ENVIRONMENTAL IMPACT ASSESSMENT

FOR

KAIGA ATOMIC POWER PROJECT (KAIGA UNIT 5 & 6), 2 X 700 MWe PHWRs

AT

KAIGA, KARNATAKA

EXECUTIVE SUMMARY

Project Proponent

NUCLEAR POWER CORPORATION OF INDIA LIMITED (NPCIL)
Nabhikiya Urja Bhavan
Anushaktinagar,
Mumbai – 400094

Environmental Consultant

MECON LIMITED
(A Govt. of India Enterprise)
No. 89, South End Road,
Basavangudi,
Bangalore, Karnataka - 560004
CERTIFICATE NO: NABET/EIA/1619/RA0068

August, 2018
Executive Summary

1.0 INTRODUCTION

Nuclear Power Corporation of India Limited (NPCIL) is a Public Sector Enterprise under Department of Atomic Energy (DAE), Government of India. NPCIL's mission is to develop nuclear power technology and to produce nuclear power as a safe, environmentally benign and economically viable source of electrical energy to meet the increasing needs of the country.

In pursuance of Environmental (Protection) Act, 1986 and EIA notification 2006, new projects necessitate statutory prior environmental clearance by conducting an Environmental Impact Assessment (EIA) study. NPCIL entrusted MECON Limited to conduct an EIA study for the proposed project.

2.0 PROJECT DESCRIPTION

2.1 Location

The project site and township of NPCIL is located at Kaiga and Mallapur-Virje village respectively in Uttara Kannada district of Karnataka state. The proposed project site is situated at about 3.5 km from Karwar-Illilikal SH-6 and 16 km upstream of Kadra dam on the left bank of Kali river. The site is situated at about 120 km and 140 km from Hubli and Goa airport respectively. The nearest railway station is Karwar at about 53 km from the project site. The nearest seaport is Karwar, which is located at about 58 km from the project site.

The proposed expansion units of 5 & 6 at Kaiga will be in the same plant area earmarked earlier for 2 x 235 MWe adjacent to the existing operating units 3 & 4 in eastern direction. The longitude and the latitude of the proposed site are 74° 26' 40" E and 14° 51' 20" N respectively. The proposed site and study area of 16 km radius falls in Survey of India topo-sheets No. 48J/5, J/6, J9 & J10. Project site designated in seismic zone III close to the border with zone-II as per Bureau of Indian Standards, IS: 1893 (2002).

Project area

A total of 1665 hectare of land is under possession of NPCIL, out of which 829 hectare is submerged in Kadra reservoir. In the remaining 836 hectare, 665 hectare is forestland. A total of 120 hectare of forestland had been diverted to NPCIL to establish six units at Kaiga vide letter no. FFD 303 FGL 83 dated 19/02/1988. In the 120 hectare of diverted forestland, Kaiga 1 & 2 and its common facilities occupies about 37.33 hectare. The unit 3 & 4 covers about 11.88 hectare. In addition to the above, 16.7 hectare is utilized for switchyard, circulating water intake tunnel, approach roads, boundary walls and fencing. The balance of 54.09 hectare forest land along with the land in possession of NPCIL will be utilized for setting Kaiga 5&6.

The aforementioned forestland of 120 hectares falls in block no. XXVI, compartment no. 46, 47 & 48 and the balance of 171 hectares of non-forestland falls in survey no. of 6 to 14, 15-25, 43, 48-53, 69, 70, 71/2, 80, 81, 82, 84, 85 and 86 respectively.
Township area

Township is already established in an area of about 95.91 hectare at Mallapur-Virje to cater the housing need of Kaiga Generating Station’s (KGS) employees. Out of which, 51.38 hectare is already utilized for township facilities and the remaining 44.53 hectare will be used for augmentation of residential accommodations which can accommodate about 789 employees of proposed unit 5 & 6 of NPCIL.

2.2 The proposed project

The proposed Kaiga 5 & 6 units will produce 2 X 700 MWe power. It falls under category of "Nuclear Power Project & Processing of Nuclear Fuel". The major equipment needed are end-shield calandria, coolant channels, end fittings assembly, primary coolant pumps, steam generators, heat exchangers, fuelling machine, etc.

The buildings planned to house the plant equipment are as follows:

- Reactor Building (RB) and Reactor Auxiliary Building (RAB) houses the main reactor and associated process systems respectively
- Buildings other than nuclear consists of control building, station auxiliary building, ventilation stack with monitoring room, D2O upgrading plant, waste management facility and associated ventilation, natural draught cooling tower, induced draught cooling towers, safety related pump house, fire water pump house, underground tunnels and trenches, diesel oil storage area, covered passage etc. are planned as per the design features of the plant.

The salient technical features of the reactor unit (700 MWe PHWR) of Kaiga 5 & 6 is given in Table ES-01.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated output electrical</td>
<td>700 MWe</td>
</tr>
<tr>
<td>2</td>
<td>Rated output thermal</td>
<td>2166 MWt</td>
</tr>
<tr>
<td>3</td>
<td>Fuel</td>
<td>Natural UO₂, 37 element bundle</td>
</tr>
<tr>
<td>4</td>
<td>Moderator and reflector</td>
<td>Heavy water</td>
</tr>
<tr>
<td>5</td>
<td>Coolant</td>
<td>Heavy water</td>
</tr>
<tr>
<td>6</td>
<td>Type</td>
<td>Horizontal pressure tube</td>
</tr>
<tr>
<td>7</td>
<td>Pressure tube</td>
<td>392, 103.4 mm ID, Zirconium 2.5 % and Niobium Alloy</td>
</tr>
<tr>
<td>8</td>
<td>Primary coolant total flow</td>
<td>8019 kg/s</td>
</tr>
<tr>
<td>9</td>
<td>Pressure (outlet header)</td>
<td>100 kg/cm²</td>
</tr>
<tr>
<td>10</td>
<td>Channel inlet temperature</td>
<td>266°C</td>
</tr>
<tr>
<td>11</td>
<td>Channel outlet temperature</td>
<td>310°C</td>
</tr>
<tr>
<td>12</td>
<td>Shut down system-1</td>
<td>28 Mechanical rods, Cadmium Sandwiched in Stainless Steel (SS)</td>
</tr>
<tr>
<td>13</td>
<td>Shut down system-II</td>
<td>Liquid poison – Gadolinium Nitrate Injection in Moderator</td>
</tr>
<tr>
<td>14</td>
<td>Steam generators</td>
<td>4 Steam Generators with inverted u-tubes and integral steam drum (mushroom shaped)</td>
</tr>
</tbody>
</table>
Power evacuation scheme will be finalized by Central Transmission Utility (CTU) in consultation with Central Electricity Authority (CEA) and constituents of Southern Regional Grid.

