FINAL EIA REPORT
(ANNEXURES: X to XXIV)
TOR REFERENCE: NO. 10-53/2020-IA-III DATED 29TH OCTOBER, 2020
BASELINE PERIOD: DECEMBER 2019 TO FEBRUARY 2020

ENVIRONMENTAL IMPACT ASSESSMENT

FOR ENVIRONMENTAL & CRZ CLEARANCE OF ON-GOING PROJECT FOR ESTABLISHMENT OF

NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA)

AT ULWE, PANVEL TALUKA, RAIGAD DISTRICT, MAHARASHTRA

SUBMITTED TO:
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE
(MOEF & CC), NEW DELHI

SUBMITTED BY:
NAVI MUMBAI INTERNATIONAL AIRPORT PVT. LTD. (NMIAL)

ENVIRONMENT CONSULTANT:
VIMTA LABS LIMITED, HYDERABAD
(QCI/ NABET ACCREDITED SR.NO.139)

SEPTEMBER 2021

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ANNEXURE-X
CIDCO REHABILITATION & RESETTLEMENT POLICY

Rehabilitation & Re-settlement (R & R) Plan- NMIA

1. Project Background:

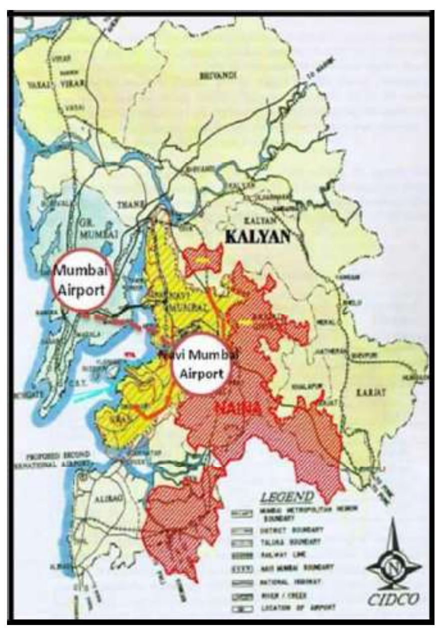
Objective:

Mumbai, being the financial and commercial capital of India, requires aviation facilities of the highest order. Presently Mumbai airport is handling 45.12 MPPA (Million Passengers Per Annum) and is experiencing severe constraints in augmenting the air side facilities to meet the future growth. Air Travel Demand for MMR is growing rapidly and the forecasted air Traffic is expected to be around 100 MPPA by 2034. To meet this anticipated air travel demand, the Ministry of Civil Aviation (MoCA) granted approval for the development of a Greenfield airport at Navi Mumbai. The Navi Mumbai Airport is proposed to be developed through Public-Private Participation (PPP) by setting up a Special Purpose Vehicle (SPV) with equity contribution from CIDCO.

In July 2008, Government of Maharashtra granted approval for development of Navi Mumbai International Airport project on PPP basis and appointed CIDCO as the nodal agency for its implementation. The total land earmarked for the airport project is 2268 Ha. CIDCO has obtained clearances from various Govt. Statutory bodies such as, Ministry of Civil Aviation (MoCA), MoEF, Ministry of Defence, Wild Life Clearance, Bombay High Court permission for removal of Mangroves and Final Forest clearance. CIDCO is in process of appointment of main developer for NMIA and has completed the bidding process. The developer will be in place after obtaining approval from State Cabinet.

Location:

The Navi Mumbai International Airport is located near Ulwe, almost the geographical center of Navi Mumbai between the existing National Highway No.4B (east side) and Aamra marg (west side) at a distance of approx. 35 kms. from existing airport in Mumbai, almost at the geographical centre of Navi Mumbai.

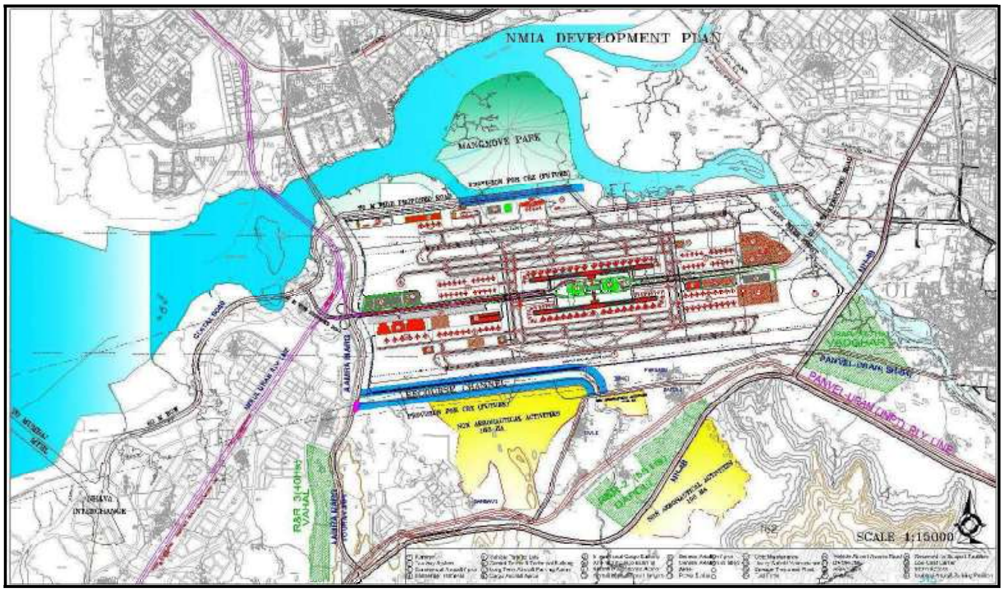


Location plan of NMIA

Salient Features:

The Navi Mumbai International Airport is located on a core area of 1160 ha and is proposed to have two parallel and independent runways for simultaneous and independent operations along with full length taxiways on either side of runways.

The airfield is compatible to ICAO Standard of aerodrome 4-F and designed to accommodate the new large aircrafts (A-380/B-747-8 and equivalent). The Airport is planned for an ultimate capacity of 60 mppa (million passengers per annum) and the first phase is planned for 10 mppa

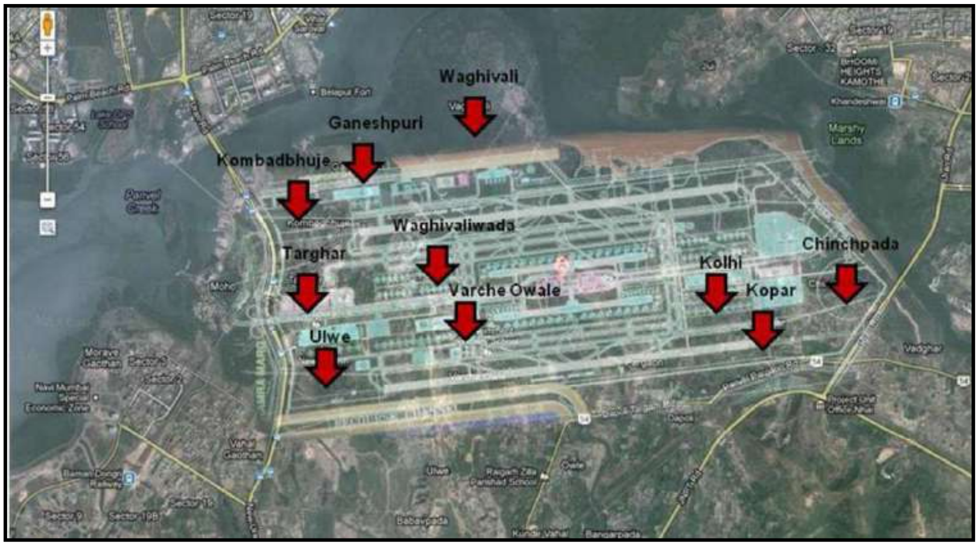


Master Plan of Navi Mumbai Airport

2. <u>Rehabilitation and Land Acquisition</u>

- **Resettlement & Rehabilitation (R & R)**

There are 3000 households in 7 villages (10 settlements) that are required to be rehabilitated. Sites near the airport have been identified for the same and development of these sites is going on. The Rehabilitation & Resettlement is being carried out as per the GR issued by GoM.



- **Land Requirement**

The total area of the airport is 2268 Ha. of which 1597 ha is in possession with the Government/CIDCO and 671 Ha of private land is being acquired.

3. Need for Rehabilitation and Resettlement :

Out of the land required for this project about 671 hectares private land was notified for acquisition and it has now been acquired. There are 3000 structures, required to be shifted & resettled at the R&R pockets selected & earmarked for this purpose. These structures are located within 10 gaothans as indicated below, which are falling in the proposed core airport area and in the land required to be used for allied purposes.

4. Affected Villages :

- Chinchpada
- Kopar
- Kolhi
- Upper Owale
- Waghivalivada
- Vaghivali
- Ganeshpuri
- Kombadbhuje
- Targhar
- Ulwe.

5. Constraints and Challenges

The rehabilitation of the existing settlements was a complex issue and convincing the villagers was the biggest constraint before the State Government. A series of meetings were held with the villagers. The determination of the entitlement was the biggest challenge for the organization and the State Government.

Initially the villagers opposed the land acquisition and resettlement of their existing villages. They demanded 35% developed land in lieu of their land holdings. However, several negotiations took place with the villagers wherein all their issues were discussed and attempted to resolve amicably. A series of meetings took place with the representatives of the villagers and local representatives, and at the highest level ie Hon Chief Minister, during which a consensus was reached.

Based on this consensus, as per the provision of the section 108 (1) & (2) of the Right to Fair Compensation & Transparency in Land Acquisition, Rehabilitation & Resettlement Act-2013, the State Govt. framed a policy/law for payment of higher compensation than calculated under the said act & announced it vide Govt. Resolution Urban Development Dept. No.CID-1812/CR-274/UD-10 dtd. 1st March 2014. The state Govt. has also granted similar benefits of Rehabilitation & resettlement vide Govt. Resolution Urban Development Dept. No.CID-1812/CR-274/UD-10 dtd. 28th May, 2014 to the structure owners whose structures are constructed on CIDCO land.

The land notified for acquisition within the core airport areas has been acquired from the land owners who have given their consents and opted for option given under the above Govt. Resolution. The remaining land is being acquired. The R&R land awards have been issued to several villagers who have come forward and the process is still on.

6. Approved Policy of Land Acquisition and R & R:

The salient features of the approved policy of Land Acquisition and Rehabilitation & Resettlement as per Govt. Resolution dtd. 1st March 2014 & 28th May, 2014 are given below:

I. Rehabilitation & Resettlement Package:-

1. Allotment of developed plot, three times the roof area of self-residing structure which existed on Sept. 2013 in project area, with 1.5 FSI. Built up area in multi storied structure will be considered for determining entitlement.

2. Financial aid for construction of new structure at Rs.1000/sqft for equivalent area of existing structure for all eligible structures in project area.

3. Developed plot of equivalent area will be allotted in lieu of structures being used for commercial purpose in project area.

4. The persons who are using the structure for commercial as well as residential purpose will be permitted to utilise 15% FSI for commercial purpose.

5. One time subsistence Allowance of Rs.0.36 lacs @ Rs.3000/- per month for 1 year to each structure holder family

6. One time financial assistance of 750 days of agriculture labour wages per structure holder family.

7. Rs. 50000/- one time financial assistance for transportation.

8. Permission to take away all types of old material by the structure holder.

9. All non-refundable amounts and deposits are waived off.

10. Free of cost vocational training.

11. Allotment of 100 shares of the face value of Rs.10 each to the family of structure holder.

12. Allotment of reclamation works of the amount of 50% through the registered contractors to whom CIDCO has awarded contracts.

13. The minimum plot area to be allotted would be 40 sq.mtr. & the maximum would be 700 sq.mtr.

Similar benefits are to be given to the structure owners on CIDCO land as provided vide Govt. Resolution Urban Development Dept. No.CID-1812/CR-274/UD-10 dtd. 28th May 2014.

II. Land Acquisition Package:-

1. Allotment of 22.5% gross land (i.e. net land of 15.75% excluding the land required for Infrastructural development) with 2.00 FSI for those who are eligible under 12.5% scheme or allotment of 10% gross land (i.e. net land of 7.00% excluding the land required for Infrastructural development) with 2.5 FSI for those who are not eligible under 12.5% scheme.
2. Allotment of 100 shares of face value of Rs.10 each to khatedar family.
3. Allotment of reclamation works of the amount of 50% through the registered contractors to whom CIDCO has awarded contracts.
4. Free of cost vocational training.

