incident, Controller being present on site, the standby personnel will report to him/her for directions. Detailed information will be filled in when the site gets operational.

All the other employees will assemble at the emergency assembly points.

Mock- drills

The Disaster and Safety Management Council will formulate procedures and conduct mock drills periodically to test the efficacy of personnel evacuation systems and practices in place. The periodicity and procedures will be continuously updated based on experience.

INO considers policies and procedures for Disaster and Safety Management as being of utmost importance and will dedicate efforts and resources to improve the related systems continuously

Table 1: Key Personnel of the Organization & Responsibilities Assigned to them in Case of an Emergency

Sr.No.	Designation
1.	Head, INO activities at Pottipuram
2.	Head, Safety and Disaster Management
3.	Chief of Security and fire services, Member, Disaster and Safety management council
4.	Senior-most electrical engineer, Member, Disaster and Safety management council
5.	Senior-most electrical engineer, Member, Disaster and Safety management council
6.	Senior-most civil engineer, Member, Disaster and Safety management council
7.	Senior-most mechanical engineer, Member, Disaster and Safety management council
8.	Senior-most resident operating scientist, Member, Disaster and Safety management council
9.	Senior-most Administrative/ Accounts Officer, Member, Disaster and Safety management council

Table 2: Information on Preliminary Hazard Analysis

Sr. No.	Hazardous area	Location	Hazard	How to Mitigate
1.	Diesel Generator Area	DG Room	Fire/Spill	Isolate the electrical & fuel Oil supply. Use CO2 / DCP type fire extinguisher. Call Fire and Security Team if required. Stop the leakage. Contain the leakage .Collect the waste and dispose Use adequate PPE.
2.	Electrical Substations	All Sections	Fire	Isolate the electrical supply and use CO2 / DCP type fire extinguisher, call Fire and Security Team if required. Use adequate PPE.
3.	Transformers	All Sections	Fire/Spill	Isolate the electrical supply. Use CO2 / DCP type fire extinguisher. Call Fire, Security and Ambulance (if any injury), Evacuate the area. Use Fire Tender foam if required. Stop the leakage. Contain the Leakage .Collect the waste and dispose. Use adequate PPE.
MISCELLANEOUS				
4.	Food Poisoning	Canteens	Multiple Casualty	Stop serving the food. Seal the affected food. Barricade the area.

India-Based Neutrino Observatory

				Contact Company Medical Advisor. Inform police and FDA and Hospital. Send affected patients to Hospital. Send the sample of food for testing to FDA.
5.	Sabotage, Terrorism, Civil Commotion, Air Raid, Arson, Riots, etc.	Anywhere in the Plant or Vicinity	Accident / Fire / Explosion / spill	Inform HR Dept. Call Fire and Security Team. In case of any casualty send to Hospital .Inform Civil Police. Stop the leakage. Contain the leakage .Collect the waste and dispose. Use Foam/ CO ₂ / DCP type fire extinguisher; Use PPE.
NATURAL CALAMITIES				
6.	Storm, Heavy Rainfall.	Anywhere in the Plant or vicinity	Electrical Short Circuit / Fire	Call Fire and Security Team. Isolate the electrical supply of the area. Check if anyone is trapped inside the area. Alert personnel and evacuate the area. Pump out water by using portable pump. Use PPE. A very low probability hazard
7.	Earthquake	Anywhere in the Plant	Major Accident	Alert all personnel and evacuate workplace. Rescue if any personnel trapped inside the debris. Carry out head counting at Assembly Point. Use PPE
8.	Lighting	Anywhere in the Plant	Electrical Shock / Fire	Evacuate the area .Remove the debris and damages. Reorganize the affected area. Send the affected personnel to Hospital .In case of any fire, use fire extinguisher. Call Fire and Security Team. Use PPE.

Description of Hazardous chemicals at site

Sr. No.	Name of the Hazardous Substances	Phase	Average Storage Quantity
1	Fuel (petrol, diesel, LPG)	Construction phase	45 tons
	Fuel (petrol, diesel, LPG)	Operation phase	5 litres/day
2	Blasting gelatine	Construction phase	450 tons
3	Gas (R134a, isobutane, SF6)	Construction phase	(95:4.5:0.5) 200 m ³
4	Gas (R134a, isobutane, SF6)	Operation phase	As required

1.2.3 Emergency Control Centre (ECC)

- a) During normal working hours – Security Office.
- b) During other period including holidays – Security Office.

For the purpose of handling emergency, the Security Gate will be the Emergency Control Centre. All communications will be through the ECC.

1.2.4 The Emergency Control Centre will contain:

1. A copy of the On-Site Emergency Plan.
2. List of important telephone numbers such as Police, Fire Brigade, Hospitals, and OEP Team Members.
3. Address and Telephone Numbers of the Directorate Industrial Safety and Health (DISH), State Pollution Control Board (SPCB), Office, etc.
4. Dedicated internal telephone (Intercom).
5. Portable P.A. Systems, Manual Siren, Torches, Shovel, Manila / Nylon Ropes, Fire Blankets, Self-Contained Breathing Apparatus, Full Face Cartridge Mask, Fire Retardant Jackets, First Aid Box, Plastic Chains / Tape for Barricading, Glow Sticks and Emergency Lamps etc.
6. Note Pads, Pens, and Pencils to record messages received and any instructions for delivery by runners.
7. Attendance Register.
8. White Board with Pens.
9. Premises layout indicating Storage of Hazardous Materials.

1.2.5 Potential hazard cases considered

The plan has been drawn up keeping the following potential hazard cases.

1. Fire
2. Leakage
3. Food Poisoning.
4. Natural Calamities.

Disaster potential at INO

Sr.No	Cause	Damage potential	Comment
1	Earth Quake	Very low	The site falls under seismic zone 2. The main facilities are located deep underground (about 1290mrs below ground) in very stable rock.
2.	Flood waters due to rain/flash floods	Very low	The site falls in rain shadow area. Average annual rainfall is low. The terrain allows rapid draining of water. No river is running close by.

3.	Land slips	Very low	Land slips at the site have not been noticed in the recent past because of soil conditions and also because the rainfall is low.
4	Wild fire	Very low	Wild forest fires are not reported around the site, in these parts. Further, the main facilities are deep underground. There is no possibility of emitting inflammable gas to cause a major fire.
5	Tidal waves	Nil	The site is far away from sea (> 200 km) and the laboratory caverns are located at about 300 mtrs above mean sea level.

Man-made disasters

Sr.No	Cause	Damage potential	comment
1	Fire	Very low	The detector consists of passive elements made up of steel plates sandwiched with RPC detectors. Inflammable materials are not used except in trace quantities. Oil-less and fire retardant equipment and materials with adequate protective devices will be employed to eliminate electrical fires in the unlikely event.
2	Floods	Nil	No reservoir of large capacity is Existing near the site or required for the project.
3	Release of toxic gases	Very low	Gas mixture of R134a, isobutane and SF6 used in the RPC detector is nontoxic. There is no use /release of toxic gases in the systems and processes employed.
4	Radiation	Nil	No radio-active materials are used or produced in the system/ processes.