The reactors are designed to use natural uranium oxide as fuel and heavy water (D₂O) as coolant and moderator with on-power fuel loading facilities. Steam generators supply nearly dry saturated steam to the turbine, which is directly coupled to an electrical generator, which produces electricity. The generator transformer steps up generator voltage. The concept of defense-in-depth is adopted in design of safety systems. Provision of multiple barriers, double containment structures with liner on inner containment wall of reactor building, containment spray cooling system, emergency core cooling system, reactor shut down systems etc. ensures safe operation of reactor. Reactor protection system ensures shutdown requirements through two independent fast acting shut down systems. Reactor regulating system enables automatic control of reactor power and maintains neutron flux profile.

During operation of the reactors, spent fuel bundles are removed from the reactor core and transferred to Spent Fuel Storage Bay (SFSB), where it is stored till it cools down to dry storage level (about 10 reactor years). SFSB can accommodate 10 years of spent fuel and one full core load. Subsequently, the spent fuel will be stored in an Away From Reactor Facility (AFR) or Additional Away From Reactor Facility (AAFR) to be constructed at the site. AFR/AAFR facility at the site is planned to have total capacity adequate to store the spent fuel bundles unloaded during operation of all the Kaiga units (1 to 6). Further action on the spent fuel is governed by the policy of the Department of Atomic Energy/Government of India.

Project schedule

NPCIL is planning to take up the construction activities of both units of 2 X 700 MWe. Construction activities are planned to be started in the year 2020 and with a completion target in 2026.

Manpower

During construction stage maximum of 4000 persons likely to be engaged temporarily during peak construction stage of the project, whereas during operation and maintenance the permanent manpower deployed would be about 789 nos.

Construction power

During construction period of the project the power demand would be about 10 MW which will be sourced from the operating units of Kaiga 1 to 4.

Water requirement

The water requirement for the project will be met from Kadra reservoir, Karnataka Government has allotted 185 cumecs (6,66,000 m³/hr) of water for six units of Kaiga. Out of the above allocation, about 2.5 cumecs (9000 m³/hr) will be used for the proposed units 5 & 6. The existing intake and outfall facilities will be utilized for the proposed units.
Township

The Existing township at Mallapur-Virje will be suitably augmented to accommodate the staff of Kaiga 5 & 6 of about 789 and their families, the features of the township is as follows:

1) Total land area at Kaiga Township is 95.91 Ha
2) Land area available for Kaiga 5 & 6: 44.53 ha
3) Area proposed for Kaiga 5 & 6 including reconstruction with existing constructed areas of township 28.73 ha.
4) Ground coverage area: 28.73 ha (64.85%).
5) Built up area: 4.66 ha (16%)
6) Township buildings will be of ground +12 stories
7) Water consumption: 0.54 Million Litres per Day (MLD)
8) Power requirement: 2000 KVA
9) Power back-up: Existing DG sets will cater the power back-up for proposed township
10) Connectivity: The township at Mallapur-Virje is connected by SH-6. The Kaiga plant site is about 18 km from township in SE direction and well connected by road.
11) Parking requirements: Adequate parking space of about 1500 cars, light commercial vehicles, buses etc. will be provided in the township.
12) Community facilities: Hospital, community centre, school and shopping centre recreation club, sports complex, playground, bank, post office, petrol pump etc. are available and these facilities will be augmented.
13) All the civic amenities like park, roads etc will be augmented
14) The water requirement of township will be met from Kadra reservoir. MOU between NPCIL and Kadra dam authorities exists to utilize 8 MLD of raw water for Kaiga township. Sufficient water is available for the expansion of township to cater to the requirements of Kaiga 5 & 6. The estimated construction water demand for Kaiga 5 & 6 units will be about 25 m3/day.
15) Additional Sewage Treatment Plant (STP) of about 0.5 - 1 MLD is planned to be constructed to augment the existing 1 MLD STP for treating the sewage water generated from the proposed housing units. The treated water will be disinfected/filtered and used for gardening/wash room flushing purpose.
16) Green belt will be developed within and around the periphery of plant and township, which will further strengthen the existing green cover.
17) Fire extinguishing system as per the requirements of National Building Code will be provided.

The estimated cost of 2 X 700 MWe PHWR Atomic Power Project and expansion of township would be about Rs. 21000 Crore.

3.0 DESCRIPTION OF THE ENVIRONMENT

The 16 km radius from the project site is considered as study area for conventional pollutants and other studies. The baseline data collection was carried out for three seasons viz. Post monsoon (Oct. to Dec. 2016), Winter (Dec. 2016 to Feb. 2017) and Summer (March to May 2017). The radiological monitoring was carried out up to 30 km radius around the project site.
3.1 Meteorology

Meteorological data were collected for three seasons i.e. from October 2016 to May 2017. The summary of the wind pattern as observed during the monitoring period is given in Table ES-02.