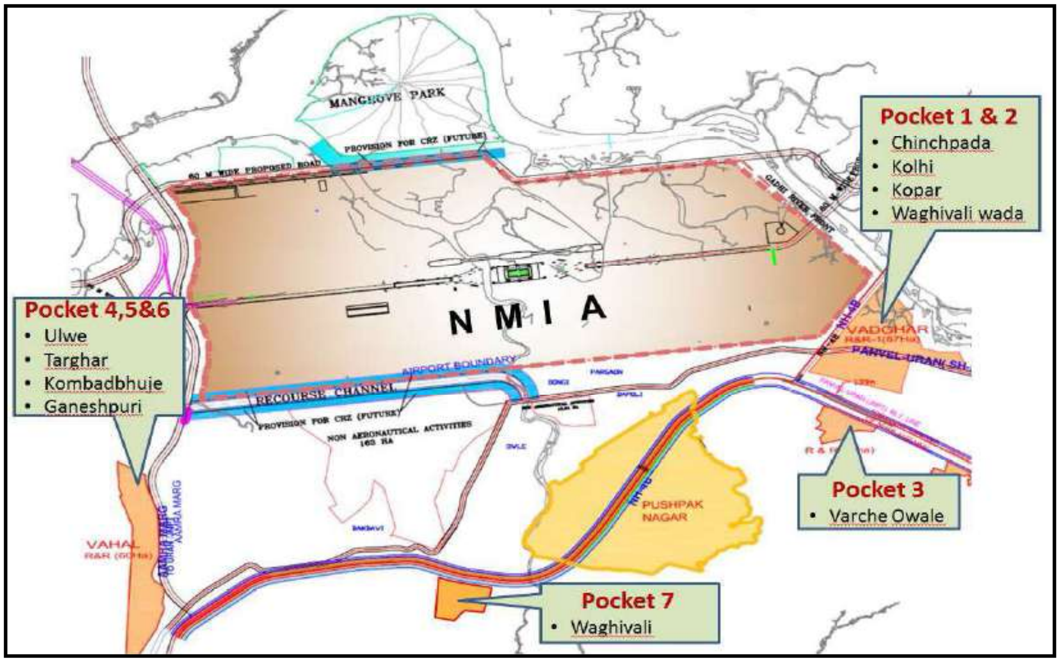
III. Other Infrastructural benefits:-

CIDCO will develop a complex consisting of all Govt /Non Govt offices such as:-

i) Gram Panchayat
ii) Talathi Office
iii) Primary Health Centre
iv) Post Office
v) Bank
vi) Community Centre

CIDCO will provide:-

i) Schools
ii) Religious Complex with open space for village festivals.
iii) Cremation Ground
iv) Shed for State Bus Service
v) Market



Location plan of R & R pockets and allocation of different villages

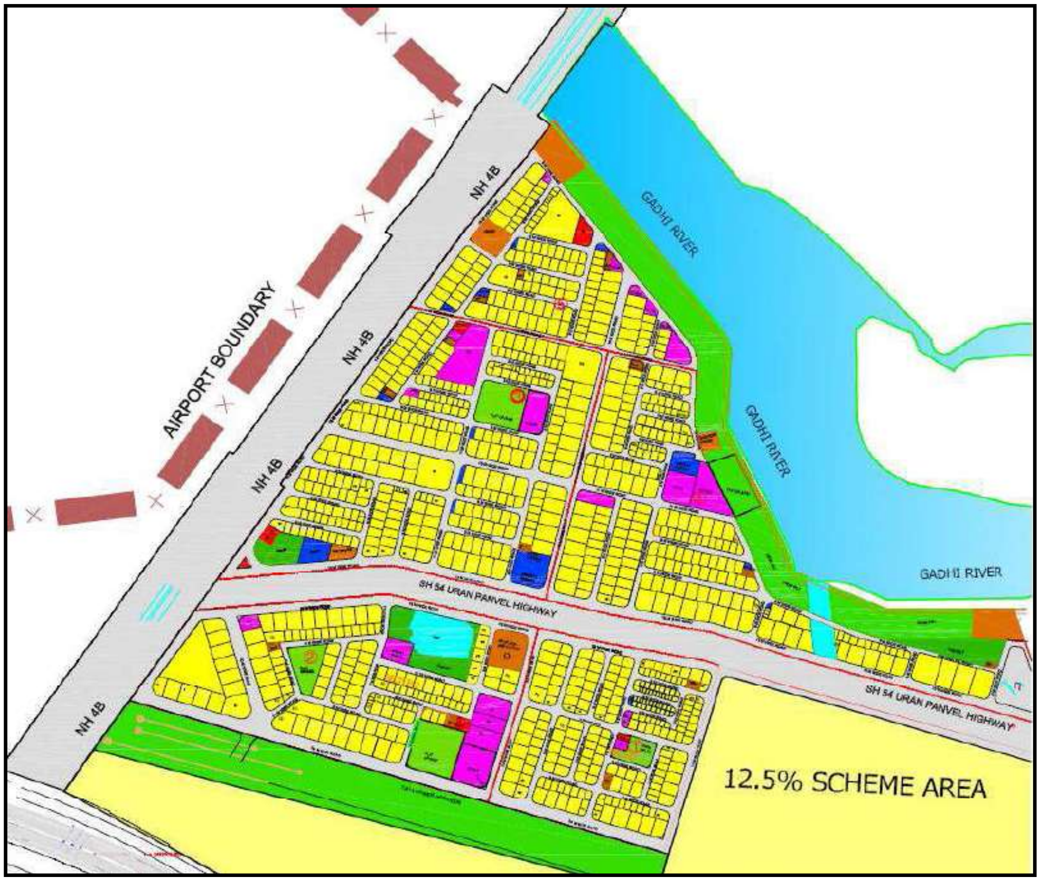
7. Site identified for Resettlement and Rehabilitation:

The sites for resettlement were identified as per availability of acquired land nearby the existing villages. The location for each village was decided after consultation with the local representatives. The following 7 pockets were identified for resettlement of the villages.

8. Approval to the R & R Plan:

The State Government has approved the policy for the rehabilitation of Villages. CIDCO being a New Town Development Authority has the powers to approve the rehabilitation plan under the Maharashtra Regional & Town Planning Act, 1966. Accordingly the layout plans are prepared and approved for implementation.

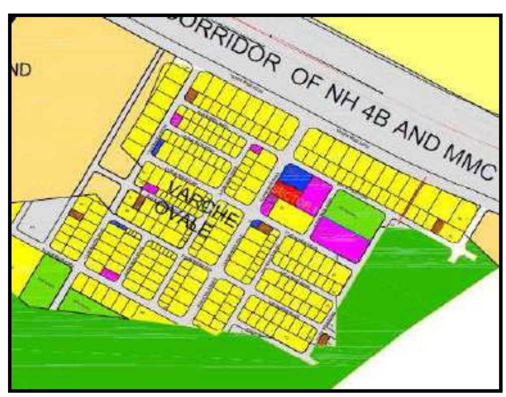
9. Vadghar – R & R Pocket No.1&2:



This R & R Pocket is divided into two segments with the physical separation by the State Highway No. 54. The gross area of these pockets is 40 ha and 21 ha respectively. The villages proposed to be rehabilitated at these pockets are Chinchpada, Kopar, Kolhi and Vaghiwaliwada. This area is proposed to be developed with all necessary facilities required for the village resettlement.

10. Vadghar – R & R Pocket No.3:

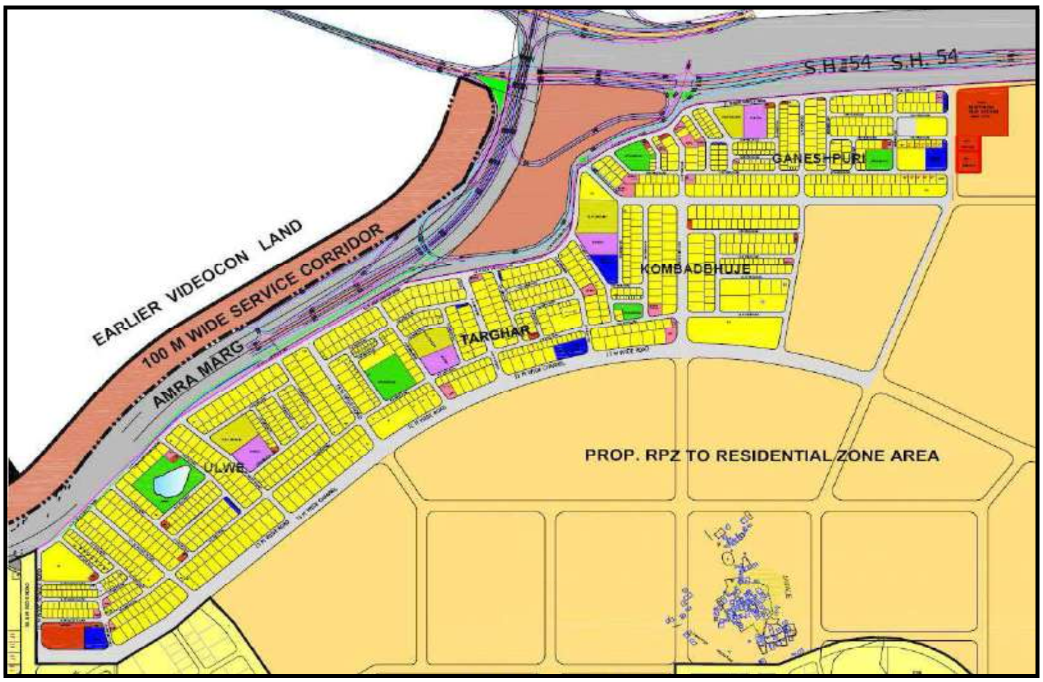
The village Varche Owale is being resettled along NH-4B. The total area identified for resettlement is 15 Ha.



This area is proposed to be developed with all necessary facilities required for the village resettlement.

11. Vahal – R & R Pocket No.4,5&6:

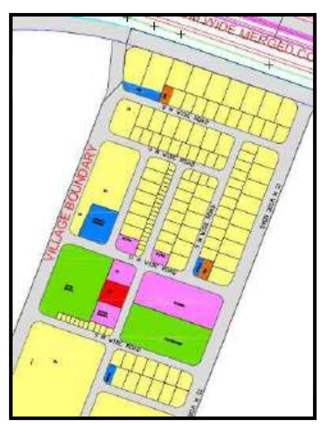
CIDCO has earmarked the Vahal R&R pocket 4, 5 & 6 at Sector 24,25 & 25A of Ulwe node at Vahal. The gross area of these pockets is 27 ha, 18 ha & 20 ha respectively. The villages to be rehabilitated in this pocket are Ulwe, Targhar, Kombadbhuje and Ganeshpuri. This area is also proposed to be developed with all necessary facilities required for the village resettlement.



12. Kundevahal – R & R Pocket No.7:

CIDCO has earmarked 10 ha of land at Kundevahal near Pushpaknagar for resettlement of Waghiwali village.

This area is proposed to be developed with all necessary facilities required for the village resettlement.



13. Social Infrastructure:

The following social facilities are proposed within the layouts of each village

1. Administrative Complex & Market with Parking
2. Community centre
3. Space for Mahila Mandal
4. School
5. Playground
6. Plot for Bus Terminus is proposed within R & R pockets at Karnjade node & Ulwe node. Bus stops will be provided as per local requirement.
7. Crematorium plots are identified for each node.
8. Temple complex with open space for village festivals is proposed for each village for shifting of existing religious structures from old villages.
9. Recreational open spaces will be developed along river front with facilities such as jogging path, senior citizens centre, children play area, ampitheatre and ghat for Ganesh visarjan etc.

14. Implementation of the R & R policy

According to the Govt. Resolution Revenue & Forest Dept. No.LQN-05/2014/ CR39/A-2 dtd. 16.06.2014 & Govt. Resolution Revenue & Forest Dept. No.RPA 2014/CR52/R-3 dtd. 25.06.2014 the Dy. Collector (Land Acquisition) & Dy. Collector (Rehabilitation) are authorised to determine entitlement of the concerned land/structure owners as to grant of plots & other benefits as per GR dtd.01.03.2014 & 28.05.2014 as the case may be. Out of the structures, 2431 structure owners have been determined eligible for grant of plots & other benefits and except a few cases, allotment letters of the plot have been issued by CIDCO.

15. Allotment of Plots as per Package through lottery:

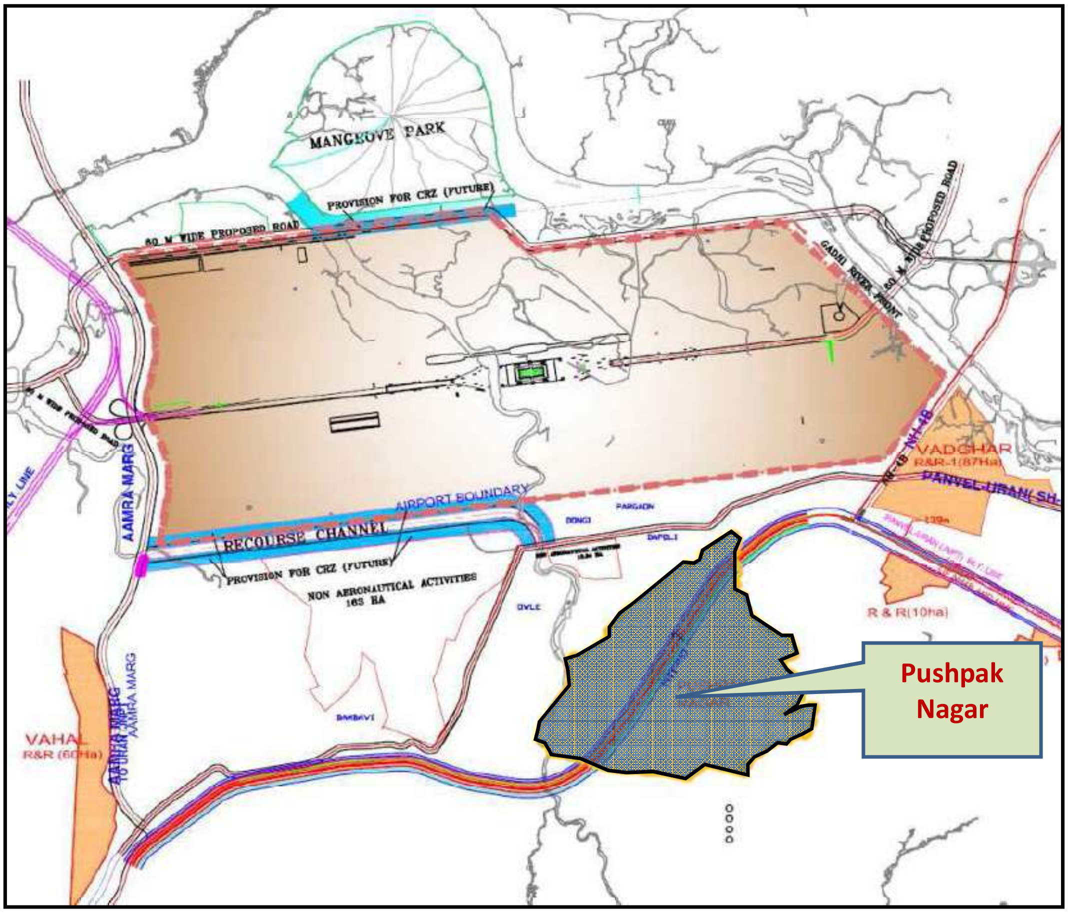
The allotment of plots is done as per eligibility of the PAP trough location lottery within the village layout. These lotteries are carried out in a transparent manner using software approved by Standardization Testing and Quality Certification Directorate (STQC), Pune, Govt. of India. These are carried out in presence of PAPs along with live webcasting so that the PAPs can view the lottery from anywhere through internet. Four lotteries were done for locational allotment of Plots.