1.2.6 Likely dangers to the plant

Emergency may occur due to

- Plant activities such as improper usage and storage of flammable materials, lack of preventive maintenance, leakage & vehicles, Fire in the vicinity, Mob Violence Riots, Food Poisoning, Animal bites, Insect bites, Bombing etc. and
- Natural calamities as thunder, storm, earthquake, flood, lightening etc. The action plan worked out for the disaster control is based on the above-mentioned causes.
- Emergencies occur in any unit handling hazardous/flammable chemicals due to the LOSS OF CONTROL. Hence loss prevention is the only basic technique of avoiding such emergencies. These emergencies are classified as
 - Fire
 - Toxic release
 - The consequences are providing in the form of fatality of human being at different distances in case of various fires.

1.2.7 General guidelines for employees

Discipline: Utmost discipline shall be followed in handling the emergency and available guideline of Do's and Don'ts listed below will be adhered to

DO's

1. Follow all instructions meticulously.
2. Report to your Team Leader and carry out the task assigned to you.
3. Guide the visitors / contract workers to the designated Assembly Points.
4. Only qualified First Aiders shall render services to the injured wherever required and wait for the arrival of the Doctor.
5. The Employees Should Run Across The Wind Direction.

DONT'S

1. Do not panic.
2. Do not communicate with any external agency unless instructed by Site Controller / Incident Controllers / Liaison Officer.
3. Do not spread unwanted or exaggerated information, rumors to anyone.
4. Do not approach the emergency site as a spectator.
5. Do not engage unnecessarily, the communication aids like Telephone / Public Address System and other means. Make the same available for handling the emergency.
6. Do not disturb the Team Leaders assigned with specific work for handling the emergency.

Measures to be employed for meeting the objectives-

1. Define and assess the hazardous incidents.
2. Provide the information to all concerned.
3. Warning and advising affected people.
4. Call-up for assistance from outside.
5. Inform the employees, authorities and general public about the assessed risks, safeguards provided, residual risk and the role to be played by one and all in the incident.
6. Collecting data on latest developments, other information and requirements and disseminating the same.
7. Coordinating action taken by various agencies

1.2.8 Emergency Action Plan

ANY ONE NOTICING EMERGENCY SITUATION LIKE FIRE, EXPLOSION, TOXIC GAS LEAKAGE ETC. MUST

DO's

1. Attract the nearby person/employee by shouting "FIRE – FIRE – FIRE. "
2. Seek help from the persons working nearby.
3. Try to control the incident at its initial stage with available means/sources quickly.
4. Inform Shift In-charge / Duty Officer (In Night Shift) about the Incident.

DON'Ts

1. Do not be panicky.
2. Do not run – Walk fast.

1.2.9 Functional Requirement of Team

Incident Controller Must

DO's

IF FIRE / OTHER INCIDENTS ARE CONTROLLABLE

1. Approach the emergency site immediately taking note of wind direction.
2. Assess the situation.
3. Inform Security Officer, Tell – NAME, TYPE OF INCIDENT, ACTION
4. TAKEN, HELP NEEDED and Order Security Officer/Guard to inform all KEY persons.
5. Take lead in controlling emergency until such time concerned
6. Section Manager takes over the charge.

DON'TS

1. Do not be panicky.
2. Do not lose temperament.

IF FIRE/OTHR INCIDENTS ARE NOT CONTROLLABLE

In Addition to Above (A)

1. Order to blow emergency `ALERT' Siren.
2. Organize Fire fighting / rescue team members to control the Incident.
3. Take stock of situation if required shut down the plant / process in affected area
4. Call Fire Brigade if situation demands.
5. Evacuate affected area.
6. Organize head count of the plant.
7. Act as INCIDENT CONTROLLER till such time senior person takes charges as indicated in Emergency organization

NOTE:

- 1) Messenger will wait until such time Security Officer arrives.
- 2) Also inform incident controller.

SECURITY OFFICER / GUARD

DO's

1. Do not allow any vehicle to come inside the factory.
2. Do not entertain any outside call except for emergency purpose.
3. Do not allow visitors to move around.
4. Inform all key persons about location and type of emergency.
5. Follow this sequence – Inform concerned HOD/Section Head, Main Site Controller, Main Incident Controller & Safety Officer and other KEY persons.
6. Inform Main Site Controller about Government visitors, if any.

DON'Ts

1. Do not entertain any outside call except for emergency purpose.
2. Do not allow visitor to move around, from reception

SECURITY GUARD

DO's

1. Immediately report at Security Gate in shortest possible time.
2. Follow instructions of Officer In-charge.
3. Assist in controlling emergency.
4. Assist in controlling contractors, vehicle movement and mob.
5. Assist in cordoning off the area.
6. Take note of wind direction while approaching emergency site.
7. Render all possible help for controlling overall situation.

DON'Ts

1. Do not leave the site unless asked to do so.

EMERGENCY VEHICLE DRIVER

DO's

1. Immediately start vehicle and reach assembly point.
2. Take vehicle near to emergency site as directed.
3. Take note of wind direction.
4. Reverse the emergency vehicle for quick transports of injured, if any.
5. Keep vehicle engine running.
6. Always be on Driver's seat of the vehicle.
7. Take the injured to the hospital as directed.

DON'Ts

1. Do not leave the vehicle.
2. Do not take the vehicle very near to the site.

INCIDENT CONTROLLER

DO's

1. Approach emergency site as early as possible taking note of wind direction.
2. Take stock of situation.
3. Interact with all concerned departments as the situation demands.
4. Keep Main Site Controller informed about the latest emergency situation on continuous basis.

SITE CONTROLLER

DO's

1. Will approach emergency site immediately / assess the situation.
2. Consult Incident Controller.
3. Consult advising Committee Members.
4. Instruct Main Incident Controller.
5. Communicate to higher ups and Govt. authorities, if required.
6. Decide upon need for evacuation and blow 'Emergency Siren'.
7. After getting satisfied with the situation, give instruction to blow ALL CLEAR Siren.

DON'Ts

1. Do not instruct to blow ALL CLEAR siren unless the situation is fully under control.
2. Don't evacuate the entire plant unless the situation demands.

FIRE FIGHTING TEAM ON HEARING SIREN

DO's

1. Inform fellow employees/Officers.
2. Report to Assembly point.
3. Find out emergency location.
4. Approach emergency site immediately.
5. Take quick action as per the instructions from Incident controller.
6. Bring emergency under control as early as possible.

DON'Ts

1. Do not leave process/equipment in UNSAFE CONDITION.
2. Do not leave emergency site unless ALL CLEAR siren blown.
3. Do not use improper fire extinguisher.
4. Do not be panicky.

ALL GENERAL EMPLOYEES EXCEPT THOSE WHO ARE IN EMERGENCY ORGANIZATION ON HEARING SIREN

DO's

1. Be alert and be available if required.
2. Wait for further instructions.
3. Bring down the process/plant/equipment in SAFE CONDITION in case of DISASTER siren as per instructions from Incident Controller.
4. Approach respective safe assembling points route as taking note of wind direction.
5. Help in taking roll call.
6. After hearing ALL CLEAR, go back to the departments.
7. Start the work again after setting instruction from Incident controller.

DON'Ts

1. Do not be panicky. Do not run.
2. Do not approach emergency site unless asked for.
3. Do not engage telephone except for emergency purpose. Keep lines free.

TECHNICAL TEAM: MAINTENANCE DEPARTMENT / ENVIRONMENT, SAFETY AND HEALTH DEPARTMENT ON HEARING SIREN

DO's

1. Be available in Maintenance Department at respective location for any help.
2. Approach emergency site with required tools and equipment's and should work on Instructions of Incident controller.
3. Help Incident Controller to provide technical assistance.
4. Isolate lines, process equipment's, if required by Incident Controller.
5. Provide emergency equipment's like Fire Extinguisher, Hoses, etc., if asked by Incident Controller.
6. Carry out electrical isolation of area as per instructions from Incident Controller.