**Table ES-02**

<table>
<thead>
<tr>
<th>Season</th>
<th>Predominant wind direction</th>
<th>Second predominant wind direction</th>
<th>Predominant wind speed (m/s)</th>
<th>% Calm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Night</td>
<td>Day</td>
<td>Night</td>
</tr>
<tr>
<td>Post monsoon</td>
<td>EES</td>
<td>EES</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Winter</td>
<td>EES</td>
<td>EES</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Summer</td>
<td>WSW</td>
<td>WSW</td>
<td>W</td>
<td>W</td>
</tr>
</tbody>
</table>

3.2 Ambient Air Quality (AAQ)

Eight (8) AAQ monitoring stations were established in the study area. The summarized values of Particulate Matter (PM$_{10}$ & PM$_{2.5}$), SO$_2$, NO$_x$ and CO at different locations for three seasons i.e. October 2016 to May 2017 are summarized in Table ES-03. The monitored values are well within the national AAQ standards for industrial, residential, rural & other areas as well as for ecologically sensitive areas.

**Table ES-03**

<table>
<thead>
<tr>
<th>Parameters in (µg/m$^3$)</th>
<th>Township (A1)</th>
<th>Virje (A2)</th>
<th>Kuchegar (A3)</th>
<th>Hartuga (A4)</th>
<th>Kaiga project site (A5)</th>
<th>Harur (A6)</th>
<th>Basal (A7)</th>
<th>Balemane (A8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{10}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min.</td>
<td>36</td>
<td>35</td>
<td>31</td>
<td>31</td>
<td>30</td>
<td>32</td>
<td>33</td>
<td>30</td>
</tr>
<tr>
<td>Max.</td>
<td>73</td>
<td>69</td>
<td>69</td>
<td>70</td>
<td>71</td>
<td>69</td>
<td>70</td>
<td>69</td>
</tr>
<tr>
<td>Avg. (all seasons)</td>
<td>57.5</td>
<td>56.9</td>
<td>46</td>
<td>50.2</td>
<td>50.8</td>
<td>49.4</td>
<td>48.1</td>
<td>52.1</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min.</td>
<td>18</td>
<td>20</td>
<td>16</td>
<td>16</td>
<td>15</td>
<td>13</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Max.</td>
<td>48</td>
<td>45</td>
<td>39</td>
<td>44</td>
<td>44</td>
<td>44</td>
<td>39</td>
<td>45</td>
</tr>
<tr>
<td>Avg. (all seasons)</td>
<td>29.8</td>
<td>32.3</td>
<td>25.5</td>
<td>26.8</td>
<td>26.4</td>
<td>26.5</td>
<td>27.1</td>
<td>28.3</td>
</tr>
<tr>
<td>SO$_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min.</td>
<td>&lt;4</td>
<td>&lt;4</td>
<td>&lt;4</td>
<td>&lt;4</td>
<td>&lt;4</td>
<td>&lt;4</td>
<td>&lt;4</td>
<td>&lt;4</td>
</tr>
<tr>
<td>Max.</td>
<td>13.8</td>
<td>15.5</td>
<td>10.6</td>
<td>10.5</td>
<td>15.8</td>
<td>13.7</td>
<td>15.4</td>
<td>11.8</td>
</tr>
<tr>
<td>Avg. (all seasons)</td>
<td>7.7</td>
<td>9.4</td>
<td>6.7</td>
<td>6.3</td>
<td>7.6</td>
<td>7.1</td>
<td>6.8</td>
<td>6.7</td>
</tr>
<tr>
<td>NO$_x$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min.</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Max.</td>
<td>17.6</td>
<td>23.2</td>
<td>13.1</td>
<td>13</td>
<td>16.5</td>
<td>18.1</td>
<td>21.7</td>
<td>21.1</td>
</tr>
<tr>
<td>Avg. (all seasons)</td>
<td>12.5</td>
<td>13.78</td>
<td>12.1</td>
<td>11.6</td>
<td>12.3</td>
<td>12.2</td>
<td>12.4</td>
<td>12.6</td>
</tr>
</tbody>
</table>

3.3 Ambient noise

Noise monitoring was conducted at eight (8) locations within the study area covering the project site during post-monsoon, winter and summer seasons respectively. The
noise levels at all stations were below the respective statutory norms as applicable. However, in post monsoon at Kuchegar (silence zone) during night time a few values are exceeding the norms by 0.6 dB (A) whereas during winter season in residential areas few values are exceeding the norms from 3.8 to 5.8 dB(A) which could be attributable to traffic movement in the villages.

3.4 Water environment

Six (6) surface and eight (8) ground water samples were collected and analyzed for the study during post-monsoon, winter and summer seasons.

Rainfall

Annual average rainfall (2007-2016) of Kaiga site is about 3645 mm.

Surface water

Surface water analysis during post monsoon 2016, winter 2017 and summer 2017 reveals that the quality is within the CPCB norms for Water quality criteria of Class C (drinking water source after conventional treatment and after disinfection).

Groundwater

Post monsoon 2016

Results of ground water analysis indicates that value of aluminum at Balemane (0.37 mg/l) is marginally exceeding the permissible limit of drinking water standard of 0.2 mg/l. Boron at Virje observed to be 1.12 mg/l which is marginally exceeding the permissible limits i.e. 1 mg/l of drinking water standard. Similarly, Iron content at Virje (1.18 mg/l), plant site (1.1 mg/l), Balemane (0.32 mg/l) and Basal (1.32 mg/l) are marginally exceeding the desirable limits of 0.3 mg/l.

Winter season 2017

During winter 2017, the value of aluminum in addition to Balemane (0.23 mg/l), Harur (0.31 mg/l) also marginally exceeding the permissible limit of drinking water standard of (0.2 mg/l). As far as Iron is concerned in addition to Basal (2.62 mg/l), Harur (2.69 mg/l) also recorded higher than the desirable limits of 0.3 mg/l with no relaxation for permissible limits. Similarly, the Manganese content in Harur (0.39 mg/l) is marginally higher than the permissible limits of 0.3 mg/l.