16. Rental Policy :-

With a view to enable the structure owners to shift their structures and vacate the land CIDCO, has announced rental policy for them. Under this policy it is decided to rent from to those who are willing to dismantle their structures & vacate the land.

ALLOTMENT OF PLOTS TO THE LAND OWNERS WHOSE LAND HAS BEEN ACQUIRED

PUSHPAK Nagar – Land for Land Entitlement.



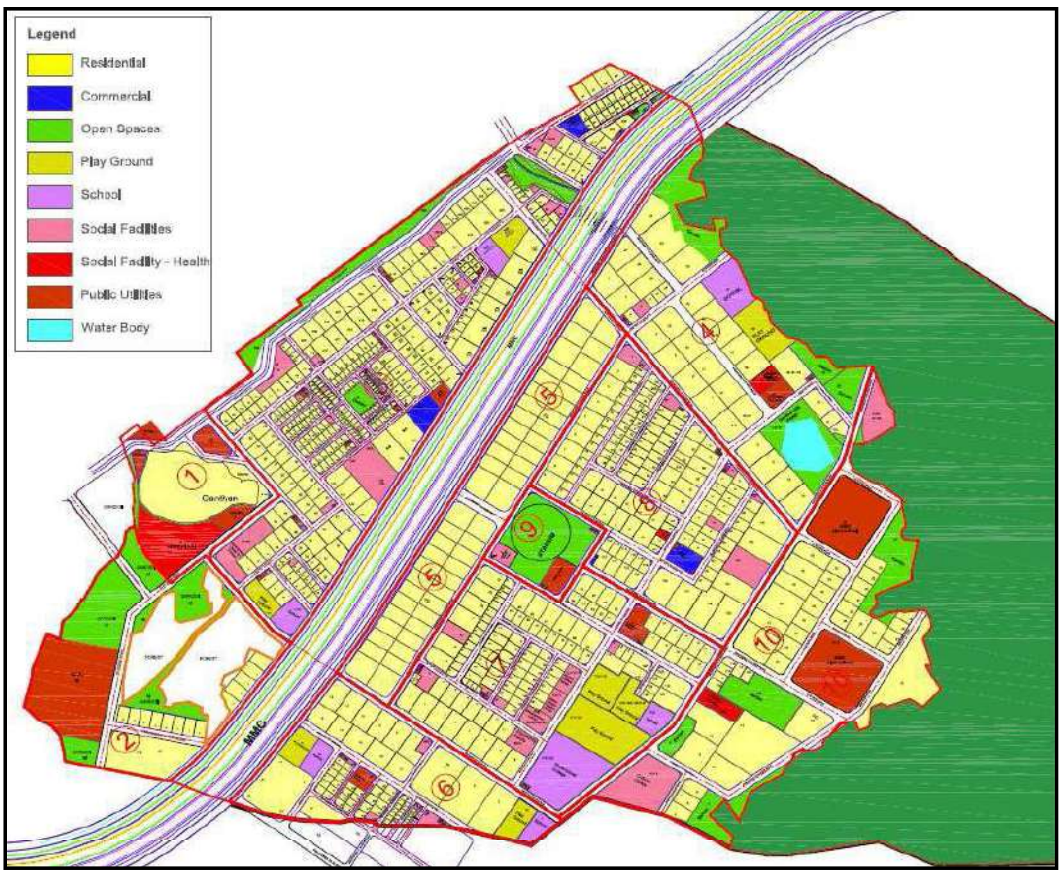
Location of Pushpak Nagar

- CIDCO has earmarked about 222 Ha. of land and designated this area as PUSHPAK Nagar for allotment of plots under 22.5% scheme as per decision of the Govt. of Maharashtra dtd. 01.03.2014. This land is located to the south of NMIA on existing NH-4B at a distance of 0.5 Km from proposed Airport boundary. It is proposed to provide world class civic amenities with good infrastructure facilities at this place.

- The 139 m wide joint corridor of NH4B and Virar Alibaug Multi-Modal Corridor, will pass through Pushpak Nagar. The Multi-Modal Corridor is proposed with all surface transportation facilities like Expressway, Metro Rail, BRTS (Bus Rapid Transport System), Service roads and Buffer Zone.

- Out of 222 Ha. of land about 49.77 % land will be used for Residential purpose (110 Ha.) and 4.5 % land will be used for Residential + Commercial purpose (10 Ha.). Out of the remaining land 7.85 % land will be used for Social Facilities (17.44 Ha.), 26.80 % will be used for transport facilities (59.55 Ha.), 7.76 % land will be used for Greenery and Open spaces (17.25 ha) and 3.32 % land will be used as Water Bodies (6.76 ha).

- The plots allotted at this place will have average 2 FSI in accordance with General Development Control Regulation.



- The development work of this area consists of Land development, provision of Storm water drains, laying of water supply lines, construction of roads, Laying of power supply line with sub- station and provision of Sewerage network with treatment plant and treated water supply network.

- Out of 103 Ha. of land to be allotted, lottery of the area of 100 Ha of land is drawn for allotment of plots to the 805 Khatedars

नवी मुंबई प्रकल्पातंर्गत उभारण्यात येणा-या नवी मुंबई आंतरराष्ट्रीय विमानतळ व तदनुषंगिक कामांसाठी तसेच नवी मुंबई प्रकल्पासाठी जमिनीचे संपादन करणेबाबत....

महाराष्ट्र शासन
शासन निर्णय क्रमांक : सिआयडी-१८१२/प्र.क्र.२७४/नवि-१०
नगर विकास विभाग,
मंत्रालय, मुंबई - ४०० ०३२,
दिनांक : १ मार्च, २०१४.

वाचा : १. नगर विकास विभाग शासन निर्णय क्रमांक : एलक्यूएन-१९८५/१७१०/ सीआर-२१७/८५/नवि-१०, दि. ६ मार्च, १९९०
२. नगर विकास विभाग शासन निर्णय क्रमांक : सिआयडी-१०९४/२०९४/ प्र.क्र.२८७/नवि-१०, दि. २८ ऑक्टोबर, १९९४

प्रस्तावना :-

नवी मुंबई आंतरराष्ट्रीय विमानतळ प्रकल्प राज्याच्या व देशाच्या विकासासाठी अत्यंत महत्वाचा असून सदर प्रकल्पासाठी भूसंपादनाची प्रक्रिया सिडकोमार्फत सुरु असून नवी मुंबई नवनगर प्रकल्पाकरीताही भविष्यकाळात जमिनीचे संपादन संकल्पित आहे. तथापि, भूसंपादनाचा मोबदला व पुनर्वसन या मुद्यांवर अनेक ठिकाणी बाधीत भूधारकांचा भूसंपादनास विरोध असल्याचे शासनाचे निदर्शनास आले आहे. याच दरम्यान दि.१ जानेवारी २०१४ पासून "The Right to Fair Compensation & Transparency in Land Acquisition Rehabilitation & Resettlement Act, 2013" हा नवीन केन्द्रीय अधिनियम अस्तित्वात आला असून, सदर कायद्याच्या प्रास्ताविकात बाधीत व्यक्तींना विकासात भागिदार करुन घेण्याचे नमुद केले आहे. तसेच, सदर नवीन केन्द्रीय कायद्याच्या कलम १०८ चे उपकलम (१) व उपकलम (२) अन्वये जेथे राज्य शासनाच्या कायदा किंवा धोरणाप्रमाणे सदर नवीन केन्द्रीय कायद्यामधील तरतुदीं पेक्षा जास्त मोबदला आणि चांगल्या पुनर्वसनाची तरतुद असेल आणि बाधीत व्यक्तीने किंवा त्याच्या कुटूंबाने किंवा त्याच्या कुटूंबातील सदस्याने अशा राज्य शासनाच्या कायदा किंवा धोरणाप्रमाणे मोबदला व तरतूदींचा लाभ मिळावा असा पर्याय दिला असेल तेथे त्या पर्यायाप्रमाणे मोबदला व पुनर्वसनाचे लाभ देण्याची तरतूद आहे. सदर नवीन केन्द्रीय कायद्याच्या कलम १०८ ची तरतूद पहाता राज्य शासनाच्या कायद्याप्रमाणे किंवा धोरणाप्रमाणे सदर नवीन केन्द्रीय कायद्यात प्रस्तावीत केलेल्या जमिन संपादनाच्या मोबदल्यापेक्षा जास्त मोबदला तसेच पुनर्वसनाच्या तरतूदी पेक्षा एकंदरीत जास्त लाभ देय असतील तर जमिन मालकांची किंवा बाधीत व्यक्तींची संमती असल्यास असा जास्त मोबदला आणि पुनर्वसनाच्या जास्त लाभदायक तरतुदी लागू करता येतील. या पार्श्वभूमीवर नवी मुंबई अंतराष्ट्रीय विमानतळ प्रकल्प व नवी मुंबई प्रकल्पास चालना देण्याच्या दृष्टीने सदर प्रकल्पासाठी होणाऱ्या भुसंपादनामुळे बाधीत होणाऱ्या व्यक्तींना वर उल्लेखित नवीन केन्द्रीय कायद्यापेक्षा जास्त मोबदला व अधिक लाभदायक पुनर्वसन योजना लागू करण्याविषयी धोरण ठरविण्याची बाब शासनाच्या विचाराधीन होती. यानुषंगाने भूसंपादन आणि पुनर्वसन व पुनर्स्थापना यासंबंधी दि.०१.०१.२०१४ पासून लागू झालेल्या केंद्र शासनाच्या "The Right To Fair Compensation And Transparency In Land Acquisition, Rehabilitation And Resettlement Act,

2013" या नविन केन्द्रीय कायद्यातील कलम २४ व कलम १०८ मधील तरतुदी विचारात घेवून बाधित व्यक्तींना द्यावयाच्या देय मोबदल्यासंबंधी सिडकोने शासनास सादर केलेल्या प्रस्तावाचा परामर्श घेवून शासनाने पुढीलप्रमाणे निर्णय घेतला आहे.

शासन निर्णय :-

नवी मुंबई आंतरराष्ट्रीय विमानतळ व आनुंषगिक कामांसाठी तसेच नवी मुंबई प्रकल्पासाठी भविष्यात संपादित करण्यांत येणाऱ्या जमिनीच्या भूधारकांसाठी भूसंपादनापोटी देय मोबदल्याबाबत आणि त्यानुषंगिक पुनर्वसन विषयक लाभांसंदर्भात शासन पुढीलप्रमाणे धोरणास मान्यता देत आहे :-

१. ज्या प्रकरणी भूसंपादन अधिनियम १८९४ चे कलम ४ उपकलम (१) अन्वये अधिसूचना दि.१.१.२०१४ पूर्वी प्रसिद्ध करण्यात आली आहे परंतू भूसंपादन अधिनियम १८९४ च्या कलम ११ अन्वये निवाडा जाहीर झालेला नाही अशा प्रकरणी "The Right To Fair Compensation And Transparency In Land Acquisition, Rehabilitation And Resettlement Act, 2013" या नवीन केन्द्रीय कायद्यातील मोबदला निश्चीत करण्याच्या तरतूदी लागू होतात. तसेच सदर नवीन केन्द्रीय कायद्याच्या कलम १०८ चे उपकलम (१) व उपकलम (२) अन्वये जेथे राज्य शासनाच्या कायदा किंवा धोरणाप्रमाणे सदर नवीन केन्द्रीय कायद्यामधील तरतुदीं पेक्षा जास्त मोबदला आणि चांगल्या पुनर्वसनाची तरतुद असेल आणि बाधीत व्यक्तीने किंवा त्याच्या कुटूंबाने किंवा त्याच्या कुटूंबातील सदस्याने अशा राज्य शासनाच्या कायदा किंवा धोरणाप्रमाणे मोबदला व तरतूदींचा लाभ मिळावा असा पर्याय दिला असेल तेथे त्या पर्यायाप्रमाणे मोबदला व पुनर्वसनाचे लाभ देण्याची तरतूद आहे. या अनुषंगाने नवी मुंबई आंतरराष्ट्रीय विमानतळ प्रकल्प व आनुंषगिक कामांसाठी तसेच नवी मुंबई प्रकल्पासाठी भूसंपादन करीत असतांना :-

अ) केवळ जमिनीचे भूसंपादन होणाऱ्या भूधारकांसाठी या शासन निर्णया सोबतच्या परिशिष्टातील (I) प्रमाणे मोबदला व लाभ अनुज्ञेय व देय असतील; आणि

ब) फक्त बांधकामाखालील जमिनीचे भूसंपादन होवून स्थलांतरीत होणा-या भूधारकांसाठी या शासन निर्णया सोबतच्या परिशिष्टातील (II) प्रमाणे लाभ अनुज्ञेय व देय राहतील.