ADVISORY COMMITTEE (ALL DEPARTMENT HEADS)

DO's

1. Approach emergency site as early as possible.
2. Render advice to Main Incident Controller and Main Site Controller to control emergency.

COMMUNICATION COMMITTEE – (Admin team)

DO's

1. Consult Main Site Controller.
2. Give necessary instructions to security
3. Give instruction to Security to control traffic / crowd.
4. Look after injured; communicate with the family members, if situation demands.
5. Arrange transportation, if required.

DON'Ts

Do not communicate to any one or brief press without permission of Main Site Controller.

GENERAL INSTRUCTIONS

DO'S

1. Stop work at height. / Stop all hot works.
2. Stop all vessel entry.
3. Take note of wind direction.
4. On hearing Emergency Siren evacuates as per evacuation route without running and panicky and assembles at respective safe Assembly Points.

DON'Ts

1. Do not use telephone except for emergency purpose.
2. Does not start work at height, vessel entry, hot work unless permit conditions are verified.

3. Do not allow unauthorized person to approach emergency site

IDENTIFIED EMERGENCY & ACTION PLAN

Sometime due to individuals' carelessness, incident takes place. These types of incidents may lead to a major accident. Hence strictly follow standard operating procedures without complacency.

Some of the Potential incidents & the actions taken during this period are given below:

In case of Fire

1. Immediately start fire hydrant system with mechanical foam.
2. Barricade the area. Check for any casualty.
3. Call local fire brigade if required.
4. Evacuate area if required.
5. Follow all safety precautions during handling the emergency.

PLEASE TAKE NOTE OF THE WIND DIRECTION DURING AN EMERGENCY

In case of Electrical Short circuit due to unauthorized Operation: -

INDIVIDUAL WORKER ON THE SPOT

1. Remove injured persons from the spot to First Aid Centre. First Aid is an immediate and temporary care, given to the victim of an accident or sudden illness.
2. First aid is to preserve life, assist recovery, prevent aggravation and minimize
 1. Complication at later date and minimize pain / agony
 2. Ask nearby co-worker to inform the matter to SUPERVISOR.
 3. Inform the maintenance department to take further necessary action.
 4. Remove the patients from the source of danger. Make the air passage clear and clean.
 5. Restore natural breathing by artificial respiration. Send the patient to the hospital.

In case of Snakebite due to unauthorized movement at boundary

1. Act quickly.
2. Do not allow the person to run.
3. Apply a ligature above to the wound if the bite is in the leg or hand.
4. Wash the wound with Potassium permanganate solution or with soap or water.
5. Reassure the patient and immediately hospitalize.

In case of Burns and Injury: -

1. Place the part under running cold water.
2. Cover the wound with several layers of sterilized cloth
3. Artificial respiration if needed
4. Prevent or treat shock
5. Immediate medical attention

Inhaling of fumes / Chemical burns on the eyes

1. Immediate washing of the Eyes at least for fifteen minutes.
2. Apply sterile bandage and send the patient to the hospital.

Suffocation

Remove the patient from the source. Restore respiration by artificial respiration. Send the patient to the hospital if necessary.

Unconsciousness

1. Make the patient lie down in prone position.
2. Check breathing, pulse & heartbeat.
3. Loosen tight clothing.
4. Clean the airway
5. Give artificial respiration.
6. Transport the patient to the hospital.

1.2.10 Method Of Reporting Emergency Sequential Actions During Emergency

Incident

There are possibilities of occurrences of various types of the accidents or mishaps in the factory premises or around the factory. Most of the occurrences will be of minor nature.

While few occurrences may be of major type. If the factory is fortunate enough, there may not be a single incident or mishap during its lifespan.

However, when any incident occurs, it cannot be distinguished immediately whether it is minor or major, the subsequent development, or gravity of situation or seriousness of such occurrence is required safe handling irrespective of its nature, if it cannot be controlled.

It should be general practice that whenever any person notices the accident/ fire/explosion/ mishap at the site, he should immediately shout "FIRE", "FIRE" or "HELP" ,"HELP" and such message should reach to the Supervisor/ Shift Officer/ Senior Person of the unit.

Responding Actions

It is needless to mention that the root cause of occurrence should be removed immediately. Similarly, if any incident takes place in the premises, using available resources, within the factory as well as nearby, to their optimum, it should be so responded that the incident is contained immediately before spreading. If the incident looks severe and could not be controlled by simple efforts, the Shift Officer or Senior Personnel should rush to the place and make every effort to control the incident using various resources at the site.

Further, if the incident is uncontrollable even using own resources, he should immediately call for additional helps form outside resources such as Mutual Aiders, Fire Brigade, etc. He should act the incident Controller and immediately start the following actions.

1. Sound the siren or ring the emergency bell.

2. Take continuous responding actions with the use of other helps.
3. Call the higher authorities and Site Main Controller.

While conveying the messages regarding the incident, the following details should be incorporated.

1. Brief description of incident
2. Type of help required & direction
4. Action immediately taken
5. Development of the incident

The person who first detects any type of hazard or emergency will report to emergency control centre (ECC) through available communication channel. Personnel at ECC will receive the first hand information and he should immediately pass on the same to the Incident controller.

Depending upon the gravity the ECC will actuate the Emergency Siren- (Intermittent wailing sound for 30 seconds)

- (a) Incident Controller will give the information about the Incident in brief to Site Controller.
- (b) Try to control the emergency, leakages by available means.

On receiving the information of the Incident controller Rescue crew (Task Force) should rush to the Incident Site with fire extinguishers / mobile water tanker and assess the magnitude of situation and try to control the situation. The control room acts as focal point in case of an emergency from where the operations to handle the emergency are directed and co-ordinated. It is equipped with Site plan; external and internal telephone numbers and connections, hospital telephone numbers etc.

The public address system such as megaphone, list of essential telephone numbers, list of key persons and their addresses, a list of chemical and hazardous substances and their safety data sheets.

TASK FORCE:

The trained fire fighting members are available for handling the emergency situation in the factory shift-wise. The task force will consist of the following:

- (a) Trained fire fighting members.
- (b) Maintenance Staff Workers on duty.
- (c) Security guards.

Duties of Task Force:

- a) Fire Fighting
- b) Emergency engineering work i.e. isolating equipment and process materials.
- c) Movement of equipment's to or from the scene of the Incident.
- d) Provision of first aid.
- e) Acting as runners, manning assembly points and communication centres.

EMERGENCY ASSEMBLY POINTS:

In case of emergency, upon hearing the warning alarm employees of the company, Contractors, and visitors will assemble at the nearest assembly point.

The designated assembly point observer will take the roll call and communicate it with Site controller.

A list updated for employees department-wise shift-wise is made available so that roll call could be taken.