Summer season 2017

During summer 2017, the values of arsenic at all the locations (0.03 mg/l) are marginally exceeding the desirable limit of drinking water standard i.e. 0.01 mg/l but, it is well within the permissible limits of 0.05 mg/l. Manganese content in Basal (0.22 mg/l) is marginally exceeding than the desirable limits of 0.1 mg/l but well within the permissible limits of 0.3 mg/l.

Rest of the parameters are well within the prescribed drinking water norms of IS: 10500.

On the whole, the analytical results of three season indicates that the groundwater quality in the study area is observed to be good and suitable for domestic consumption.
except few parameters like iron and aluminum which is exceeding marginally. The reason could be attributable to geological formation of the area.

No ground water will be used for construction and operation of Kaiga 5 & 6.

3.5 Soil

Eight numbers of soil samples were collected from the study area. The results of the analyses conducted on representative samples collected from the study area indicate that the soil is suitable for green belt development without any soil amendments. Results did not indicate any characteristic, which may adversely affect plant growth. The soil samples collected from agricultural and plantation site indicate that the soil is in good condition.

3.6 Ecological features

The project site is located in the interior part of Western Ghat of peninsular India. Kali (Dandeli-Anshi) Tiger Reserve (KTR/DATR) extends from NE to NW. The minimum distance observed varies between 718m to 1734m from Kaiga site Exclusion zone boundary.

The schedule-I faunal/avifaunal species present in the study area, among reptiles are monitor lizard and Indian python, among mammals Indian bison, elephant, leopard cat, slender loris, Indian pangolin, sloth bear, leopard, tiger and mouse deer while among Avi fauna malabar pied hornbill, hill myna, common peacock, pariah kite or black kite, brahminy kite, shikra.

3.7 Traffic density

The traffic density on SH-6 (In front of Mallapur township main gate) is highest for two wheeler (1668/d), followed by LMV (837/d) and HMV (278/d). The traffic density on road leading to project site from SH - 6 is highest for two wheelers (2537/d), followed by LMV (948/d) and HMV (289/d).

3.8 Geohydrology

The groundwater table is varying from depth of 0.05 to 15.12m below ground level and it is an un-confined aquifer.

3.9 Socio-economic status

The 16 km study area consists of 28970 persons (Census 2011) and 30252 persons (projected for 2018). The socio-economic features prevailing in this area are as follows:

- The population density up to 16 km radius is 36 persons/sq. km (2011 census data)
- The study area consists of mostly rural population
- Predominance of individual land holdings in small (<1 acre) to marginal category
- Paddy is mostly grown followed by arecanut, banana, groundnut, sugarcane etc.
- The employment rate is good: 81.9% are engaged as main workers, 18.1% as marginal workers. Agriculture and small commercial activities plays an important role in rural economy
3.10 Baseline study for radiological environment

Monitoring of background radiation level at different places in surrounding villages is carried out using sensitive low level μR survey meter. In general, radiation fields are 0.05-0.10 μGy/hr. Cumulative radiation dose is measured using Environmental TLDs placed at 23 locations, around Kaiga site on quarterly basis.

The pre-operational (unit 5&6) baseline levels of natural and fallout radio-nuclides were measured during 2016 in terms of radio-nuclides of natural (238U, 232Th) and fallout (137Cs and 90Sr) origin by taking environmental samples from terrestrial and aquatic environments. Water, soil, cereals, pulses and vegetation samples were collected from the study area & analyzed.

Air samples

Fifty one (51) air samples were analysed for gross alpha, gross beta and iodine 131 activities. The gross alpha and gross beta activities are observed in the range of <0.02 to 0.09 and <0.02 to 1.57 mBq/m³ respectively. The iodine 131 are observed <0.02 mBq/m³ from all the locations. Four (4) samples of Cesium 137 and Strontium 90 were analysed and the observed values are in the range of <0.002-0.02 and <0.002-0.007 mBq/m³ respectively. One hundred and twenty nine (129) air moisture samples were collected to find out tritium in air. The observed values are in the range of <0.2 to 11.31 Bq/m³.

Radioactivity levels in water samples

Water samples of 203 nos. for testing tritium, 173 nos. for analyzing 137Cs and 10 nos. to record 90Sr were collected and analysed during the year of 2016. The observed values for tritium, 137Cs and 90Sr are in the range of <8.0 to 85.76 Bq/l, <2.0 mBq/l and <0.2 mBq/l respectively.

Radioactivity levels in soil

17 nos. of soil samples and 12 nos. of sediment samples were collected and analyzed using Gamma spectrometry method for 232Th and 238U activity. In soil samples, the observed 232Th and 238U values are in the range of 6.16 to 85.14 and 9.6 to 50.14 Bq/kg of dry wt. respectively whereas, in sediments, it is recorded in the range of 12.56-21.31 and 8.9-16.96 Bq/kg of dry wt.

Radioactivity levels in biological samples

Thirty Three (33) dietary samples like vegetables, cereals, meat, fish, eggs and fruits were analysed for gamma emitting radio nuclides (137Cs) during the year 2016. The observed 137Cs levels were in the range of <0.05 Bq/l to 1.06 Bq/l.