क) शेतजमीन व घराखालील जमीन संपादित होणा-या भूधारकांच्या संदर्भात त्यांच्या संपादित होणाऱ्या शेतजमिनीसाठी या शासन निर्णयासोबतच्या परिशिष्टातील (I) प्रमाणे व बाधित बांधकामासाठी परिशिष्टातील (II) प्रमाणे लाभ अनुज्ञेय व देय असतील. मात्र, सदर लाभांपैकी नवी मुंबई विमानतळ प्रकल्प कंपनीच्या समभागाचे वाटप, प्रकल्पबाधितांना कंत्रांटांतर्गत काम देणे व प्रकल्पबाधितांचे व्यावसायिक प्रशिक्षण हे सामाईक लाभ संबंधित भूधारकास एकदाच देय राहतील.

नवीन केन्द्रीय भूसंपादन कायद्याच्या कलम १०८ अन्वये भूसंपादनापोटी ज्या बाधीत व्यक्ती या शासन निर्णयासोबतच्या परिशिष्टा प्रमाणे अनुज्ञेय व देय लाभांचा पर्याय मान्य करतील त्यांनाच त्यांच्या जमिनीचे संपादन करण्या करिता सदर परिशिष्टामध्ये नमूद लाभ सिडकोकडून प्रदान करण्यात येतील.

२. ज्या भूधारकांना वरील पर्याय मान्य नसेल किंवा इतर कोणत्याही कारणास्तव नुकसान भरपाई म्हणून त्यांना विकसित जमिन देता येणे शक्य होत नसेल, अशा भूधारकांना सदर नवीन केन्द्रीय भूमीसंपादन

अधिनियमानुसार देय होणारी रोख रक्कमेमधील नुकसान भरपाई व इतर लाभ सिडकोकडून देय राहतील. तथापी अशा प्रकरणी सदर नवीन केन्द्रीय भूमीसंपादन अधिनियमानुसार २० टक्के जमिन देण्याची तरतूद लागू होणार असल्यामुळे, असे भूधारक संदर्भिय शासन निर्णय दि. ०६.०३.१९९० व शासन निर्णय दि. २८.१०.१९९४ अन्वये मिळणाऱ्या विकसित भूखंडाच्या वाटपाचा लाभ घेण्यास पात्र ठरणार नाहीत.

महाराष्ट्राचे राज्यपाल यांच्या आदेशानुसार व नावांने,

1/3/2014

(मनु कुमार श्रीवास्तव)
शासनाचे प्रधान सचिव

प्रत,

मा. राज्यपाल, महाराष्ट्र राज्य यांचे सचिव
मा. मुख्यमंत्री यांचे प्रधान सचिव, मंत्रालय, मुंबई.
मा. राज्यमंत्री, नगर विकास विभाग, मंत्रालय, मुंबई यांचे खाजगी सचिव.
मा. मुख्य सचिव, महाराष्ट्र शासन
अपर मुख्य सचिव (वित्त), मंत्रालय, मुंबई.
अपर मुख्य सचिव (नियोजन), मंत्रालय, मुंबई.
प्रधान सचिव (वने), मंत्रालय, मुंबई.
प्रधान सचिव (१), नगर विकास विभाग, मंत्रालय, मुंबई.
प्रधान सचिव (२), नगर विकास विभाग, मंत्रालय, मुंबई.
उपाध्यक्ष तथा व्यवस्थापकीय संचालक, शहर व औद्योगिक विकास महामंडळ (महाराष्ट्र) मर्यादित (सिडको), नरिमन पॉईन्ट, मुंबई-४०० ०२१.
विभागीय आयुक्त, कोकण विभाग, नवी मुंबई.
आयुक्त, नवी मुंबई महानगरपालिका
जिल्हाधिकारी, ठाणे
जिल्हाधिकारी, रायगड
निवड नस्ती (नवि-१०).

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<u>नगर विकास विभाग, शासन निर्णय क्रमांक : सिआयडी-१८१२/प्र.क्र.२७४/नवि-१०</u>
<u>दिनांक : १ मार्च, २०१४ सोबतचे</u>

परिशिष्ट

(I) केवळ जमीनीचे संपादन होणा-या भूधारकांसाठी देय व अनुज्ञेय लाभ

१. विकसित भूखंडाच्या स्वरूपात मोबदला :-

१.१ प्रचलित भूमी संपादन अधिनियमानुसार जाहिर करण्यांत येणा-या निवाडयाप्रमाणे अंतिमत: सर्व घटकांसह देय होणा-या नुकसान भरपाईच्या रोख रक्कमे ऐवजी, संबधित भूधारकांना २.५ चटई क्षेत्र निर्देशांकासहित १० टक्के विकसीत जमिन व १२.५ टक्के भूवाटप योजनेनुसार पात्र असणा-या भूधारकांना १.५ चटई क्षेत्र निर्देशांकासहित १२.५ टक्के विकसीत जमिन अनुज्ञेय व देय राहील. त्यानुसार बाधित भूधारकास भूसंपादनाच्या मोबदल्यात अनुज्ञेय व देय विकसीत भूखंडाचा तपशील खालीलप्रमाणे आहे :-

अ.क्र.	तपशिल	प्रति हेक्टरी निव्वळ देय भूखंड (चौ.मी.)	अनुज्ञेय चटईक्षेत्र निर्देशांक	अनुज्ञेय चटईक्षेत्र निर्देशांकानुसार बांधकाम योग्य क्षेत्र (चौ.मी.)
१.	नुकसान भरपाईच्या रोख रक्कमेऐवजी १० टक्के विकसित जमिन	७००	२.५	१७५०.००
२.	१२.५ टक्के भूवाटप योजना	८७५	१.५	१३१२.५०
एकूण	**२२.५ टक्के**	**१५७५**		**३०६२.५०**

१.२ वर नमूद केल्यानुसार एकूण अनुज्ञेय चटई क्षेत्र निर्देशांकाचा पुर्णत: त्याच भूखंडावर वापर करण्यासाठी अशा भूखंडाचे कमीत-कमी क्षेत्र १००० चौ.मी.असणे गरजेचे आहे. त्यामुळे १००० चौ.मी.पेक्षा कमी क्षेत्राचे भूखंड देय होणाऱ्या भूधारकांनी वाटपापूर्वी इतर भूधारकांसमवेत एकत्रीत येवून १००० चौ.मी. किंवा त्याहून जास्त क्षेत्राच्या भूखंडाची मागणी केल्यास त्यानुसार त्यांना एकत्रीत भूखंडाचे वाटप करण्यात येईल.

१.३ १००० चौ.मी.पेक्षा कमी क्षेत्र वाटप झालेल्या भूखंडधारकांनी, बांधकाम परवानगीच्या वेळी बाजूच्या भूखंडांशी एकत्रिकरण करुन बांधकाम करण्यास परवानगी मागितल्यास त्याप्रमाणे ती नियमानुसार देय राहोल.

१.४ ज्या भूखंडधारकांना एकत्रिकरणाचा लाभ घ्यावयाचा नसेल अशा भूखंडधारकांना त्यांच्या पात्रतेनुसार भूखंडाचे वाटप करण्यात येईल व काही विशिष्ट निर्बंधांमुळे पूर्ण अनुज्ञेय चटई क्षेत्र निर्देशांकाचा त्याच भूखंडावर वापर करता येत नसल्यास शिल्लक राहिलेल्या चटईक्षेत्र निर्देशांकाचा वापर सदर भूखंडधारक स्वत: किंवा विक्री करुन त्याच नोडमधील इतर भूखंडावर रहिवासी कारणासाठी इतर नियमांना अधिन राहून करू शकेल.

यासंदर्भातील तरतूद संबंधीत विकास नियंत्रण नियमावलीमध्ये अंतर्भूत करण्यात येईल.

२. नवी मुंबई विमानतळ प्रकल्प कंपनीच्या समभागाचे वाटप :-

नवी मुंबई विमानतळ प्रकल्पासाठी संपादित करण्यात येणा-या जमिनीच्या भूधारकांच्या कुटूंबांना सदर प्रकल्पासाठी स्थापन करण्यात येणा-या विमानतळ कंपनीचे रुपये १०/- दर्शनी मुल्यांचे १०० समभाग नि:शुल्क सिडकोकडून देण्यात येतील.

३. प्रकल्पबाधितांना कंत्राटांतर्गत काम देणे :-

नवी मुंबई विमानतळाच्या कामासाठी नोंदणीकृत कंत्राटदारांना प्रदान करण्यात येणा-या कामांपैकी माती भरणीच्या कामांपैकी ५०% किंमतीची कामे प्रचलित जिल्हा दर सूची (DSR) मधील दराने प्रकल्पबाधितांमार्फत करवून घेण्याची अट समाविष्ट करण्यासंबंधी सिडकोकडून आवश्यक ती कार्यवाही करण्यात येईल जेणेकरून प्रकल्पबाधितांना सदर कंत्राटांतर्गत काम मिळेल.

४. प्रकल्पबाधितांना व्यावसायिक प्रशिक्षण :-

प्रकल्पबाधित कुटूंबामधील पात्र व्यक्तींना सिडकोच्या खर्चाने व्यावसायिक प्रशिक्षण देण्यात येईल.

(II) केवळ बांधकामाखालील जमीनीचे संपादन होवून स्थलांतरण होणा-या भूधारकांसाठी देय व अनुज्ञेय लाभ

१. प्रकल्पबाधितांच्या निवासी व मिश्र वापराच्या बांधकामासाठी विकसित भूखंड :-

नवी मुंबई विमानतळ क्षेत्रामधील स्वत: राहत असलेल्या प्रकल्पबाधित बांधकामधारकास त्याच्या घराच्या छप्पराखालील क्षेत्राच्या तिप्पट क्षेत्राएवढा, त्याचप्रमाणे स्वत: रहात असलेल्या प्रकल्पबाधित बांधकामधारकास त्याच्या बहुमजली इमारतीमधील, छत नस्लेली बाल्कनी व टेरेस यांचे क्षेत्र वगळून, बांधीव क्षेत्राच्या तिप्पट क्षेत्राएवढा विकसित भूखंड १.५ चटई निर्देशांकासह अनुज्ञेय व देय राहील.

२. प्रकल्पबाधितांच्या वाणिज्यिक वापराच्या बांधकामाबद्दल भूखंड:-

नवी मुंबई विमानतळ क्षेत्रातील वाणिज्यिक वापराच्या बांधकामाखालील क्षेत्राबद्दल, संबंधीत प्रकल्पबाधित बांधकाम धारकास समतुल्य क्षेत्राच्या विकसित वाणिज्यिक भूखंडाचे वाटप अनुज्ञेय राहील.

वरीलप्रमाणे प्रकल्पबाधित कुटूंबास निवासी अथवा वाणिज्यिक प्रयोजनार्थ देय भूखंडाचे किमान क्षेत्र ४० चौ. मि. असेल. भूखंडासाठी कमाल क्षेत्रफळाची मर्यादा सिडकोकडून स्वतंत्रपणे ठरविण्यात येईल.

३. प्रकल्पबाधितांना गृहबांधणीसाठी अर्थसहाय्य :-

नवी मुंबई विमानतळ क्षेत्रातील प्रकल्पबाधित स्वत: रहात असलेल्या तसेच वाणिज्यिक प्रयोजनासाठी वापरीत असलेल्या बाधित होणाऱ्या बांधकामाबद्दल सदर क्षेत्रफळाएवढे बांधकाम करण्यासाठी प्रती चौरस फुटास रुपये १०००/- (अक्षरी रुपये एक हजार मात्र) या दराने बांधकाम खर्च देण्यात देय राहील.

४. मिश्र वापराबद्दल १५ टक्के वाणिज्यिक वापरास अनुमती :-

नवी मुंबई विमानतळ क्षेत्रातील प्रकल्पबाधितांच्या मिश्र वापराच्या बांधकामापोटी प्रकल्पबाधितांस देय विकसित भूखंडाच्या अनुज्ञेय चटई क्षेत्राच्या १५ टक्के चटई क्षेत्राचा वापर वाणिज्यिक प्रयोजनासाठी करणे अनुज्ञेय राहील.

५. प्रकल्पबाधित कुटूंबास एक रक्कमी निर्वाह भत्ता :-

स्थलांतरीत होणा-या प्रत्येक प्रकल्पबाधित कुटूंबास एक रक्कमी रु.३६,०००/- निर्वाह भत्ता देय राहील.

६. प्रकल्पबाधित कुटुंबास एक रक्कमी आर्थिक सहाय्य :-

स्थलांतरीत होणा-या प्रत्येक प्रकल्पबाधित कुटूंबास किमान कृषी मजूरीच्या दराने ७५० दिवसांच्या कृषी मजूरी इतकी रक्कम एक रक्कमी आर्थिक सहाय्य म्हणून देय राहील.