Table 3: Assembly Points

Sr. No.	Assembly Point Number	Location
1	Point No. 1	Security Gate
2	Point No. 2	Near administration Office
3	Point No. 3	Near Parking

Table 4: Details of Emergency Equipment's

Sr. No.	Equipment	Type	Location
1	Fire Tender	Fire Engine Equipped with Hose Reel	Security Gate
1	Extinguisher	CO ₂	Diesel bunk, Utility building,
			Tunnel area, Craven area, detector assembly
			Transformer room
2	Extinguisher	DCP	Canteen, workshop
3	Extinguisher	Water CO ₂ , mechanical Foam	Tunnel area, Craven area, detector assembly, Diesel bunk,

EMERGENCY ACTIONS

1. On receiving information, the Emergency Control Centre will activate and urgently establish the contact with the required persons, agencies and authorities.
2. The essential workers, responsible to carry out certain specific functions, will have to start work immediately. (Maintenance, Security)
3. The non-essential workers should go to the assembly centre.
4. The Roll Call should be started.
5. The cordoning the incident area will be ensured. (By Task Force)
6. The experts for the responding to emergency situation will be consulted, if required.
7. The authorized officer will provide authentic information for incident to Press/Public only. (External Co-Coordinator)
8. Removal of the flammable, dangerous materials, cylinders, etc. will be arranged along with isolation from fire.
9. The trapped personnel, if any, in incident will be rescued (By Task Force)
10. All assistant will be provided to the Fire Brigade to control spreading of fire.
11. Any remotest possibility of re-ignition or explosion will be looked into & controlled.

SHUT DOWN PROCEDURE

1. The Maintenance department personnel present on the site, on hearing the Emergency siren will instantly establish contact with the Site controller:-
2. They will gather the information on where the Mishap or emergency has occurred, the nature and extent of damage accordingly:
3. The Main electrical supply will be cut-off/ switch-off. Similarly, the pipelines supplying flammable gas, liquid or chemicals will be immediately shut –off by valves and will be isolated from the process line.
4. The rescue team members shall assist the Maintenance personnel.
5. After mitigation they will analyse the situation and as per instructions of Site controller will arrange for re-start of the plant or the section.
6. This process shall be known and communicated to Maintenance and Plant Head.

POST EMERGENCY

The internal committee will be formed to investigate into the causes of the accident/ incident comprising key persons listed above they will ensure the all below points:

1. Once the emergency situation will be brought under control, following post emergency actions will have to be taken.
2. The affected area will be declared safe from any toxic and other after effects by Maharashtra Pollution Control Board authority after through checking and confirmation
3. Then the Government authority will declare the emergency as over & rehabilitation work will be started in the area.
4. Then emergency clear siren will be blown.
5. The rehabilitation work will be started in the affected area. It will be ensured that all fires are extinguished and there is no risk of re-ignition prior to commencement of rehabilitation.
6. It will be ensured that there is no chance of secondary explosion. The wreckage and debris at incident site will not be disturbed, expect for rescuing the injured personnel or for recovering the dead bodies, until permitted to do so by the statutory authority.
7. All victims, dead or alive, will be systematically identified and the records will be kept accordingly. If asked for, necessary information may be provided to the victim's relatives.
8. All relevant information will be recorded.
9. Photographs/video of incident site will be taken or suitable sketches of the incidence will be prepared.
10. The incident will be reported to the statutory Authorities with complete details of occurrence/ accident, if not informed.
11. Necessary permission for restarting the plant will be obtained from the statutory Authorities
12. The registers for recording the incident, relevant entries, details, inventory, list of persons, etc. will be maintained and all the relevant documents, log books, maps, registers and all records taken from the site will be preserved.
13. The record of help, Co-operation etc. from Mutual Aiders and sought from others will be maintained and letters of gratitude will be initiated to all of them.

14. Details of expenses incurred during the emergency will be worked out and allocated to different heads and the records will be maintained. Statement for total expenditures will be prepared.
15. All necessary cooperation will be extended and help will be provided to the Agencies, Authorities, who will be enquiring into the incident.
16. The internal committee will be formed to investigate into the causes of the accident/incident, if necessary.

CORRECTIVE ACTIONS

The accident is always eye-opener toward the irregularities. Similarly, the occurrence of major emergency directly indicates the shortcomings or weakness of the plant, handling method, transportation, working procedure, storage procedure, unsafe condition or unsafe actions, etc. It may reveal from the investigation or recommendations of the committee. Necessary corrective steps/ actions in light of the investigation report or findings are required to be taken to ensure that such emergency accidents do not repeat.

Therefore, modification, alterations, changes in operation, instruction, process, handling, etc. as suggested by investigating Authority and internal committee should be implemented accordingly to make the plant working.

REHEARSAL /MOCK DRILL

Exercise / Rehearsal for working of ON- SITE- EMERGENCY PLAN are known as MOCK DRILL. As a normal practice, it is recommended to conduct the Mock Drill at an interval of six months, or after modification of hazardous process, storage, plant operation, and extension.

OBJECTIVE : It is necessary that all aspect of emergency plan are tested sufficiently often to ensure that the personnel and equipment involved in emergency plan carry out their responsibility and function as specified and particular to:

1. Test the response from workers, emergency services, and other responsible persons.
2. Test and evaluate the interaction of various agencies /authorities involved & ensure that all components are properly coordinated.
3. Evaluate the available resources, equipment, their effectiveness, accuracy
4. Gain more and more experience

AUTHORITY OF EXERCISE / REHEARSAL

The site controller of the Company is required to assume the responsibilities to make decision be seen as legitimate.

Table Discussion: The first part of experience is 'Table Top' exercise to test emergency plan may not interrupt the day-to-day running of their respective concerns. This exercise will recognize the difficulties involved and practical approaches to encounter the same. The scenarios will be decided and consideration will be given to live practices involving all concerned at suitable intervals, in addition to those of a theoretical nature.

NATURE: Origin, date and time, location and duration of Mock Drill exercise etc. will be predefined in particular manner.

AFFECTED AREA: It is the indication of the spread of disaster. This will be reflected in Blue print, given detailed of original place, units, surrounding identities etc.

PREPARATION STAGE: The responsibilities & duties will be allotted to each group, services, etc. involving all personnel. Educative meeting will be arranged and the role of each participant group will be explained in detail.

SEQUENTIAL ACTIONS; The whole exercise / rehearsal will be arranged in the form of sequential actions, to be taken one by one, as per Onsite Emergency Action Plan. Thus, actual exercise will be conducted, as rehearsal.

OBSERVATIONS: The outside / third party will perform the role of observers and they will submit their reports on various site- observations with shortcomings and good features.

DE- BRIEF MEETING: On completion of exercise, a de-briefing meeting will be convened to discuss the features of conducted exercise; to give views on performance of each area; explain difficulties; resources; limitation; planning; etc. All these observations along with corrective steps will be noted and the reports will be prepared circulated to concern and maintained.

1.3 Disaster Management Plan- Off-Site Emergency Plan

1.3.1 Off-Site Emergency Plan

Objective: If the effects of the accident or disaster inside the plant are felt outside its premises, it calls for an off-site emergency plan, which should be prepared and documented in advance in consultation with the District Authorities.

1.3.2 Key Personnel

The ultimate responsibility for the management of the off-site emergencies rests on the Collector /District Magistrate/Deputy Commissioner. He will be assisted by representatives from all concerned organisations, departments and services at the District level. This core group of officers would be called the District Crisis Management Group (CMG). The members of the group will include:

- 1) Collector/District Magistrate Deputy Commissioner
- 2) Commissioner of Police
- 3) Municipal Commissioner, if municipalities are involved
- 4) Deputy Director, Health
- 5) Pollution Control Board Representative

An Operation Response Group (ORG) will then be constituted to implement the directives of the CMG.

The various government departments, some or all of which will be concerned, depending on the nature of the emergency, could include Police, Health & Family Welfare, Medical, Revenue, Fire Service, Transport, Electricity, Animal Husbandry, Agriculture, Civil Defence, Civil Supplies, Panchayats.