Total dose to public

The total dose received by members of public has been evaluated by adding external gamma dose due to FPNG and 41Ar and internal dose from inhalation, ingestion and skin absorption due to 3H. The results are given in Table ES-04. Fig. ES-01 presents the annual effective dose in different zones during 2016, Fig. ES-02 presents a comparison of estimated annual effective public doses during the period from 2012-2016.
Effective dose to the members of the public (Year 2016)

<table>
<thead>
<tr>
<th>Distance (km)</th>
<th>External dose due to FPNG (µSv)</th>
<th>External dose due to Ar-41 (µSv)</th>
<th>Internal dose due to $^3$H (µSv)</th>
<th>Total effective dose (µSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>0.8</td>
<td>0.008</td>
<td>0.5</td>
<td>1.3</td>
</tr>
<tr>
<td>2.3–5</td>
<td>0.6</td>
<td>0.006</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>5–10</td>
<td>0.4</td>
<td>0.004</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>10–15</td>
<td>0.2</td>
<td>0.002</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt;15</td>
<td>0.1</td>
<td>0.001</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The results of the environmental surveillance program carried out during the year 2016 at Kaiga site shows that the doses received by a representative person of the member of public staying at fence post (2.3 km) is 1.3 µSv which is 0.13% of the annual dose limit of 1000 µSv prescribed by AERB/ICRP and much less than the annual global dose of 2400 µSv due to natural radioactivity.

Fig. ES-01 Annual effective dose in different zones during 2016
4.0 ANTICIPATED ENVIRONMENTAL IMPACTS & MITIGATION MEASURES

4.1 Impact and mitigation: Construction phase

The proposed unit 5&6 will be accommodated within existing Kaiga plant site boundary and no additional land is required to be acquired for this purpose. The total area admeasuring about 54.09 hectare land out of 120 hectare of diverted forest land along with the land in possession of NPCIL will be utilized for Kaiga 5&6. Since, the land is already under possession of NPCIL thus, R & R issues are not expected. Construction phase may cause land disturbance, land use, water quality, air quality, noise etc. Moreover, problems associated with influx of labour force, sourcing of construction/filling material are also expected. However, adequate mitigation measures will be adopted to bring these temporary impacts to minimum.

A minor drop in air quality during construction stage is predicted and given in Table ES-05. It can be seen from the predicted results that the ambient air quality during construction stage will be well below the national AAQ norms near the receptor villages. However, the following mitigation measures are planned to be implemented:

- Wet suppression and wind curtains (wind barriers) to control open dust sources,
- Stringent construction material handling/transport procedures to control dust,
- Regular maintenance of construction equipment, vehicles and generator sets etc.

### Table ES-05

**Air quality during construction stage at the receptor location**

<table>
<thead>
<tr>
<th>Station</th>
<th>Background PM&lt;sub&gt;10&lt;/sub&gt; Concentration</th>
<th>Predicted PM&lt;sub&gt;10&lt;/sub&gt; due to construction activity</th>
<th>Total during construction phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Post monsoon</td>
<td>Winter</td>
<td>Summer</td>
</tr>
<tr>
<td>NPCIL Township</td>
<td>73.0</td>
<td>65.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Virje</td>
<td>69.0</td>
<td>68.0</td>
<td>68.0</td>
</tr>
<tr>
<td>Kuchegar</td>
<td>63.0</td>
<td>61.0</td>
<td>69.0</td>
</tr>
<tr>
<td>Hartuge</td>
<td>70.0</td>
<td>69.0</td>
<td>64.0</td>
</tr>
</tbody>
</table>
Station | Background PM$_{10}$ Concentration | Predicted PM$_{10}$ due to construction activity | Total during construction phase
--- | --- | --- | ---
Kaiga plant site | 71.0 | 71.0 | 63.0 | 71.0 | 9.33 | 80.33
Harur | 65.0 | 68.0 | 69.0 | 69.0 | 0.10 | 69.10
Basal | 61.0 | 70.0 | 68.0 | 70.0 | 0.15 | 70.15
Balemane | 64.0 | 66.0 | 69.0 | 69.0 | 1.29 | 70.29

4.2 Impacts and mitigation: Design phase

The state-of-the-art reactor technology is being introduced. A number of environment friendly/safety features with high redundancy have been envisaged which ensures that the anticipated adverse environmental impacts are either avoided or minimized.

The basic design of the atomic power plant allows for:

a. The releases of radioactive or chemical pollutants during normal operations to the environment within statutory limits of AERB/SPCB.
b. The releases during off-normal situations with probability of occurrence within statutory limits. The engineered safety features of the plant will keep the radiological released during operational and accidental condition to the minimum.

An appropriate monitoring mechanism is also designed to ensure that the design objectives are met by controlling the plant operating conditions.

The second approach aims at designing the facility with multilayer of safety system in such a way that even if the events are to occur, the resulting off normal releases are contained as far as practical. Provisions are made for directing the releases along planned flow paths, thereby permitting their collection and treatment before discharge to the environment. This is facilitated by handling/processing radioactive material in confined space, the confinement being assured by providing multiple barriers between the environment and the radiation sources. The multiple barrier approach is applied not only in processing, but also in storage of hazardous materials/wastes.

The concept of defense-in-depth is adopted in the design of safety systems using state-of-the-art technology, viz.

Barriers to radioactive release

Multiple series of fission product barriers are designed to prevent radioactivity release in public domain, viz.

i) Fuel matrix
ii) Fuel cladding
iii) Primary heat transport system
iv) Containment
v) Exclusion zone
Special safety features

The safety features are:

- Reactor regulating system enables automatic control of reactor power and maintains neutron flux profile
- Reactor protection system ensures shutdown requirements through two independent fast acting shut down systems
- Emergency core cooling system
- Containment spray cooling system
- Double containment structures with liner on inner containment wall of reactor building
- Abundant water storage
- Special zoning of the plant to minimize the contamination potential within the plant
- Exclusion zone

The entire operating island is designed to be divided into three (3) distinct zones based on the contamination potential. These zones have been designated as Zone-1, Zone-2 and Zone-3 in the ascending order of contamination potential. These zones are equipped with required safety features to limit the potential radiation exposure.

4.3 Operational phase impact

4.3.1 Radio-active releases

The uranium di-oxide (UO₂) is used as fuel. At normal operating conditions all solid fission products are permanently retained in UO₂ matrix and only a fraction of noble gases and volatile products diffuse into the inter space between fuel and cladding.