७. प्रकल्पबाधितांना वाहतुकीसाठी आर्थिक सहाय्य :-

स्थलांतरीत होणा-या प्रत्येक प्रकल्पबाधित कुटुंबास रु.५०,०००/- इतकी रक्कम सामान वाहतुकीसाठी देय राहील.

८. जुन्या बांधकामांची सामुग्री नेण्यास अनुमती :-

जुन्या बांधकामांची सामुग्री विनामुल्य नेण्यास संबंधित प्रकल्पबाधित बांधकामधारकास अनुमती राहील.

९. ना-परतावा रक्कम भरण्यास सूट :-

बांधकाम परवानगी इत्यादीसाठी सिडकोकडे भरावयाच्या ना-परतावा व परतावा-पात्र रक्कमा भरण्यापासून स्थलांतरीत होणा-या प्रकल्पबाधीत कुटूंबास सूट देण्यात येईल.

१०. **प्रकल्पबाधितांना व्यावसायिक प्रशिक्षण :-**

स्थलांतरीत होणा-या प्रकल्पबाधित कुटूंबामधील पात्र व्यक्तींना सिडकोच्या खर्चाने व्यावसायिक प्रशिक्षण देण्यात येईल.

११. **नवी मुंबई विमानतळ प्रकल्प कंपनीच्या समभागाचे वाटप :-**

बांधकामाखालील जमीनीच्या संपादनामुळे स्थलांतरित होणाऱ्या प्रकल्पबाधित कुटुंबाना नवी मुंबई विमानतळ प्रकल्पासाठी स्थापन करण्यात येणा-या विमानतळ कंपनीचे रुपये १०/- दर्शनी मुल्यांचे १०० समभाग नि:शुल्क सिडकोकडून देण्यात येतील. संपादीत करण्यात येणा-या जमिनीबद्दल संबधित भूधारकास हा लाभ प्राप्त होणार असल्यास, बांधकामाखालील जमीनीच्या संपादनामुळे स्थलांतरीत होणारे कुटुंब म्हणून हा लाभ त्यास पुन्हा देय होणार नाही.

१२. **प्रकल्पबाधितांना कंत्राटांतर्गत काम देणे :-**

नवी मुंबई विमानतळाच्या कामासाठी नोंदणीकृत कंत्राटदारांना प्रदान करण्यात येणा-या कामांपैकी माती भरणीच्या कामांपैकी ५०% किंमतीची कामे प्रचलित जिल्हा दर सूची (DSR) मधील दराने प्रकल्पबाधितांमार्फत करवून घेण्याची अट समाविष्ट करण्यासंबंधी सिडकोकडून आवश्यक ती कार्यवाही करण्यात येईल जेणेकरून प्रकल्पबाधितांना सदर कंत्राटांतर्गत काम मिळेल.

(III) या परिशिष्टांतर्गत देय लाभांसाठी पात्रता निश्चित करणे :-

१. भूखंड वाटपासाठी सप्टेंबर २०१३ च्या उपग्रह नकाशावर दिसणारी सर्व बांधकामे विचारात घेतली जातील.
२. इतर लाभांसाठी सप्टेंबर २०१३ ची स्थिती लक्षात घेतली जाईल.

(IV) पुनर्वसीत क्षेत्राच्या ठिकाणी दिले जाणारे सर्वसाधारण लाभ:-

१. प्रकल्पबाधितांच्या पुन:स्थापनेच्या ठिकाणी शासकीय/निमशासकीय संकुल :-

प्रकल्पबाधितांच्या पुन:स्थापनेच्या ठिकाणी खालील शासकीय / निमशासकीय कार्यालयांसाठी सिडकोमार्फत संकुल विकसित करुन देण्यात येईल :-

- ग्राम पंचायत कार्यालय
- तलाठी कार्यालय
- टपाल कार्यालय
- बँक
- समाजमंदिर

२. सिडकोच्या निकषानुसार सामाजिक सुविधांची तरतूद :-

प्रकल्पबाधितांच्या पुन:स्थापनेच्या ठिकाणी सिडकोकडून खालील सामाजिक सुविधांची पूर्तता करण्यात येईल :-

- शाळा व सार्वजनिक मैदान
- सण / उत्सवासाठी मोकळया जागेसह धार्मिक संकुल
- स्मशानभूमी
- बसथांबा
- मार्केट

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नवी मुंबई आंतरराष्ट्रीय विमानतळामुळे
स्थलांतरीत होणाऱ्या सिडकोच्या ताब्यातील
जमिनीवरील अनधिकृत बांधकाम
धारकांच्या पुनर्वसन व पुन:स्थापनेबाबत....

महाराष्ट्र शासन
शासन निर्णय क्रमांक : सिआयडी-१८१२/प्र.क्र.२७४/नवि-१०
नगर विकास विभाग,
मंत्रालय, मुंबई - ४०० ०३२,
दिनांक : २८ मे, २०१४.

वाचा : १. नगर विकास विभाग शासन निर्णय क्रमांक : सिआयडी-१८१२/प्र.क्र.२७४/नवि-१०, दि. १ मार्च, २०१४
२. उपाध्यक्ष व व्यवस्थापकीय संचालक, सिडको यांचे पत्र क्र. सिडको/व्य.सं./वि.त.पुन:स्थापना/२०१४, दि. २ मे, २०१४

प्रस्तावना :-

शासनाने संदर्भ क्र. १ वरील दि. १.३.२०१४ रोजीच्या शासन निर्णयान्वये नवी मुंबई आंतरराष्ट्रीय विमानतळ व तद्नुषंगिक कामांसाठी तसेच नवी मुंबई प्रकल्पासाठी भविष्यात संपादित करण्यांत येणाऱ्या जमिनींच्या भूसंपादनापोटी देय मोबदल्याबाबत आणि त्यानुषंगिक पुनर्वसन विषयक लाभांसंदर्भात धोरणास मान्यता दिली आहे. त्यास अनुसरुन सिडकोच्या ताब्यातील जमिनीवरील अनधिकृत बांधकामांच्या संदर्भात संबंधित बांधकाम धारकांनासुध्दा उपरोक्त नमुद शासन निर्णय दि. १.३.२०१४ च्या परिशिष्टामधील भाग-२ अन्वये देय होणारे लाभ काही फरकासह विशेष बाब म्हणून लागू करावेत असा प्रस्ताव सिडको यांनी संदर्भ क्र. २ वरील पत्रान्वये सादर केला आहे. सदर प्रस्तावास अनुसरुन शासनाने विचारांती पुढीलप्रमाणे निर्णय घेतला आहे.

शासन निर्णय :-

नवी मुंबई आंतरराष्ट्रीय विमानतळ प्रकल्पाचे महत्व व तो सत्वर कार्यान्वीत होण्याची गरज लक्षात घेवून सिडकोने संदर्भ क्रमांक २ वरील पत्रान्वये सादर केलेल्या प्रस्तावाचा विचार करता नवी मुंबई आंतरराष्ट्रीय विमानतळ व तद्नुषंगिक कामांसाठी सिडकोच्या ताब्यातील जमिनीवर असलेल्या अनधिकृत बांधकाम धारकांनासुध्दा या शासन निर्णयासोबतच्या परिशिष्टात नमुद केलेले लाभ एक विशेष बाब म्हणून मंजूर करण्याच्या प्रस्तावास मान्यता देत आहे.

महाराष्ट्राचे राज्यपाल यांच्या आदेशानुसार व नावांने,

२८.५.२०१४

(एस. के. सालीमठ)
शासनाचे उप सचिव

प्रत,

मा. राज्यपाल, महाराष्ट्र राज्य यांचे सचिव.
मा. मुख्यमंत्री यांचे प्रधान सचिव, मंत्रालय, मुंबई.

(कृ.मा.प.)

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मा. राज्यमंत्री, नगर विकास विभाग, मंत्रालय, मुंबई यांचे खाजगी सचिव.
मा. मुख्य सचिव, महाराष्ट्र शासन
अपर मुख्य सचिव (वित्त), मंत्रालय, मुंबई.
अपर मुख्य सचिव (नियोजन), मंत्रालय, मुंबई.
प्रधान सचिव (वने), मंत्रालय, मुंबई.
प्रधान सचिव (१), नगर विकास विभाग, मंत्रालय, मुंबई.
प्रधान सचिव (२), नगर विकास विभाग, मंत्रालय, मुंबई.
सचिव (मदत व पुनर्वसन), महसूल व वन विभाग, मंत्रालय, मुंबई.
उपाध्यक्ष तथा व्यवस्थापकीय संचालक, शहर व औद्योगिक विकास महामंडळ (महाराष्ट्र) मर्यादित (सिडको), नरिमन पॉईन्ट, मुंबई-४०० ०२१.
विभागीय आयुक्त, कोकण विभाग, नवी मुंबई.
आयुक्त, नवी मुंबई महानगरपालिका
जिल्हाधिकारी, ठाणे
जिल्हाधिकारी, रायगड
निवड नस्ती (नवि-१०).

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नगर विकास विभाग शासन निर्णय क्रमांक : सिआयडी-१८१२/प्र.क्र.२७४/नवि-१०
दि. २८ मे, २०१४ सोबतचे

परिशिष्ट

(I) नवी मुंबई आंतरराष्ट्रीय विमानतळ प्रकल्प व तद्नुषंगिक कामांमुळे स्थलांतरीत होणा-या सिडकोच्या ताब्यातील जमिनीवर असलेल्या अनधिकृत बांधकामधारकांसाठी अनुज्ञेय लाभ.

१. प्रकल्पबाधितांच्या निवासी व मिश्र वापराच्या अनधिकृत बांधकामासाठी विकसित भूखंड :-

नवी मुंबई विमानतळ क्षेत्रामधील सिडकोच्या ताब्यामधील जमिनीवरील बांधकामामध्ये स्वत: रहात असलेल्या प्रकल्पबाधित बांधकामधारकास त्याच्या घराच्या छप्पराखालील क्षेत्राच्या तिप्पट क्षेत्राएवढा, त्याचप्रमाणे स्वत: रहात असलेल्या प्रकल्पबाधित बांधकामधारकास त्याच्या बहुमजली इमारतीमधील, छत नसलेली बाल्कनी व टेरेस यांचे क्षेत्र वगळून, बांधीव क्षेत्राच्या तिप्पट क्षेत्राएवढा विकसित भूखंड १.५ चटई निर्देशांकासह अनुज्ञेय राहील.

सिडकोच्या ताब्यातील गावठाणाबाहेरील जमिनीवरील स्वत: रहात असलेल्या एकाच बांधकामाबद्दल संबंधीत बांधकामधारकास या शासन निर्णयानुसार लाभ देय होतील. त्याच्या इतर बांधकामासाठी त्याला कोणतेही लाभ देय होणार नाहीत.

२. प्रकल्पबाधितांच्या वाणिज्यिक वापराच्या अनधिकृत बांधकामाबद्दल भुखंड :-

नवी मुंबई विमानतळ क्षेत्रातील सिडकोच्या ताब्यामधील जमिनीवरील वाणिज्यिक वापराच्या बांधकामाखालील क्षेत्राबद्दल, संबंधित प्रकल्पबाधित बांधकामधारकास समतुल्य क्षेत्राच्या विकसित वाणिज्यिक भूखंडाचे वाटप अनुज्ञेय राहील.

सिडकोच्या ताब्यातील गावठाणाबाहेरील जमिनीवरील वाणिज्यिक वापर करत असल्यास, एकाच बांधकामाबद्दल संबधीत बांधकामधारकास या शासन निर्णयानुसार लाभ देय होतील. त्याच्या इतर बांधकामासाठी त्याला कोणतेही लाभ देय होणार नाहीत.

वरील प्रमाणे प्रकल्पबाधित कुटुंबास निवासी अथवा वाणिज्यिक प्रयोजनार्थ देय भूखंडाचे किमान क्षेत्र ४० चौ.मि. असेल. भूखंडासाठी कमाल क्षेत्रफळाची मर्यादा सिडकोकडून स्वतंत्रपणे ठरविण्यात येईल.

३. प्रकल्पबाधितांना गृहबांधणीसाठी अर्थसहाय्य :-

नवी मुंबई विमानतळ क्षेत्रातील प्रकल्पबाधित स्वत: रहात असलेल्या तसेच वाणिज्यिक प्रयोजनासाठी वापरीत असलेल्या बाधित होणा-या बांधकामाबद्दल सदर क्षेत्रफळाएवढे बांधकाम करण्यासाठी प्रती चौरस फुटास रुपये १०००/- (अक्षरी रुपये एक हजार मात्र) या दराने बांधकाम खर्च देय राहील.

४. मिश्र वापराबद्दल १५ टक्के वाणिज्यिक वापरास अनुमती :-

नवी मुंबई विमानतळ क्षेत्रातील प्रकल्पबाधितांच्या मिश्र वापराच्या बांधकामापोटी प्रकल्पबाधितांस देय विकसित भूखंडाच्या अनुज्ञेय चटई क्षेत्राच्या १५ टक्के चटई क्षेत्राचा वापर वाणिज्यिक प्रयोजनासाठी करणे अनुज्ञेय राहील.

५. प्रकल्पबाधित कुटूंबास एक रक्कमी निर्वाह भत्ता :-

स्थलांतरीत होणा-या प्रत्येक प्रकल्पबाधित कुटूंबास एक रक्कमी रु. ३६,०००/- निर्वाह भत्ता देय राहील.