The SC and IC, of the on-site emergency team, will also be responsible for communications with the CMG during the off-site emergency.

Education to Public

People living within the influence zone should be educated how to tackle emergency plan. This can be achieved only through the Local and District Authorities. However, the Project Authority can extend necessary information to the Authorities.

Table 5: External Agencies Contact Numbers Required During an Emergency-

Sr. No.	External Agency/Person	Contact Number
1.	Police Station	100
2.	Fire Station	101
3.	Hospital /Ambulance	102 or 108

ENVIRONMENTAL MANAGEMENT PLAN

The proposed India-based Neutrino Observatory (INO) project at Pottipuram, Theni district, Tamil Nadu envisages of construction of an Access Tunnel nearly 1957m long, four underground caverns of varying sizes-the largest one being 133m long, 26 m wide and 32.5m high- besides Inter connecting tunnel, Additionally driven Intermediate tunnel (ADIT) and other surface buildings for facilitating scientific research in the government poromboke land allotted by Government of Tamil Nadu. The activities of this developmental project along side with the Environmental Impacts of this project during construction phase and the Management of the same are adumbrated in this Chapter. The document includes a systematic assessment of environmental impacts of the project that are mainly envisaged to occur in the construction phase that lasts about three years. After a brief outfitting phase when the detectors will be constructed *in situ* in the cavern, the operation phase will be quiet with few (up to 20-30) personnel and with negligible environmental impact.

Environmental Policy Statement of INO

The challenge for INO is to build a world-class science laboratory, keeping in mind the ecological and environmental concerns, especially during the construction phase, and to actively participate in on-going conservation efforts in the region.

- During its normal operation phase, the laboratory is not expected to cause any damage to the environment. All efforts will be made to minimize the disturbance during the construction phase.
- INO will ensure that its activities are in conformity with environmental laws as are applicable.
- All members of the collaboration, executing agencies and their workers will be trained to cooperate in ensuring compliance with environmental guidelines.

It is imperative to recognize that the study of Nature's innermost workings need not be at loggerheads with Nature itself. Models of S & T development that are sensitive to environmental conservation thus assume importance. The proposed India-based Neutrino Observatory (INO) offers immense opportunities and a challenge for realizing such a model.

2. ENVIRONMENTAL MANAGEMENT PLAN

2.1 Impacts during Construction

2.1.1 Impacts due to tunneling operations

Tunneling operations broadly include Surveying, Drilling of holes, loading with detonators and blasting, defuming of gases released; by ventilation, mucking and transporting outside the tunnel, scaling of loose rock blocks left during blasting and immediate supporting by rock bolts and shotcreting. A combination of these activities are known as a Cycle and after end of one Cycle another starts. The time taken for one cycle is known as cycle time. Each activity has its own impact on tunneling operations and the environs and therefore utmost care is to be taken while tunneling irrespective of the tunneling media also known as ground classes.

Drilling and Blasting

The excavations will be made by drilling and blasting method (DBM) and controlled and cautious blasting will be resorted to during excavation so as to not to disturb the environs and the rock envelope. Various types of tunneling equipment are required to tackle different types of strata. In the present project, conventional technique of Drilling and Blasting with '**Heading and Benching method**' will be adopted in the initial reaches till completely hard rock is met with in the Face of the tunnel and thereafter the excavation will be achieved by Full Face method. The large Caverns will be excavated in stages and not in single operation. In the Drilling and Blasting technique, holes of requisite diameter, length and direction, as determined from the blast design and pattern are drilled into the tunnel face at designated locations. The profile of the drilling holes is marked on the face of the tunnel with the help of precision surveying. The charge comprising of designed quantity of suitable explosives together with a delay detonator of designed delay shall be inserted into each drill hole. Charging with suitable explosives will be arrived by a series of trial blasting before finally adopting the correct one. The blasting will be carried out by electrical means with millisecond delays so as to obtain smooth walls and also for reducing the throw testing all misfires will be detected and the detonators which have not fired will be defused appropriately. During blasting all precautionary measures will be taken up including engaging only professionally trained and certified blasters with very good track record. Statutory warning will be issued at the entry of the tunnel while blasting is in progress and only after defuming of the tunnel, workers will be allowed inside with necessary protective gear. Large blocks of rocks only will be generated during blasting to minimise dust generation. The impact of tunneling operations on the environment have been studied for construction phase with reference to site specific conditions and are as are identified are given below:

A. Surface Settlements

The opening of underground works causes a deformation of the soils and rocks around the excavation area. Such deformations may trigger sudden collapses if the media is very poor, subsidence and sinking that can damage both the work under construction and pre-existing nearby structures. Generally, the response to the opening of the underground work and, as a consequence, the extent of settlements depends on the following elements:

- Excavation technique
- Dimension and geometry of the excavation
- Class of Rock mass to be excavated
- The cover above the Crown of the tunnel

Mitigation Measure

The proposed tunnel will be constructed through a hillock which is made up of hard Charnockitic gneiss, fresh and with 3 to 4 sets of joints. Rock mass quality has been assessed to be Fair to Good which means the tunnel by and large can stand on its own without any support or with bare minimum depending on the size of the tunnel based on seven boreholes drilled at the site and logged by Geological Survey of India personnel and they prognosticated tunneling in such a rock mass media will be smooth with some light support measures required at places such as Rock bolt, shotcrete, etc. particularly in the low cover reaches.

The tunnel portal will be cut based on slope stability analyst and will be designed accordingly therefore no subsidence is likely to occur. Settlement pillars in the initial reach on the ground surface will also indicate about sudden failures that can occur.

B. Storage and disposal of excavated muck

- Effective planning of a tunnel construction project has to consider the handling of the excavated material. During the construction of tunnels large quantities of excavated material are produced. It is estimated that an amount of 2.3 lakh cum. of excavated material will be generated from the underground excavations.

Mitigation Measures

- A considerable portion of muck will be utilized for the project construction work. Necessary discussions were held with Forest Department and Revenue Department authorities of Tamil Nadu who have agreed to dispose off/use the rest quantity of the tunnel muck on a daily basis. Tunnel muck area suitably located of 2 ha will be made into 2 segments each to facilitate simultaneous loading and lifting of tunnel muck without difficulties.

- The top soil shall be kept separately and shall be reused for plantation/ landscape development purpose in the project, and also utilized for soil conditioning by the local farmers.

2.1.2 Noise and Vibrations

The tunneling operation during the construction phase can create noise and vibration levels above the existing level for the workers for a temporary duration. The nearest village is located nearly 2km away will not be affected except for the noise of passing vehicles. A range of construction activities with the potential to generate noise and vibration are already identified and assessed including.

- Noise from blasting for the excavation of tunnel.
- Noise from drilling machines, instruments, loading, etc.
- Noise from construction vehicles, such as trucks during loading and haulage.

The project's tunnel will be constructed using Hydraulic drills, road headers and other equipment, which could generate ground-borne noise and vibration. All the workers will be provided with protective kits etc. gears such as ear muffers, glass masks. For the existing site conditions, such as the nearest village being located 2km away from the site and their activities towards the site being minimum, it is assessed that the impact will be minimum. However continuous monitoring of this aspect will be in place during construction and corrective and control measures will be initiated as and when necessary.