All the processes/operations are carried out in leak tight enclosures, under negative pressure so that the probability of the radioactive materials reaching the working environment is reduced to a bare minimum. However, under normal operation the radioactivity discharges are such that the nuclear radiation dose at exclusion zone boundary (also called fence post, 2.3 km radius around the plant) is only a small fraction of the radiation dose permitted by AERB for general population and thus under normal operation of the plant impacts due to radio-activity releases do not have any adverse impact on the surrounding environment.

Waste management operations (liquid and solid), involves handling of radioactive waste from all the facilities for their ultimate storage/disposal.

The radiation dose limit specified by AERB for the general public at the fence post (exclusion zone) due to operation of all facilities within the site through all pathways is 1 mSv/yr. Compliance to this regulatory requirement is ensured by dose apportionment estimation for different types of radio-nuclides of all the facilities. The dose apportionment estimation implicitly specifies discharge limits for each kind of anticipated radionuclide. A conservative estimate of dose apportionment of radioactivity released from Kaiga unit 5 & 6 is 0.197 mSv/y.
Radioactive air emissions

Impacts

The operation of nuclear power plant leads to generation of gaseous radioactive effluents which will give in terms of radioactive dose to public. The gaseous radioactive effluents generated from reactors and service buildings may contain different radioactivity levels, if they are discharged directly into the atmosphere may cause radiation exposure to environment.

Mitigation measures

- Design of the plant is based on minimizing the leakages from the plant system into plant buildings so that generation of radioactive effluents is minimized
- Gaseous radioactive effluents from reactor and service building ventilation exhaust are passed through HEPA filters before discharge through ventilation stack of 100m
- Gaseous effluents are continuously monitored for radioactivity content before discharging through ventilation stack

With the integration of the above mitigation measures the dose to the members of public due to air emission will be a small fraction of AERB approved dose limit.

Radioactive liquid effluent discharges

Impacts

Liquid effluent containing radioactivity levels above AERB norms if discharged to receiving water bodies may cause radiation exposure to downstream users and biotic environment of the reservoir water.

- Substantial heat is generated during the process and water is used to cool the condenser. For Kaiga 5 & 6 closed loop cooling tower NDCTs are planned and hence there will not be any discharge of hot water into the surface water body
- Untreated sewage from plant and township may contaminate the receiving water bodies

Mitigation measures

- Design of the plant is based on minimizing the radioactive leakages from the plant system into plant buildings to minimize generation of radio-active effluents
- Radioactive waste management facilities will be designed to treat different levels of radioactive effluents to meet the authorized release limits stipulated by AERB
- Total waste water (after dilution) to be discharged from Kaiga site to Kadra reservoir will be 2654 m³/hr, which will be continuously monitored for radioactivity levels
- STP will be in place to treat the sewage generated from the plant and township
- Periodical monitoring of receiving water body quality at up-stream and downstream of the effluent discharge point.

With the integration of the above mitigation, measures the dose to the members of public due to liquid discharges will be small fraction of AERB approved dose limit.
Radio-active solid waste disposal

Radioactive solid waste will be segregated at source depending upon it’s nature (compactable/non-compactable) and surface dose rate.

Impacts

Solid waste generated from different units may cause radiological implications to the surroundings. However, the radioactive solid waste are contained within the plant premises and do not pose any direct radiological impact either on the public or environment.

Mitigation measures

- Treatment and disposal of radioactive solid waste at the plant will be carried out as per AERB/SG/D-13
- Solid wastes will be transported to Waste Management Plant (WMP) in shielded containers/casks, for treatment/conditioning (if needed) and then will be disposed off in engineered barriers (trenches, vaults and holes) at the Near Surface Disposal Facility (NSDF)
- Packages having higher activity will be disposed off at the bottom of trenches/vaults and will be suitably sealed permanently as per established practices
- The NSDF area will be fenced and necessary access control procedures will be established
- The dose rate on the top of the sealed earth trenches and RCC trenches/vaults will not exceed 0.01 mGy/h

4.3.2 Conventional pollutants

Air environment: Impacts

At Kaiga site, there is no direct use of fossil fuel in the plant process. HSD is used for testing/operation of emergency diesel generator sets. The impact on air environment due to testing/operation of emergency diesel generator sets of Kaiga site is estimated considering the following two scenarios:

- Scenario 1: When one DG set runs for 1/2 hour per week as test run. (The other DG sets are kept under standby and are tested in subsequent days and hours of the week). The sequence of testing are as follows:
  - For Kaiga 1&2 (6 EDGs) each EDG are tested for half an hour in a week
  - For Kaiga 3&4 (6 EDGs) each EDG are tested for half an hour in a week
  - For proposed Kaiga 5&6 (8 EDGs) each EDG will be tested for half an hour in a week
- Scenario 2: Off-site power failure

EDGs will run for 24 hours continuously during the period off site power is not available and it is not restored within a day (worst case scenario).

The resultant AAQ from scenario 1 is presented in Table ES-06
### Table ES-06

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Pollutants in</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PM</td>
<td>SO₂</td>
</tr>
<tr>
<td>1</td>
<td>Max. predicted GLC</td>
<td>0.089</td>
<td>0.469</td>
</tr>
<tr>
<td>2</td>
<td>Max. monitored value of all stations</td>
<td>73</td>
<td>15.8</td>
</tr>
<tr>
<td>3</td>
<td>Total maximum concentration (1+2)</td>
<td>73.089</td>
<td>16.269</td>
</tr>
<tr>
<td></td>
<td>Norms</td>
<td>100</td>
<td>80</td>
</tr>
</tbody>
</table>

The resultant AAQ from scenario 2 is given in Table ES-07.