६. प्रकल्पबाधित कुटूंबास एक रक्कमी आर्थिक सहाय्य :-

स्थलांतरीत होणा-या प्रत्येक प्रकल्पबाधित कुटूंबास किमान कृषी मजूरीच्या दराने ७५० दिवसांच्या कृषी मजूरी इतकी रक्कम एक रक्कमी आर्थिक सहाय्य म्हणून देय राहील.

७. प्रकल्पबाधितांना वाहतुकीसाठी आर्थिक सहाय्य :-

स्थलांतरीत होणा-या प्रत्येक प्रकल्पबाधित कुटूंबास रु. ५०,०००/- इतकी रक्कम सामान वाहतुकीसाठी देय राहील.

८. जुन्या बांधकामांची सामुग्री नेण्यास अनुमती :-

जुन्या बांधकामाची सामुग्री विनामुल्य नेण्यास संबधित प्रकल्पबाधित बांधकामधारकास अनुमती राहील.

९. ना-परतावा रक्कम भरण्यास सूट :-

बांधकाम परवानगी इत्यादीसाठी सिडकोकडे भरावयाच्या ना-परतावा व परतावा - पात्र रक्कमा भरण्यापासून स्थलांतरीत होणा-या प्रकल्पबाधीत कुटूंबास सूट देण्यात येईल.

१०. प्रकल्पबाधितांना व्यावसायिक प्रशिक्षण :-

स्थलांतरीत होणा-या प्रकल्पबाधित कुटूंबामधील पात्र व्यक्तींना सिडकोच्या खर्चाने व्यावसायिक प्रशिक्षण देण्यात येईल.

११. नवी मुंबई विमानतळ प्रकल्प कंपनीच्या समभागाचे वाटप :-

बांधकामाखालील जमीनीच्या संपादनामुळे स्थलांतरीत होणा-या प्रकल्पबाधित कुटूंबाना नवी मुंबई विमानतळ प्रकल्पासाठी स्थापन करण्यात येणा-या विमानतळ कंपनीचे रुपये १०/- दर्शनी मुल्यांचे १०० समभाग नि:शुल्क सिडकोकडून देण्यात येतील. संपादीत करण्यात येणा-या जमिनीबद्दल संबंधित भूधारकास हा लाभ प्राप्त होणार असल्यास, बांधकामाखालील जमीनीच्या संपादनामुळे स्थलांतरीत होणारे कुटूंब म्हणून हा लाभ त्यास पुन्हा देय होणार नाही.

१२. प्रकल्पबाधितांना कंत्राटांतर्गत काम देणे :-

नवी मुंबई विमानतळाच्या कामासाठी नोंदणीकृत कंत्राटदारांना प्रदान करण्यात येणा-या कामांपैकी माती भरणीच्या कामांपैकी ५०% किंमतीची कामे प्रचलित जिल्हा दर सूची (DSR) मधील दराने प्रकल्पबाधितांमार्फत करवून घेण्याची अट समाविष्ट करण्यासंबंधी सिडकोकडून आवश्यक ती कार्यवाही करण्यात येईल जेणेकरुन प्रकल्पबाधितांना सदर कंत्राटांतर्गत काम मिळेल.

(II) या परिशिष्टांतर्गत देय लाभांसाठी पात्रता निश्चित करणे :-

१. भूखंड वाटपासाठी सप्टेंबर २०१३ च्या उपग्रह नकाशावर दिसणारी सर्व बांधकामे विचारात घेतली जातील.

२. इतर लाभांसाठी सप्टेंबर २०१३ ची स्थिती लक्षात घेतली जाईल.

(III) पुनर्वसीत क्षेत्राच्या ठिकाणी दिले जाणारे सर्वसाधारण लाभ:-

१. प्रकल्पबाधितांच्या पुन:स्थापनेच्या ठिकाणी शासकीय/निमशासकीय संकुल :-

प्रकल्पबाधितांच्या पुन:स्थापनेच्या ठिकाणी खालील शासकीय / निमशासकीय कार्यालयांसाठी सिडकोमार्फत संकुल विकसित करुन देण्यात येईल :-

- ग्राम पंचायत कार्यालय
- तलाठी कार्यालय
- टपाल कार्यालय
- बँक
- समाजमंदिर

२. सिडकोच्या निकषानुसार सामाजिक सुविधांची तरतूद :-

प्रकल्पबाधितांच्या पुन:स्थापनेच्या ठिकाणी सिडकोकडून खालील सामाजिक सुविधांची पूर्तता करण्यात येईल :-

- शाळा व सार्वजनिक मैदान
- सण / उत्सवासाठी मोकळया जागेसह धार्मिक संकुल
- स्मशानभूमी
- बसथांबा
- मार्केट

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नवी मुंबई प्रकल्पासाठी तसेच नवी मुंबई आंतरराष्ट्रीय विमानतळ व तदनुषंगिक कामांसाठी करण्यात येणा-या जमिनींच्या संपादनाचे बाबतीत कार्यप्रणाली विहित करणेबाबत...

महाराष्ट्र शासन
महसूल व वन विभाग
शासन निर्णय क्रमांक:- एलक्युएन-०५/२०१४/प्र.क्र.३९/अ-२
मंत्रालय, मुंबई ४०० ०३२
दिनांक : १६ जून,२०१४.

वाचा:-१) शासन निर्णय, महसुल व वन विभाग क्र.एलक्युएन १६८६/प्र.क्र.३६२८/अ-२ दि.३१ आक्टोबर,१९९४
२) शासन निर्णय, नगर विकास विभाग क्र.सी.आय.डी.१८१२/प्र.क्र.२७४/नवी-१०. दि.०१ मार्च, २०१४

प्रस्तावना :-

नवी मुंबई प्रकल्पांतर्गत उभारण्यात येणाऱ्या नवी मुंबई आंतरराष्ट्रीय विमानतळ व अनुषंगिक कामांसाठी, तसेच नवी मुंबई प्रकल्पासाठी संपादित करण्यात येणाऱ्या जमिनीच्या भूधारकांना नुकसान भरपाई देण्यासाठी तसेच सदर प्रकल्पामुळे स्थलांतरीत होणा-या व्यक्तीच्या पुनर्वसन व पुनंस्थापनेसाठी शासनाने संदर्भाधीन शासन निर्णय क्र.२ अन्वये धोरणास मान्यता दिलेली आहे.

" The Right to Fair Compensation & Transparancy in Land Acquisition, Rehabilitation and Resettlement Act-2013" (भूसंपादनअधिनियम,२०१३) मंजूर झालेला असून तो दि.१ जाने,२०१४ पासून अंमलात आलेला आहे. उपरोक्त प्रकल्पासाठी आवश्यक असलेल्या जमिनीच्या भूसंपादनाच्या अनुषंगाने भूमिसंपादन अधिनियम १८९४ चे कलम ४ अन्वये प्रसिद्ध करावयाच्या अधिसूचना सदर भूसंपादन अधिनियम,२०१३ लागू होण्यापूर्वी प्रसिध्द झालेल्या आहेत. भूसंपादन अधिनियम,२०१३ चे कलम २४ मधील तरतुदीनुसार भूमि संपादनाची प्रक्रिया भूसंपादन अधिनियम,२०१३ लागू होण्यापूर्वी सुरु झाली असेल व संपादनाखालील जमिनीचे निवाडे जाहीर झाले नसतील/निवाडे जाहिर होऊन मालमत्ता धारकांपैकी बहुसंख्य मालमत्ता धारकांना मोबदला त्यांच्या बँक खात्यामध्ये जमा केलेला नसेल, तर भूसंपादन अधिनियम,२०१३ च्या केवळ नुकसान भरपाई ठरविण्याच्या तरतूदी लागू होतात. त्यामुळे त्या तरतूदीनुसार भूसंपादन अधिनियम,२०१३ प्रमाणे नुकसान भरपाई ठरवून, भूमिसंपादन अधिनियम १८९४ अन्वये संपादनाखालील जमिनीचे निवाडे घोषित करुन जमिनीचे संपादन करावयाचे आहे.

भूसंपादन अधिनियम,२०१३ चे कलम १०८ मधील तरतूदीनुसार, संपादित करावयाच्या जमिनीचा नुकसान भरपाई व पुनर्वसनाचे लाभ, भूसंपादन अधिनियम,२०१३ नुसार देय होणाऱ्या नुकसान भरपाई व लाभांपेक्षा, राज्य शासनाच्या कायद्यान्वये / धोरणान्वये निश्चित केलेली नुकसांन भरपाई व इतर लाभ भूधारकांना एकंदरीत जास्त फायदेशीर होत असतील व संबंधित व्यक्तींची सदर नुकसान भरपाई व लाभ स्विकारण्यास संमती असेल, तर अशी जास्त लाभदायक नुकसान भरपाई आणि पुनर्वसनाचे लाभ संबधित भूधारकांना स्विकारण्यास मुभा आहे. अन्यथा त्यांना भूसंपादन अधिनियम,२०१३ नुसार नुकसान भरपाई देय ठरेल. तसेच भूसंपादन अधिनियम १८९४ चे कलम ३१ चे उपकलम (३) अन्वये शासनाचे मान्यतेने भूसंपादन मोबदला हा रोख रकमेएवजी जमिनीच्या स्वरूपात देण्याची तरतूद आहे.

भूसंपादन अधिनियम,२०१३ च्या तरतूदींचा परामर्श घेवून, राज्यशासनाने संदर्भिय शासन निर्णय क्र.२ अन्वये नवी मुंबई आंतरराष्ट्रीय विमानतळ व अनुषंगिक कामांसाठी तसेच नवी मुंबई प्रकल्पासाठी भविष्यात संपादित करण्यात येणाऱ्या जमिनीच्या भूधारकांना नुकसान भरपाई देण्यासाठी तसेच सदर प्रकल्पामुळे स्थलांतरीत होणा-या व्यक्तीच्या पुनर्वसन व पुर्नस्थापनेचे धोरण जाहीर केले आहे. जे भूधारक राज्य शासनाच्या सदर धोरणानुसार नुकसान भरपाई व लाभ स्विकारु इच्छित नसतील, अथवा त्यांना हे लाभ देता येणे शक्य होत नसेल, तर भूसंपादन अधिनियम,२०१३ अधिनियमानुसार देय होणारी नुकसान भरपाई व इतर लाभ देय होतील.

उपरोक्त शासन धोरणानुसार नुकसान भरपाई व लाभ स्विकारण्यास संबधित भूधारकांनी संमती दिल्यास, त्याप्रमाणे संपादनाखालील जमिनीचे निवाडे भूमीसंपादन अधिनियम, १८९४ अन्वये जाहीर करुन, संपादित जमिनीचा ताबा घेणे आवश्यक आहे. सदर शासन धोरणाप्रमाणे संपादित होणा-या जमिनीच्या नुकसान भरपाईपोटी, रोख रक्कमेऐवजी विकसित जमीन देण्याच्या तरतूदीनुसार तसेच भूसंपादन अधिनियम,२०१३ मधील लागू असलेल्या तरतूदीनुसार, जमिनीचे संपादन करण्यासाठी संबधित अधिकाऱ्यांसाठी मार्गदर्शक अशी कार्यप्रणाली ठरविण्याची बाब शासनाच्या विचाराधीन होती. त्याबाबत सर्वंकष विचारविनिमय करुन खालीलप्रमाणे कार्यप्रणाली निश्चित करण्याचा निर्णय शासन घेत आहे.

शासन निर्णय :-

नवी मुंबई प्रकल्पातंर्गत उभारण्यात येणाऱ्या नवी मुंबई आंतरराष्ट्रीय विमानतळ व तदनुषंगिक कामासाठी तसेच नवी मुंबई प्रकल्पासाठी भविष्यात करण्यांत येत असलेल्या जमीन संपादनासाठी खालीलप्रमाणे कार्यप्रणाली विहीत करण्यास शासनाने मान्यता दिलेली आहे.

अ) शासन धोरणानुसार जमिनीचे संपादन :-

१) संदर्भिय शासन निर्णयानुसार संपादित करावयाची जमीन व त्यामधील इमारती, विहिरी, झाडे इ. साठी एकत्रित नुकसान भरपाईपोटी विकसित जमिनीचे वाटप करण्यात येणार असल्यामुळे, तसेच पूर्ण पोटहिश्याची जमीन संपादित करावयाची असल्याने, भूमि संपादन अधिनियम १८९४ चे कलम ८ प्रमाणे संपादनाखालील जमिनीची हद्दनिश्चिती व क्षेत्रफळाची परिगणना उपग्रह चित्राच्या आधारे तसेच अधिकार अभिलेख, गटबुक, गांव नकाशा वगैरे उपलब्ध अभिलेखांवरुन करुन घेण्यात यावी. तद्नंतर उपजिल्हाधिकारी (भूसंपादन) यांनी सदर अधिनियमाचे कलम ९(१) व (२) नुसार जाहीर नोटीस प्रसिध्द करावी व संबंधीत भूधारकांना कलम ९ (३) व (४)नुसार वैयक्तिक नोटीसा देण्याची कार्यवाही करावी. सदर नोटीसाबरोबर खालील कागदपत्रे जोडणे आवश्यक राहील.

i) संदर्भाधीन दि.०१.०३.२०१४ च्या शासन निर्णयाची प्रत.

ii) भूसंपादन अधिनियम, २०१३ नुसार देय होणाऱ्या नुकसान भरपाईच्या व इतर लाभांच्या परिशिष्टाची प्रत

iii) संदर्भाधीन दि.०१.०३.२०१४ च्या शासन निर्णयानुसार नुकसान भरपाई व इतर लाभ स्विकारण्याचे बाबतीत संबधित भूधारकाने सादर करावयाच्या संमती पत्राचा नमुना

iv) भूखंड वाटपासाठी लागणा-या आवश्यक त्या कागदपत्रांची यादी

२) वर नमुद केल्यानुसार वैयक्तिक नोटीस बजावल्यावर, संपादित जमिनीच्या क्षेत्रफळाबाबत किंवा हद्दीबाबत संबंधित भूधारक/ हितसंबधित व्यक्तीने विहित मुदतीत हरकत घेऊन जमिनीची जागेवर प्रत्यक्षपणे मोजणी करण्याची मागणी केल्यास, त्याप्रमाणे कार्यवाही करणे आवश्यक राहील.