Mitigation Measures

- Sufficient steps shall be taken by the Contractor to reduce the noise levels to acceptable limits of Workmen and visitors will be asked to wear ear plugs/muffs, etc. where required.
- The ground vibrations will be felt only during the initial phase of excavation; as tunneling progresses in view of the adequate rock cover and distance from entry of the tunnel, vibrations will die down and will not be felt by the nearby population. Also in case of adverse impact controlled blasting/pre-splitting blasting techniques in conjunction with suitable blasting pattern will be adopted.
- Provision of acoustic hoods wherever possible on the construction equipment and regular maintenance of the equipment.
- Recommend light and sound barriers to proposed activities/working areas.
- The construction workers will be provided with the personal protective equipment like ear muffler, hand gloves etc
- Monitoring plan for noise & vibration twice in a week or once during the major blast is suggested throughout the construction of tunnel.

2.1.3 Emission of dust and air pollutants

The tunneling process involves blasting and other excavation methods which will release large amount of particulate matter into the atmosphere. This will increase the concentration of PM10 and PM2.5 in the vicinity of the construction site. Blasting operations produce both toxic and nontoxic gaseous products; the toxic being mainly carbon monoxide (CO) and the

oxides of nitrogen (NO_x). The quantity of toxic gases produced by an explosive is affected by formulation, confinement, age of the explosive, and contamination of the explosive with water or drill cuttings, among others. Techniques to protect workers and the public from the potential hazards of explosive related dust and toxic fumes are discussed and the proposed

Mitigation Measures

- Ventilation shall be carried out in the tunnel to make the working space safe for workers by keeping the air fresh and by eliminating harmful and obnoxious dust, explosive fumes, exhaust from operating equipment, particularly diesel-operated equipment, and other gases.
- After each blasting for underground rock excavation, the ventilation measures will be set in place immediately and effectively for de-fuming and personnel should be allowed to enter only after establishing that the air quality is sufficiently acceptable.
- Air Quality Testing shall be carried out
- Proper records will be maintained of specific measurements of air quality at regular intervals throughout the day after blasts or major rockfalls.
- In case any abnormal amount of the gases are detected and found to have crossed the threshold value indicated therein, the work will be suspended immediately till permissible limits achieved by improving the ventilation or by other effective measures.
- Other openings such as ADITS will also facilitate or augment ventilation arrangements
- Monitoring plan for confined area air quality using portable Low Volume Sampler twice in a week or once during the major blast is suggested throughout the construction of tunnel.
- Use covered vehicles wetting while transporting and unloading
- New efficient vehicles/Equipment
- The wetted broken material will be further wetted for reduction in dust generation
- Water spraying to capture airborne dust
- LPG will be provided to labor
- Providing dust collectors for dust sucking
- Retaining walls will be constructed upto 4 m height of in the dumping area in addition to provision of GI sheets for another 4m height to prevent the flying of dust.
- The trucks transporting the muck will be covered with tarpaulins so that fine dust do not travel long distances.

2.1.4 Wastewater generation

- The Drilling and blasting method used in tunnel construction involves use of different dynamites under different geological conditions, and ammonium nitrate explosives with low toxicity are generally used. After a blasting, the contaminants in the resulting water are mainly suspended solids (SS), ammonia (NH₃-N), total phosphorus (TP) and oils. Water requirement during operation will be 50 CMD. Sewage generation will be around 5CMD.

Mitigation Measures

- The waste water generated from the tunnel portion will be collected in a sump leading to sedimentation and the clear water will be recycled and used.
- The quality of the water will be analyzed before it is released to the surrounding environment. If it is not found to be fit the water will be treated before it is disposed.
- Ground water occurrence is very deep and therefore ground water cannot be used for construction activities. Instead Water supply through tanker and provided by Tamil Nadu Water Supply and Drainage Board will be used.
- Modular STP/Portable sanitation, treatment and disposal facility shall be provided at construction site.
- Construction activities shall be restricted to non-rainy days only.
- Treated water will be reused for plantation
- Suitable formed drains will be provided for trained runoff

2.1.5 Soil Erosion

- No soil erosion apprehended except the soil excavation in the open cut portion of the Access tunnel for a minimum distance
- As the proposed land mostly supports shrub land erosion of soil and due to intense rainfall and tree cutting will not happen. There are no trees at the project site and the rainfall is scanty.
- Erosion taking place in the area is due to arid climate prevailing

Mitigation measures include

- Periodic maintenance of drains to check scouring of soil and limiting construction activities of culverts and bridges to dry seasons. Measures should be taken to prevent contamination of soil
- The excavated top soil will be properly stored and reused. In addition to the engineering design a green corridor will be planted with trees to support and the strengthen the soil by enhancing binding capacity.
- Wherever applicable, the top soil shall be kept separately and shall be used for plantation/ landscape development purpose in the project, and also utilized for soil conditioning by the local farmers.
- No explosives can be used for soil excavation. The major portion of excavation will be by earth moving equipments/ or manually.
- A portion of muck will be utilized for the project construction work.
- Tunnel muck area of 2 ha will be made into 2 segments each to facilitate simultaneous loading and lifting of tunnel muck
- Rest Muck will be disposed of daily with the help of District Revenue authorities

2.1.6 Solid Waste / Surplus Earth

The project will generate earthwork/rock in excavation about 2.3 lakh cum.

Soil Erosion: The loss of fertile topsoil / humus may occur.

- Soil Erosion: May occur due to the uneven topography and intensity of rainfall. A major problem of erosion may occur due to the removal of age-old trees. However, proposed land is mostly scrub land.
- Erosion may occur due to the swift velocities of drains in monsoon.

Mitigation measures include

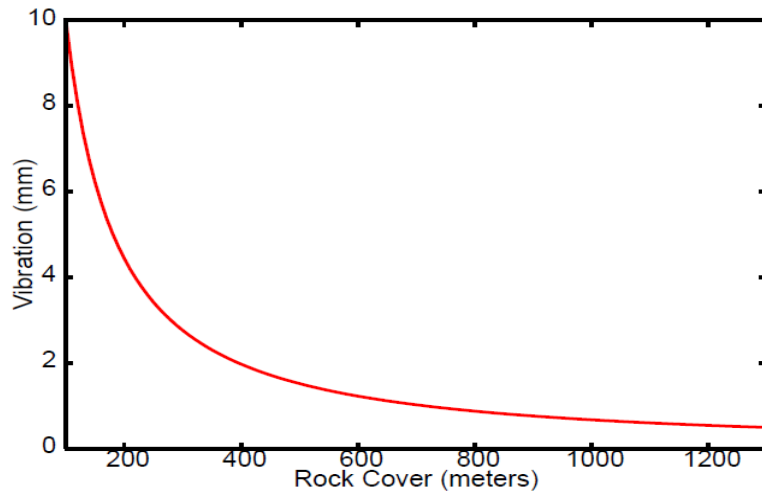
- Periodic maintenance of drains to check scouring of soil and limiting construction activities of culverts and bridges to dry seasons. Measures should be taken to prevent contamination of soil by bituminous material and other chemicals utilized during construction.
- The excavated top soil will be properly stored for reuse. In addition to the engineering design the corridor will be planted with trees to support and the strengthen the soil binding capacity.
- Wherever applicable, the top soil shall be kept separately and shall be used for plantation/ landscape development purpose in the project, and also utilized for soil conditioning by the local farmers.
- Rainy season will be avoided for cutting and filling of earthwork.
- The use of explosives for controlled blasting will be limited. The major excavation will be by earth moving equipment's.
- A portion of muck will be utilized for the project construction work.
- Tunnel muck area of 2 ha will be made into 2 segments each to facilitate simultaneous loading and lifting of tunnel muck
- Rest of the muck will be preferably disposed of daily with the help of District Revenue authorities.