### Table ES-07

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Pollutants in</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PM</td>
<td>SO₂</td>
</tr>
<tr>
<td>1</td>
<td>Max. predicted GLC</td>
<td>12.6</td>
<td>66.2</td>
</tr>
<tr>
<td>2</td>
<td>Max. monitored value of all stations</td>
<td>73</td>
<td>15.8</td>
</tr>
<tr>
<td>3</td>
<td>Total maximum concentration (1+2)</td>
<td>85.6</td>
<td>82.0</td>
</tr>
<tr>
<td></td>
<td>Norms</td>
<td>100</td>
<td>80</td>
</tr>
</tbody>
</table>

The resultant predicated values of air pollutants for scenario 1 are well within the National Ambient Air Quality norms. Whereas, in case of scenario 2 the values for SOₓ and NOₓ are marginally exceeding the AAQ norms. The exceedances are 2 µg/m³ and 3.7 µg/m³ in case of SO₂ and NOx respectively. However, the scenario II is not likely to take place as unavailability of off-site power for prolong duration is a highly unlikely event.

### Mitigation measures

During the design phase all efforts have been made to adopt latest state-of-the-art technology and to install adequate pollution control measures for point and fugitive emission sources so as to meet the MoEF&CC/CPCB air emission norms. The following mitigation measures will be employed to reduce the pollution level to acceptable limits:

- Stack monitoring to ensure proper functioning of pollution control systems
- Air monitoring in the work-zone
- Adequate plantation within the plant and periphery
- Regular monitoring of ambient air quality (AAQ)

### 4.3.3 Water environment: Impacts

Water requirement will be met from Kadra reservoir, for which necessary sanction has been accorded by Government of Karnataka. About 9000 m³/hr water will be required for unit 5 to 6, out of which 6346 m³/hr will be towards consumptive use and the rest of the 2654 m³/hr will be returned to reservoir. Total sewage generated from township will be about 424 m³/day and from the plant will be 28 m³/day. Existing STPs at Kaiga site and township will be further augmented to cater the requirements of proposed facilities also. Groundwater is not planned to be used for plant and township and hence no impact on the same is anticipated. The project site will be raised in such a way that it will not have any impact on the local area drainage pattern.
Mitigation measures

- To treat domestic wastewater at plant & township site Sewage Treatment Plant (STP) are integrated with the project design
- Effluent quality monitoring will be carried out at inlet and outlets of STP at site and in township. The STP treated water will be used for green belt development in the respective areas and excess treated water during rainy days will be discharged into reservoir
- In addition, monitoring of surface water & ground water in the surrounding area of the proposed project will be carried out regularly

4.3.4 Solid waste disposal: Impacts and mitigation measures

The hazardous wastes like oil, lubricants, scintillation liquid etc are burnt along with low radioactive level solid waste in electrical incinerator, which will have burning capacity 20 kg/hr. The incinerator will be operated for 2 to 3 days per month. The flue gas will be passed through two stage water scrubber. Continuous monitoring system is provided to monitor the gas emitted from the chimney. Ash collected from the incinerator is solidified with cementation process and disposed off in RCC trenches. The used electronic waste & lead acid batteries will be sold to authorised agencies.

4.3.5 Noise levels: Impacts

Considering the attenuation due to specially designed building within which noise generating machineries will be housed, the expected increase in noise levels will be around 1-2 dB(A) just outside the building, which will be further attenuated to ambient noise level at the exclusion zone boundary at a distance of 2.3 km. Thus, there will not be any change in the ambient noise levels due to operation of nuclear power plant units.

Mitigation measures:

- All the equipment in different units are designed/operated in such a way that the noise level will not exceed 85 dB(A) at a distance of 1m
- The noise generating equipment are housed in acoustic enclosures/buildings. The presence of exclusion zone (2.3 km) with forest/ greenbelt will serve to insulate generated noise
- Regular monitoring will be carried out for noise levels in the work zone and outside the plant premises
- Workers exposed to higher noise level area will be provided with protection devices like earmuffs and will be deployed with rotational duties
- All workers will be regularly checked medically for any noise related health problem

4.3.6 Impact of transportation

During construction stage, there will be only a marginal increase in traffic load on the road leading to the project site due to transportation of construction materials. The transportation of Over Dimensional Consignment (ODC) will be maximum to the tune of one vehicle per day likely to ply on the road. The oversized consignment vehicle will be directed to ply only during night time between 10.00 PM to 05.00 AM, to avoid traffic congestion.
During operation phase, the increase in vehicular movement for manpower transportation from township to the plant, there will be some increase in traffic load only for short duration during the opening and closing time of main shift office hours. Thus no congestion of traffic on the road leading to project site is expected.

4.3.7 Ecological features: Impact

- The level of air pollutants (SO₂ and NOₓ) due to occasional running of DG sets will be much below the National Ambient Air Quality Standards. Thus it is expected that the natural vegetation and agricultural crops will not be affected.
- Noise generated due to the project may cause disturbance to faunal species.
- Strong light in project premises during night may cause disturbance to fauna.
- Wastewater from plant and domestic use may cause surface water pollution.

Mitigation measures

- All technological measures to limit air emissions, waste water discharge and noise generation are envisaged in the proposed plant design.
- An elaborate green belt/cover has been planned within and around the plant to ameliorate the fugitive emissions and noise from the project operation.
- The domestic waste water will be treated and after treatment the same will be reused and recycled within the plant itself and only excess water will be discharged which will be meeting the statutory norm. Thus, there will be no impact on the ecological components of surface water bodies in the area.

Mitigation measures for reducing impacts on faunal species

- Direct disturbance: About ten feet high RCC concrete wall fencing is already constructed covering the entire site. Further a green belt erected within the fencing all around the proposed plant area will further reduce the impact of direct disturbance.
- Noise: The maximum noise level reaching outside the proposed plant project boundary will be below the statutory norms for residential and other areas and will be below the statutory norm. Further the green belt all along the project boundary will further reduce the noise level so as to cause any disturbance to the faunal species. Thus, the animals in the study area will not be disturbed due to the noise from the proposed project activity.
- Strong light during night: The strong light in the project premises during night may cause some disturbance to the fauna in the nearby areas. It is proposed that all the illumination light posts erected along the boundary wall will face inwards and downwards (with reflectors facing the plant and downwards), so that the lumen intensity does not spreads outside the plant boundary.