३) त्यानंतर उप जिल्हाधिकारी (भूसंपादन) यांनी भूमीसंपादन अधिनियम, १८९४ चे कलम ११(२) प्रमाणे निवाडा घोषित करतांना त्यामध्ये खालील बाबींचा समावेश असेल.

i) संदर्भिय शासन निर्णयानुसार व सिडकोने त्या अनुषंगाने प्रसृत केलेल्या कार्यप्रणालीविषयक मार्गदर्शक तत्वांचा परामर्श घेवून, संबधित भूधारकाची भूखंड मिळण्याची पात्रता व इतर लाभाबाबत उप जिल्हाधिकारी (भूसंपादन) यांनी तपासणी करुन त्याप्रमाणे सिडकोस कळविणे आवश्यक राहील.

ii)भूसंपादनाचा मोबदला व पुनर्वसनापोटी संबधित भूधारकास द्यावयाच्या भूखंड वाटपाब बतची माहिती सिडकोकडून उपजिल्हाधिकारी (भूसंपादन) यांना कळविण्यांत आल्यानंतर त्यांनी संबधित जमिनीचा निवाडा जाहीर करण्याची कार्यवाही करावी.

iii) भूमिसंपादन अधिनियम १८९४, चे कलम १२ (२) अन्वये नोटीस बजावून कलम १६ अन्वये, संपादनाखालील जमिनीचा ताबा घेण्याची कार्यवाही करावी.

iv) मध्यंतरीच्या कालावधीत सिडकोने संबंधित भूधारकांस देवू केलेल्या भूखंडाचे वाटपपत्र तयार करुन उपजिल्हाधिकारी (भूसंपादन) यांचेकडे पाठवावे.

v) संपादनाखालील जमिनीचा ताबा घेतेवेळी सिडकोने भूधारकास देवू केलेल्या भूखंडाचे वाटपपत्र संबंधित भूधारकास देण्यात यावे.

४) वरील प्रक्रीया ज्या प्रकरणांमध्ये दिनांक ३१.१२.२०१३ पूर्वी भूसंपादन अधिनियम १८९४ नुसार कलम ४ ची अधिसूचना अथवा ज्या प्रकरणांमध्ये निवाडा सुद्धा जाहीर करण्यात आला आहे परंतु सदर निवाड्यानुसार मोबदला रक्कम अद्याप बहुसंख्य मालमत्ता धारकांच्या बँक खात्यामध्ये जमा केलेली नाही अशा प्रकरणांमध्ये यथास्थिती लागू राहील.

५) उपजिल्हाधिकारी (भूसंपादन) यांनी, संपादनाखालील जमिनीचा मालकी हक्क, हिस्सा वगैरे बाबतीत वाद असल्यास, त्याप्रमाणे सिडकोस विना-विलंब कळवावे. जर वाद असणाऱ्या सर्व व्यक्तींनी शासन धोरणानुसार भूखंड स्वरुपात नुकसान भरपाई व इतर लाभ स्विकारण्याबाबतचे संमतीपत्र सादर केले असेल तर संपादनाखालील जमिनीबद्दल देय होणारा भूखंड सिडकोने राखून ठेवावा व इतर लाभाची रक्कम उपजिल्हाधिकारी (भूसंपादन) यांचे कार्यालयाकडे जमा करावी. सिडकोने कळविल्यानुसार भूखंडाचा आवश्यक तो तपशिल निवाडयात नमुद करुन उपजिल्हाधिकारी (भूसंपादन) यांनी निवाडा जाहीर करुन जमिनीचा ताबा घेण्यासाठी आवश्यक ती कार्यवाही करावी. त्यानंतर सदर प्रकरणी उपजिल्हाधिकारी (भूसंपादन) यांनी मा. न्यायाल्यास / प्राधिकाऱ्यास सदर प्रकरणी संदर्भ करणे आवश्यक आहे. सदर प्रकरणामध्ये संबधित भूधारकास देय होणारा भूखंड सिडकोने राखून ठेवल्याचे मा.न्यायालयास / प्राधिकाऱ्यास कळवून, देय होणारी इतर लाभाची रक्कम असल्यास मा.न्यायालयात जमा करावी. सदर प्रकरणाबाबत मा. न्यायालयात होणा-या अंतिम निर्णयाप्रमाणे पुढील कार्यवाही उप-जिल्हाधिकारी (भूसंपादन) यांनी करावी.

५) संदर्भित शासन निर्णय क्र.१ प्रपत्र अ मधील सूचना क्र.४, ६ ते ८ मधील सूचनांचे कटाक्षाने पालन करण्यात यावे.

ब) राज्य शासनाच्या धोरणानुसार नुकसान भरपाई व लाभ न स्विकारणाऱ्या भूधारकांच्या जमिनीचे संपादन :-

जे भूधारक राज्य शासनाच्या संदर्भीय शासन निर्णयांतर्गत धोरणानुसार नुकसान भरपाई व लाभ स्विकारण्यास संमती देणार नाहीत, त्यांना भूसंपादन अधिनियम,२०१३ नुसार देय होणारी नुकसान भरपाई व इतर लाभ देण्यात यावेत. भूसंपादन अधिनियम,२०१३ चे कलम २४ अन्वये भूमिसंपादनाची प्रक्रिया भूसंपादन अधिनियम,२०१३ लागू होण्यापूर्वी सुरु झालेली असल्याने, ती भूमिसंपादन अधिनियम, १८९४

अन्वये तशीच पुढे चालू ठेवावी. तथापि, संबंधित भूधारकास देय होणारी नुकसान भरपाई व इतर लाभ भूसंपादन अधिनियम,२०१३ नुसार देण्यात यावेत.

१) भूसंपादन अधिनियम,२०१३ च्या दुसऱ्या परिशिष्टामधील अ.क्र.३ नुसार नागरीकरणासाठी संपादित केलेल्या जमिनींपैकी, विकसित केलेल्या जमिनीच्या २०% जमिन राखून ठेवून, संपादित केलेल्या जमिनीच्या प्रमाणात भूधारकास देवू करावयाची असून त्याने सदर जमीन स्विकारण्यास सहमती दिल्यास, जमीन संपादनाची किंमत व सदर क्षेत्राच्या विकासासाठी झालेला खर्च त्यांचेकडून वसूल करुन, भूधारकास भूखंड वाटप करण्याची तरतूद आहे. सदर तरतूदीनुसार देय होणा-या भूखंडाचे क्षेत्र, नुकसान भरपाई व इतर लाभ तसेच भूधारकाने २०% विकसित जमिनीपैकी त्यांचे संपादित जमीनीचे प्रमाणात प्राप्त होणा-या विकसित जमिनीसाठी भूसंपादनाची रक्कम व विकास खर्चाची रक्कम अदा करुन स्विकारण्यास संमती दिली असल्यास त्याचेकडून वरीलप्रमाणे वसूल करावयाची रक्कम वजा जाता संबंधित भूधारकास द्यावयाची रक्कम उप जिल्हाधिकारी (भूसंपादन) यांनी ठरवून, त्याप्रमाणे सिडकोस कळवावे.

२) उप जिल्हाधिकारी (भूसंपादन) यांनी कळविल्याप्रमाणे, सिडकोने भूधारकास द्यावयाच्या भूखंडाचे वाटपपत्र तयार करुन, भूधारकास देण्यासाठी त्यांचेकडे सुपूर्द करावे. तसेच देय होणाऱ्या नुकसान भरपाई व इतर लाभांची रक्कम उपजिल्हाधिकारी (भूसंपादन) यांचे कार्यालयात सिडकोने जमा करावी. संबंधित भूधारकाने जर २० % विकसित जमिनीपैकी त्यांचे संपादित जमीनीचे प्रमाणात प्राप्त होणारी जमीन स्विकारण्यास सहमती दिली असेल तर वर नमुद केल्यानुसार सदर विकसित जमिनीपोटी सिडकोला देय होणारी रक्कम त्याला देय होणाऱ्या रक्कमेतून वजा करुन घेवून उर्वरित रक्कम उपजिल्हाधिकारी (भूसंपादन) यांचेकडे सिडकोने जमा करावी. त्यानंतर उपजिल्हाधिकारी (भूसंपादन) यांनी जमिनीचा निवाडा जाहीर करावा व भूसंपादन अधिनियम, १८९४ चे कलम १२ (२) अन्वये नोटीस बजावून कलम १६ अन्वये संपादनाखालील जमिनीचा ताबा घ्यावा. त्याचवेळी सिडकोने दिलेल्या भूखंडाचे वाटपपत्र व देय रक्कमा संबधित भूधारकास उप जिल्हाधिकारी (भूसंपादन) यांनी अदा कराव्यात.

३) संपादनाखालील जमिनीचा मालकी हक्क, हिस्सा, नुकसान भरपाई, क्षेत्र वगैरे बाबतीत वाद असल्यास, भूसंपादन अधिनियम,२०१३ नुसार देय होणाऱ्या नुकसान भरपाई व इतर लाभांच्या रक्कमा उपजिल्हाधिकारी (भूसंपादन) यांचेकडे सिडकोने जमा करुन भूसंपादन अधिनियम,२०१३ च्या दुसऱ्या परिशिष्टानुसार देय होणारा विकसित भूखंड राखून ठेवावा व त्याप्रमाणे उपजिल्हाधिकारी (भूसंपादन) यांना कळवावे. सिडकोने कळविल्यानुसार आवश्यक तो तपशिल निवाडयात नमूद करुन उपजिल्हाधिकारी (भूसंपादन) यांनी निवाडा जाहीर करावा व जमिनीचा ताबा घ्यावा.

क) संमती निवाडे मंजूर करण्यासाठी सक्षम प्राधिकारी :-

संदर्भिय शासन निर्णयानुसार विकसित जमीन व इतर लाभ स्विकारण्यास संमती देणाऱ्या अथवा न देणाऱ्या भूधारकांच्या बाबतीत संपादनाखालील जमिनोचे निवाडे मंजूर करण्याचें सर्व अधिकार विभागीय आयुक्त यांना राहतील. हे अधिकार त्यांना इतर कोणत्याही अधिकाऱ्यास प्रदान करता येणार नहीत. उपजिल्हाधिकारी (भूसंपादन) यांनी निवाडे जाहीर करण्यापूर्वी, प्रारूप निवाडे जिल्हाधिकारी यांचेमार्फत विभागीय आयुक्त यांना सादर करुन मंजूरी प्राप्त करुन घ्यावी व त्यानंतरच ते घोषित करण्याची कार्यवाही करावी.

महाराष्ट्राचे राज्यपाल यांच्या आदेशानुसार व नावाने,

(प्रविणसिंह परदेशी)
प्रधान सचिव,महाराष्ट्र शासन

प्रति,

मुख्य सचिव, महाराष्ट्र राज्य, मंत्रालय,मुंबई
अपर मुख्य सचिव, वित्त विभाग, मंत्रालय,मुंबई
प्रधान सचिव, विधी व न्याय विभाग, मंत्रालय, मुंबई
प्रधान सचिव, नियोजन विभाग, मंत्रालय, मुंबई.
प्रधान सचिव, नगर विकास विभाग, मंत्रालय, मुंबई.
प्रधान सचिव, कृषि विभाग, मंत्रालय, मुंबई.
प्रधान सचिव, जलसंपदा विभाग, मंत्रालय, मुंबई
सचिव, सार्वजनिक बांधकाम विभाग, मंत्रालय, मुंबई.
व्यवस्थापकीय संचालक, सिडको, नवी मुंबई.
विभागीय आयुक्त, कोकण विभाग.
संचालक, नगर रचना व मुल्यनिर्धारण विभाग, पुणे.
सह संचालक, नगर रचना व मुल्यनिर्धारण विभाग, कोकण विभाग.
जिल्हाधिकारी, रायगड.
प्रबंधक, मा. उच्च न्यायालय, मुंबई.
सदस्य सचिव, महाराष्ट्र राज्य विधी सेवा प्राधिकरण, १०५ उच्च न्यायालय,(पी.डब्ल्यू.डी. बिल्डींग) फोर्ट, मुंबई ४०० ०३२.
महासंचालक, माहिती व जनसंपर्क महासंचालनालय, मंत्रालय, मुंबई.
सर्व मंत्रालयीन प्रशासकीय विभाग.
वेब कॉऑर्डीनेटर, महसूल व वन विभाग, मंत्रालय, मुंबई.
कार्यासन अ-१, अ-३,अ-४ , महसूल व वन विभाग, मंत्रालय, मुंबई
निवडनस्ती अ-२.