2.1.7 Biological Environment

In general, the impacts of activities such as INO construction at a location will be highest at the site near the portal, with the impact gradually receding according to distance. Similarly, from a temporal point of view the impacts are likely to be higher during the phase of construction than during the operation.

Clearing vegetation for the INO construction will be restricted to the relatively sparsely vegetated puramboke land (S.No. 4/1). The vegetation in the area is scrub jungle and mixed dry deciduous type. Several plants occupying the area will get removed. Similar is the case with several small faunal species that are likely to be residing there. However, no species; either flora or fauna, recorded there so far is restricted to the puramboke land. Further, studies do not indicate loss of an important part of its habitat because of this clearing.

The area is not frequented by larger wild species such as elephants or dholes. The sound and vibrations from the blast may cause mild disruption to the normal activities, such as routine local movements, of wildlife if any. Serious vibrations, if any, are also likely to “affect den-dwelling animals”. Studies show that vibrations due to hundreds of meters of rock and soil would be dampened considerably as seen in the figure below. The noise reaching outside the tunnel will be also be considerably muffled.



High levels of noise can disturb birds and other animals frequenting the sites. Animals can perceive frequencies that are out of range for human auditory system. They are known to be highly sensitive to certain frequency ranges, even infra or ultrasonic levels. They suffer stress, and undergo metabolic and behavioural changes. Many of them leave the site of high noise level. Birds are also seen to discard nests, eggs and even fledglings in response to certain abrupt noise levels. The sound and vibrations may cause disruption to the normal activities such as local and seasonal migration and denning. However, in the case of the present locations, not many animals could be seen close to the project site and the impact is likely to be low.

The construction and operation of the project will have only a minimal effect on existing flora and fauna. Flora degradation is expected to occur marginally as a result of underground excavation that too in rock and other surface construction will be minimal. The work will directly cause minor degradation of the local ecology through the clearance of areas of vegetation (ground cover) at major work sites and ancillary sites. During construction, a short-term impact on ecology is likely to occur in and around the quarry sites, material stockpiling areas, and worksites due to vegetation clearance.

Mitigation Measures

- Construction vehicles shall use temporary roads constructed to minimize damage to agricultural land and local access roads.
- The contractor will take reasonable precaution to prevent his workmen or any other persons from removing and damaging any flora (plant/vegetation) and fauna (animal) including fishing in any water body and hunting of any animal.
- If any wild animal is found near the construction site at any point of time, the contractor will immediately upon discovery thereof acquaint the Environmental Expert/Forest Department and carry out the instructions as given by them for dealing with the same
- In the course of tunnel, road and viaduct construction the flora and fauna in the vicinity will not be disturbed; deforestation and cutting down of bushes.
- Compensatory tree plantation is suggested in the EMP.
- Construction material will be dumped on designated area.
- Movement of vehicle will be monitored and blowing excessive and unnecessary blowing of horn will be prevented.
- Plantation of indigenous plant species to attract fauna like insect/ butterfly, bird etc. will be taken up.
- Care will be taken not to disturb wildlife habitat.
- Workers will be briefed about do's and don'ts like No hunting/poaching, vegetation burning, no collection of eggs, not to disturb any habitat within and outside the project area, off-road driving, speeding etc.
- Training cum awareness program shall be conducted periodically.

2.1.8 Traffic Management

- During construction phase impacts are envisaged on existing network
- The Project site is approachable from Theni-Bodi-Uthamapalayam road near Rasingapuram village
- To avoid inconvenience to the village people and to facilitate free flow of construction material, dedicated bye-pass road of 7.5 m width for 1km length will be constructed.
- An adequate traffic light system shall be provided, maintained and operated wherever needed.
- For transportation of construction material precaution shall be taken to reduce impact of vehicular movement by restricting movement in non-peak hours.
- Use of appropriate sign boards for smooth traffic movement.
- Barricading/cordoning the construction site for safety of the traffic and workers with suitable sign boards in Tamil, English and Hindi.

2.1.9 Construction Workers Camp

Local laborers shall be employed for the construction activities to the maximum extent possible number to minimize the production of domestic waste generation.

The period of construction is tentatively worked out to be 36 months.

Potential impacts from construction worker camps also include poaching of edible animals and birds in the locality, despite prohibitions.

Mitigation Measures

- The contractor's environmental health and safety manager will be responsible for providing adequate knowledge to workers regarding the protection of fauna.
- Workers will be trained regarding nature protection and the need to avoid cutting down trees during construction.
- Contractors will be responsible for supplying appropriate fuel in the work camps to prevent fuel wood collection.
- Laborers residing in the camps shall be provided with safe drinking water, adequate sanitation facilities, kerosene/gas and all other amenities as per the prevailing labor laws.

2.1.10 Sanitation and Waste Disposal

Sewage and domestic solid waste generated at the construction workers camp will be properly disposed of to prevent health and hygiene related problems. Adequate sanitary facilities such as pit latrines/water seal latrines will be established based on the soil conditions in construction camp. Periodical health checkup of construction workers will be undertaken.

2.1.11 Impact on Local Population

The nearest human habitation, the village of T. Pudukottai, is at a distance of 2km from the boundary of INO site. The main disturbance during the construction time is from the sound of drill-blast approach to the tunnel. However this is expected to be extremely feeble at a distance of 2km (much less than the noise and vibration generated by a passing truck near the village). Even this minimal noise will be further reduced as the excavation progresses both due to increased distance as well as containment due to enclosed surroundings in a tunnel.

The other possible impact is due to the generation of the dust. The muck will be 90%-95% or more as solid chunks of rock in a form that is useful for construction. The transportation will be done in trucks only after wetting the debris generated. Hence there is no possibility of dust contamination to nearby habitations.

Inside deep tunnels the particle carriage to the outside is a remote possibility: most of it will get deposited in the tunnel itself. The rock debris will be stored in a yard designated for the purpose on INO land that will be covered on all sides to prevent any dispersion. Hence no contamination of farmlands or water sources is expected due to this dust.

2.2 Impacts during Operation Phase

2.2.1 Land Environment & Solid waste generation

- Biodegradable waste (21.6 kg/day) will be processed in OWC.
- Non-biodegradable waste generated 14.4 kg/day to authorized local vendor.

2.2.2 Air Environment

Air pollution due to,

- Domestic fuel
- DG sets exhaust
- RPC gas mixture

Mitigation measures

- LPG will be used
- DG set will be in stand-by mode only

- DG set will be in power failure only
- RPC is Non-flammable, non-toxic
- Longitudinal Ventilation System in tunnel to maintain the desired levels of ambient air quality in the tunnels.
- Monitoring of ambient air quality at the ventilation outlets and airflows will be manipulated.

2.2.3 Noise and Vibration

Maximum noise level generation will be of the order of 40 – 45 dB and suitable noise pollution measures will be put in place.

2.2.4 Water Pollution

- Water requirement : 340 CMD(Domestic & Misc. 20 and Cooling water 320 CMD)
- Sewage generation: 15 CMD

Mitigation

- Sewage will be treated in Sewage Treatment Plant
- Cooling water will be recycled
- Treated water will be reuse in flushing and gardening

2.2.5 Ecology & Biodiversity

No major negative impact is envisaged during operation phase. The staff will be briefed about do's and don'ts like no hunting/poaching, vegetation burning, no collection of eggs, not to disturb any habitat within and outside the project area, off-road driving, speeding etc. Training cum awareness program shall be conducted.