4.3.8 Occupational Safety and Health: Impacts

Negligence in plant operations may cause risk to safety and health problems.

Mitigation measures

- Based on the environmental monitoring for dust, gases, radioactivity levels, noise & vibration, the workers exposed to these will be regularly checked in medical unit and results will be intimated to management for necessary management interventions/measure.
4.3.9 Socio-economic Impacts

Advantages

- Project will generate more employment, directly and indirectly. A major portion of indirect employment will be provided to the local people residing in the surrounding area of the plant site
- Development of business opportunity in the area
- Development of infrastructure facilities like roads, drinking water facilities, medical camp will help in improving the whole area
- Improvement in living standard

Disadvantages

- People perceive that the increase in pollution may cause damage to agriculture and damage to health of people due to pollution

Mitigation measures

- The community development efforts of the project authorities for the stakeholders will fulfill their aspirations
- The project authorities will have structured interactions with the community to disseminate the measures taken by the plant and also to elicit suggestions for overall improvement for the development of the area
- More emphasis on education
- Dispensaries/health centers and availability of doctors and other para-medical staff
- Drinking water supply schemes
- Support for self-employment to open petty shops, purchase of cycle rickshaws, agricultural tools, bullock carts, fertilizers, improved seeds and drilling of well for irrigation
- All measures have been taken to keep the radiation levels due to plant operation much below AERB limits, thus any adverse effect on human health due to radiation is not envisaged. As regards conventional pollutants as shown above that conventional pollutant will be generated only during unavailability of off-site power during which period EDG sets will be running, it has been predicted that even after operation of two proposed units, the level of pollutants will be well within the national AAQ norms. Thus, impact due the same is not envisaged.

4.3.10 Impacts during decommissioning phase

At the end of the operating life of 60 years, a detailed decommissioning plan will be worked out as per AERB guidelines, which will ensure that no radiation exposure occurs in public domain/environment.

4.3.11 Impacts and mitigation measures under accidental conditions

A detailed risk assessment, on-site emergency plans & disaster management plan have been made to take care of any on-site and off-site emergency. In addition, regular mock drills will be conducted to check the effectiveness of the system. The existing off-site disaster management plan will be augmented in consultation with other unit in-charge and district authorities before operation of unit 5 and 6.
4.4 Green belt development

About 30 ha of land will be developed under green belt or plantation area within project area.

5.0 ANALYSIS OF ALTERNATIVE SITE AND TECHNOLOGY

The PHWRs proposed to be set up at Kaiga site are indigenously designed, based on the technology evolved in India. The design of plant is consistent with the standard international practices for safety systems. The effluents/emissions to water, air and land from proposed units will be within the limits prescribed by State Pollution Control Board & AERB.

6.0 ENVIRONMENTAL MONITORING PROGRAMME

All the environmental aspects will be regularly monitored by technical services unit and Environmental Survey laboratory (ESL), HPD, BARC. The two will ensure the implementation and effectiveness/monitoring of various mitigating measures envisaged/adopted. An Environmental Management Apex Review Committee (EMARC), comprising of senior management level officers will periodically assess and monitor the implementation of mitigation measures and environmental monitoring programme.

7.0 ADDITIONAL STUDIES

Socio-economic study reveals that the project is not going to cause any attributable damage to the existing agricultural situation. The project has significant employment and income effects, direct, associated with the project, as well as indirect, associated with its allied activities.

The major chemical which will be stored by the project is only High Speed Diesel Oil (HSD). However, the handled quantity is well below the threshold limit. Accordingly, only rule 17 (of “Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 1989 and its Amendment Rules 2000”) applies, i.e. preparation and maintenance of material safety data sheets are required and has been taken care off.

In case of any risk due to pool fire it is expected that the 4 kw/m² heat radiation radius will be occurring at 33m from the dyke. It is expected that in case of fire, the heat will not be felt by the public due to exclusion zone of 2.3 km

Off site and site emergency preparedness and response manuals are already in place and Kaiga-5&6 plant emergency preparedness and response manual will be prepared and the same will be implemented.

8.0 PROJECT BENEFITS

The proposed project is likely to bring in additional benefits to the areas surrounding the plant in terms of increase in educational, health, infrastructure and employment potential. NPCIL Kaiga is already carrying out various social welfare activities for surrounding villages. Like in any other project, increase in the employment potential both direct as well as through contractual labour would bring in additional income for the people living around the project area.
9.0 BUDGETARY PROVISIONS FOR ENVIRONMENTAL PROTECTION MEASURES

The estimated capital cost of the proposed project (2 X 700 MWe) is around Rs. 21000 Crore. The item wise estimated cost towards environmental protection and enhancement measures are given in Chapter-6 of the EIA report. The environmental protection and enhancement measures include engineered safety features, “Equipment, Components, Systems & Structures (ECSS)” which are an integral part of nuclear power station.

10.0 SUMMARY AND CONCLUSION

The plant is designed with latest state-of-the-art technology so as to achieve minimum radioactive releases (within AERB stipulation) from air and water route and minimal release of conventional pollutants emitted from plant operation in form of air emissions, waste water and noise levels. Further, maximum re-use of wastewater has been envisaged.

The EIA report has comprehensively assessed all the potential environmental impacts associated with the project. In addition to this the combined impacts of operating reactors were also deliberated. The environmental impacts identified by the study are manageable. Site specific and practically suitable mitigation measures are recommended to mitigate the impacts and to comply with MoEF&CC/SPCB/AERB stipulations/norms with considerable margin. Further, a suitably designed monitoring plan has been provided to monitor and control the effectiveness of envisaged mitigation measures during the operation phase. These measures will ensure that any possible impact is minimized and controlled before its occurrence.