2.2.6 Accident Hazards and Safety

- Natural background radiation from the rock is extremely low.
- All electrical equipment will be suitably designed to prevent fire/spread of fire and fast acting interlock and protection system will be provided to isolate the faulty section quickly.
- All risks will be assessed on a regular basis with the intention of either reduction or removal.
- No fire or smoke in confined spaces, Non-inflammable materials (oil free switch gear, fire retardant cables), Electrical systems adequately sized, insulated and tested, Oil/bitumen free cable jointing kits to be used, fire detection and protection systems provided with stops and barriers Natural background radiation from the rock is very low and well within limits.
- All caverns will have established measures to detect a fire and to attack it immediately.
- Automatic fire detection has been proposed.
- They will be activated by one of the effects of fire such as temperature rise, smoke, flame or heat and will be coupled to an alarm system.

Alarm system

- On receiving the message of emergency from the site, the control room will sound siren of the “wailing type” for 5 minutes.
- All electrical equipment will be suitably designed to prevent fire/spread of fire with proper circuit breakers and fast acting interlock and protection system will be provided to isolate the faulty section quickly.
- All risks will be assessed on a regular basis with the intention of either reduction or removal
- No fire or smoke in confined spaces, non-inflammable materials (oil free switch gear, fire retardant cables), Electrical systems adequately sized and tested, oil/bitumen free cable jointing kits to be used, fire detection and protection systems provided with stops and barriers.
- The message of emergency from the site, the control room will sound siren “wailing type for 5 minutes”.
- All electrical equipment will be suitably designed to prevent fire/spread of fire and fast acting interlock and protection system will be provided to isolate the faulty section quickly.
- All risks will be assessed on a regular basis with the intention of either reduction or removal
- No fire or smoke in confined spaces, Non-inflammable materials (oil free switch gear, fire retardant cables), Electrical systems adequately sized and tested, Oil/bitumen free cable

jointing kits to be used, fire detection and protection systems provided with stops and barriers

2.3 Environmental Monitoring Program

The environmental measures that to be undertaken during project construction stages are given in **Table**

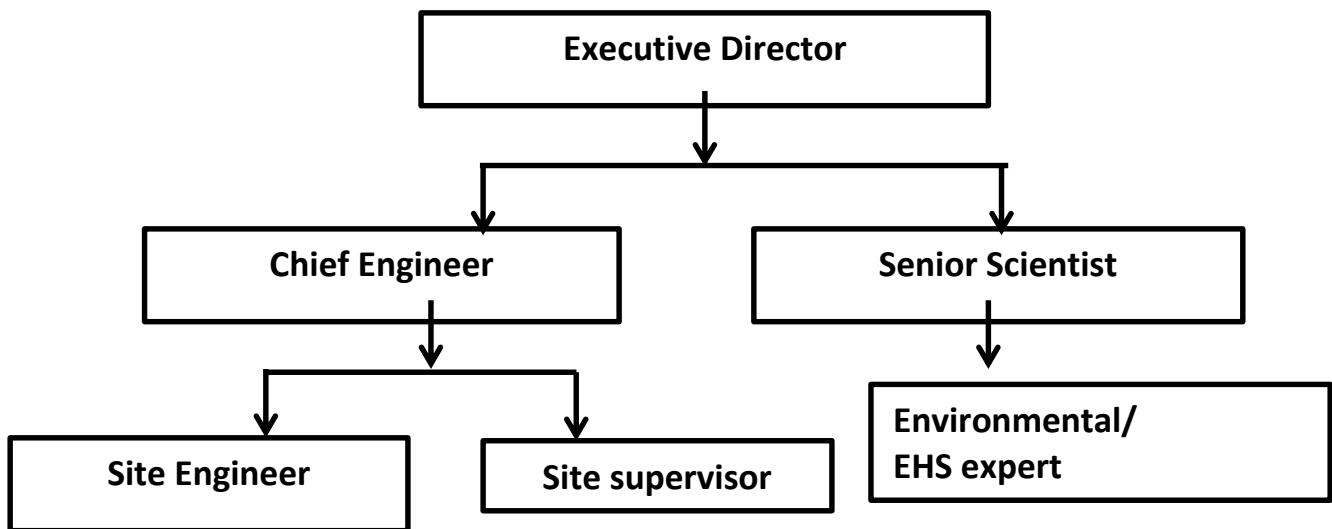
Table 6: Environmental Monitoring - Project Construction & Operation Stage

Sr. No.	Attribute	Stage	Parameters for Monitoring	Frequency of Monitoring
1.	Air	Construction	Particulate Matter, SO ₂ , NO _x , CO, Pb	Once in Month excluding monsoon (Continuous 24 hours/ or for 1 full working day)
		Operation	Particulate Matter, SO ₂ , NO _x , CO, Pb	Seasonal (Continuous 24 hours/ or for 1 full working day)
2.	Noise	Construction	Noise Level	Once in Month (Continuous 24 hours/ or for 1 full working day)
		Operation	Noise Level	Seasonal (Continuous 24 hours/ or for 1 full working day)
3.	Water	Construction	Surface Water : pH, BOD, COD, TDS, Pb, Oil & Grease, Detergents Ground Water : pH, TDS, Total Hardness, Sulphate, Chloride, Fe, Pb	Twice a year (Pre monsoon and Post Monsoon seasons) Ground water occurs in phreatic condition and at deeper levels. Not envisaged to be used
		Operation	Surface Water : pH, BOD, COD, TDS, Pb, Oil & Grease and Detergents Ground Water : pH, TDS, Total Hardness, Sulphate, Chloride, Fe, Pb	No Nearby perennial source exists. All streamlets are seasonal.
4.	Soil	Construction	Monitoring of Pb, SAR and Oil & Grease	Twice a year (Pre monsoon and Post Monsoon seasons)
		Operation	Monitoring of Pb, SAR and Oil & Grease	Once in a year

5.	Ecology & Biodiversity	Construction	Plantation of local indigenous tree species	Regular
		Operation	Animal Mortality	Regular
6.	Health & Safety	Construction	All relevant parameters including HIV	Monthly check ups
		Operation	All relevant parameters including HIV	Once in year
7.	Environmental Management Cell/ Unit		Responsibilities and roles will be decided before the commencement of work.	The Environmental Management Cell/Unit will ensure strict implementation & monitoring of environmental safeguards during construction & operation phase

2.4 Environment Management Cell

All the environmental practices will be monitored by the project proponent. An organizational set up will be formed to ensure the effective implementation of mitigation measures.



2.5 Budgetary Provision for Environmental Management Plan

Table 7: Environment Management Plan Cost

No.	Particulars	Amount in INR, Lakhs
One Time Installation Cost (Capital Cost)		
1	Air Pollution Control System	20
2	Noise Control System	10
3	Green Belt Development	15
4	Environment Monitoring and Management	20
5	Water Pollution Control System – ETP/STP	10
6	Occupational Health & Safety	15
	Total	90
Recurring Cost		
1	Environmental Monitoring Maintenance	10
2	General Maintenance of STP	5
3	Greenbelt Maintenance	5
4	Noise Pollution Control	2
5	Occupational Health	10
6	Environmental Management (Misc.)	10
	Total	42