नवी मुंबई आंतरराष्ट्रीय विमानतळामुळे
स्थलांतरित कराव्या लागणाऱ्या प्रकल्पबाधितांच्या
पुनर्वसन व पुन:स्थापनेच्या बाबतीत कार्यप्रणाली
विहित करणेबाबत.

महाराष्ट्र शासन

महसूल व वन विभाग

शासन निर्णय क्रमांक :- आरपीए २०१४/प्र.क्र.५२/र-३

मंत्रालय, मुंबई - ४०० ०३२

दिनांक : २५ जुन,२०१४

संदर्भ :-१) शासन निर्णय नगर विकास विभाग क्रमांक सीआयडी-१८१२/प्र.क्र.२७४/नवि-१० दि.१ मार्च,२०१४
२) शासन निर्णय नगर विकास विभाग क्रमांक सीआयडी-१८१२/प्र.क्र.२७४/नवि-१० दि. २८ मे,२०१४.
३) शासन निर्णय महसूल व वन विभाग क्र. एलक्युएन-०५/२०१४/प्र.क्र.३९/अ-२ दि. १६ जून, २०१४

प्रस्तावना :-

दिनांक १.१.२०१४ पासून The Right to Fair Compensation and Transparancy in land Acquisition Rehabilitation and Resettlement Act -२०१३ हा केंद्रीय अधिनियम लागू झाला आहे. सदर नवीन केंद्रीय अधिनियमाचे कलम १०८ अन्वये, संपादीत करावयाच्या जमिनीची नुकसान भरपाई व पुनर्वसनाचे लाभ, नवीन केंद्रीय अधिनियमानुसार देय होणाऱ्या नुकसान भरपाई व लाभांपेक्षा, राज्य शासनाच्या कायद्यान्वये / धोरणान्वये भूधारकांना एकंदरीत जास्त फायदेशीर होत असतील व संबंधीत व्यक्तींची सदर नुकसान भरपाई व लाभ स्वीकारण्यास संमती असेल, तर अशी जास्त लाभदायक नुकसान भरपाई आणि पुनर्वसनाचे लाभ संबंधीत भुधारकांना स्विकारण्यास मुभा आहे.

नवीन केंद्रीय अधिनियमाच्या तरतूदी विचारात घेऊन, नगरविकास विभागाने संदर्भीय शासन निर्णय दिनांक १.३.२०१४ व दि .२८.५.२०१४ अन्वये नवी मुंबई आंतरराष्ट्रीय विमानतळ व अनुषंगिक कामांसाठी संपादीत करण्यात येणाऱ्या जमिनीच्या भूधारकांना नुकसान भरपाई देण्यासाठी तसेच सदर प्रकल्पामुळे स्थलांतरीत होणाऱ्या सर्व अधिकृत व अनधिकृत बांधकाम धारकांचे पुनर्वसन व पुन:स्थापना करण्यासाठी धोरण जाहीर केले आहे. सदर शासन निर्णयांच्या अनुषंगाने खालील बाबतीत कार्यप्रणाली विहित करणे आवश्यक आहे:-

१) सदर प्रकल्पासाठी लागणाऱ्या जमिनीचे संपादन होऊन, स्थलांतरीत होणाऱ्या भूधारकांना संदर्भीय अनुक्रमांक १ वरील शासन निर्णयाच्या परिशिष्टाचा भाग - २ अन्वये अनुज्ञेय लाभ देणे

२) सदर प्रकल्पासाठी आवश्यक असलेल्या सिडकोच्या जमिनीवरील, अनधिकृत बांधकाम धारकांच्या पुनर्वसन व पुन:स्थापनेविषयी कार्यवाही करणे.

३) पुनर्वसन व पुन:स्थापनेच्या ठिकाणी सार्वजनिक सुविधा पुरविण्याविषयी कार्यवाही करणे.

उपरोक्त बाबतीत जिल्हाधिकारी रायगड यांचे अधिनस्त जिल्हा पुनर्वसन अधिकारी यांची कार्यप्रणाली विहित करण्याची बाब शासनाच्या विचाराधिन होती. त्यानुसार खालीलप्रमाणे कार्यप्रणाली विहित करण्याचा निर्णय शासन घेत आहे:-

शासन निर्णय :-

नवी मुंबई आंतरराष्ट्रीय विमानतळामुळे स्थलांतरीत होणाऱ्या संपादनाखालील जमिनीवरील बांधकामांचे तसेच सिडकोच्या ताब्यामधील जमिनीवरील अनधिकृत बांधकामांचे पुनर्वसन व पुन:स्थापना करण्यासाठी खाली विहित केलेल्या कार्यप्रणालीनुसार सिडको तसेच जिल्हाधिकारी रायगड यांनी कार्यवाही करावी:-

१) नवी मुंबई विमानतळ अनुषंगिक कामांसाठी लागणाऱ्या संपादनाधिन जमिनीचे संपादन झाल्यानंतर भूमि-संपादन अधिनियमानुसार जाहीर केलेल्या निवाड्याच्या प्रती संबंधित उप जिल्हाधिकारी (भूसंपादन) यांनी जिल्हा पुनर्वसन अधिकारी यांचेकडे पुनर्वसन व पुन:स्थापनेची पुढील कार्यवाही करण्यासाठी पाठवाव्यात. सदर निवाड्यानुसार संदर्भीय शासन निर्णयाच्या परिशिष्टामध्ये नमूद केल्यानुसार भूधारकास देय होणाऱ्या व सिडकोने उपलब्ध करुन दिलेल्या रकमा व निवासी भूखंड वितरीत करण्याची कार्यवाही जिल्हा पुनर्वसन अधिकारी यांनी करावी.

(अ) परंतु ज्या प्रकरणी संदर्भीय शासन निर्णयानुसार देय होणारे पॅकेज स्वीकारण्यास संबंधीत भूधारकांनी संमती दिलेली नाही व नवीन केंद्रीय अधिनियमानुसार नुकसान भरपाई व इतर लाभ देय होत आहेत, त्या प्रकरणी भूसंपादनांतर्गत जमिनीच्या नुकसान भरपाईची रक्कम संदर्भीय शासन निर्णयाप्रमाणे संबंधीत उपजिल्हाधिकारी (भूसंपादन) यांनी अदा करावयाची असून, पुनर्वसन व पुन: स्थापना विषयक लाभ जिल्हा पुनर्वसन अधिकाऱ्याने वितरीत करावे. तसेच जमिनीचे संपादन झाल्यानंतर त्यावरील बांधकामे सिडकोने निष्कासीत करावी.

२) नवी मुंबई विमानतळ क्षेत्रामधील सिडकोच्या ताब्यातील जमिनीवरील स्थलांतरीत होणाऱ्या अनधिकृत बांधकामधारकांच्या बाबतीत संदर्भीय शासन निर्णय दिनांक २८.५.२०१४ अन्वये पुनर्वसन व पुन: स्थापनेची खाली नमूद केल्यानुसार कार्यवाही करावी.

अ) सिडकोने त्यांच्या जमिनीवरील अनधिकृत बांधकामांचे सर्वेक्षण करुन त्याची यादी जिल्हा पुनर्वसन अधिकारी यांना उपलब्ध करुन द्यावी. त्याआधारे संदर्भीय शासन निर्णय दिनांक २८.५.२०१४ अन्वये संबंधीत बांधकाम धारकास देय होणाऱ्या भूखंडाची पात्रता व देय लाभ जिल्हा पुनर्वसन अधिकारी यांनी निश्चित करुन सिडकोस कळवावी. सिडकोने सदर माहिती बांधकाम धारकास कळवून ती जाहीर नोटीशीद्वारे स्थानिक वर्तमानपत्रात तसेच संबंधीत गावात प्रसिध्द करण्याबाबत कार्यवाही करावी.

आ) सदर नोटीशीच्या अनुषंगाने तक्रार प्राप्त होणाऱ्या प्रकरणी, सिडकोने आवश्यक ती शहानिशा करुन उचित निर्णय घ्यावा व त्याबाबत जिल्हा पुनर्वसन अधिकारी यांना कळवावे तद्नंतर जिल्हा पुनर्वसन अधिकाऱ्यांने संबंधित बांधकामधारकास भूखंड व इतर लाभ देण्यासाठी जिल्हाधिकारी रायगड यांची मंजूरी प्राप्त करुन, संबंधीत बांधकामधारकास भूखंड वाटप करण्यासाठी व इतर रकमा अदा करण्यासाठी आवश्यक असलेला तपशील सिडकोस कळवावा.

इ) जिल्हा पुनर्वसन अधिकाऱ्याकडून उपरोक्त तपशील प्राप्त होताच पुन:स्थापनेसाठी आरेखीत केलेलया ठिकाणी संबंधीत बांधकामधारकास वाटप करावयाच्या भूखंडाची सोडत सिडकोने विहित पध्दतीप्रमाणे काढावी. त्यानंतर सिडकोने पुन:स्थापनेसाठी वाटप करावयाच्या भूखंडाचे देयक पत्रक तयार करुन ते जिल्हा पुनर्वसन अधिकारी यांचेकडे पुढील कार्यवाहीसाठी पाठवावे. सिडकोने उपरोक्त कळविलेला तपशील विचारात घेऊन त्यानुसार जिल्हा पुनर्वसन अधिकारी यांनी प्रकल्पबाधीत बांधकामधारकांच्या पुन:स्थापनेसाठी देण्यात येणाऱ्या भूखंडाबद्दल व इतर लाभांबद्दल आदेश पारीत करावा. त्याचबरोबर जिल्हा पुनर्वसन अधिकाऱ्याने कळविल्याप्रमाणे, संबंधीत बांधकामधारकास देय होणाऱ्या इतर लाभांच्या रकमा सिडकोने उपलब्ध करुन देऊन जिल्हा पुनर्वसन अधिकारी यांनी अदा कराव्यात. तसेच संबंधीत बांधकामधारकांकडून ते आपले बांधकाम विहित मुदतीत पुन:स्थापनेच्या ठिकाणी स्थलांतरीत करुन जागा मोकळी करुन देतील असे हमी पत्र घेऊन भूखंडाचे वाटपपत्र द्यावे व त्यांस देय होणाऱ्या इतर लाभांच्या रकमा अदा कराव्यात.

ई) सदर वाटपपत्राप्रमाणे संबंधीत बांधकामधारकाबरोबर भूखंडाच्या भाडेपट्ट्याचा करारनामा सिडकोने करुन त्यास भूखंडाचा ताबा द्यावा. संदर्भीय शासन निर्णयाच्या प्रकल्पबाधीत बांधकाम धारकांचे स्थलांतरीत होणारे बांधकाम सिडकोने निष्कासीत करावे.

उ) बांधकामाचा मालकी हक्क, हिस्सा वगैरे बाबतीत वाद असलेल्या प्रकरणी सक्षम न्यायालयाकडून आवश्यक ते आदेश प्राप्त करुन सिडकोने संबंधीत व्यक्तीस कळवावे. त्याचप्रमाणे जिल्हा पुनर्वसन अधिकारी यांना सदर बाब सत्वर कळविण्यात यावी. संदर्भीय शासन निर्णय दिनांक २८.५.२०१४ अन्वये पुन:स्थापनेसाठी देय होणारा भूखंड व इतर लाभांच्या रक्कमा सिडकोने राखून ठेवून तसे जिल्हा पुनर्वसन अधिकारी यांना कळवावे. सदर बांधकामे निष्कासीत करण्याची जबाबदारी सिडकोची राहील.

ऊ) न्यायालयीन प्रकरणाचा अंतिम निर्णय सिडकोने जिल्हा पुनर्वसन अधिकारी यांना कळविल्यानंतर पात्र व्यक्तीस भूखंडाचे वाटप करण्याची व इतर लाभ देण्याची कार्यवाही जिल्हा पुनर्वसन अधिकाऱ्याने करावी. त्यानंतर संबंधीत भूखंड वाटपदार व्यक्तीसमवेत नेहमीप्रमाणे करारनामा करणे, भूखंडाचा ताबा देणे इत्यादी कार्यवाही सिडकोने करावी.

३. पुनर्वसन व पुन:स्थापनेच्या ठिकाणी संदर्भीय शासन निर्णयानुसार आवश्यक त्या सर्व सार्वजनिक सुविधा उपलब्ध करुन देण्याची जबाबदारी सिडकोची राहील. तर या कामाचे समन्वयन जिल्हा पुनर्वसन अधिकारी करतील. जिल्हा पुनर्वसन अधिकाऱ्याकडून करण्यात येणाऱ्या उपरोक्त

कामासाठी जिल्हा पुनर्वसन अधिका-यास आवश्यक तांत्रिक कर्मचारी व सुविधा उपलब्ध करुन देण्याची जबाबदारी सिडकोची राहील.

४. नवी मुंबई आंतरराष्ट्रीय विमानतळामुळे स्थलांतरीत कराव्या लागणाऱ्या प्रकल्पबाधीतांच्या पुनर्वसन व पुन:स्थापनेच्या सर्वंकष कार्यवाहीचे सनियंत्रण सिडकोच्या माध्यमातून प्रशासकीय विभाग म्हणून नगरविकास विभागाचे राहील.

महाराष्ट्राचे राज्यपाल यांच्या आदेशानुसार व नावाने,

(मिलिंद म्हैसकर)
सचिव, महाराष्ट्र शासन

प्रत,

१. मा. राज्यपाल, महाराष्ट्र यांचे सचिव
२. मा. मुख्यमंत्री यांचे प्रधान सचिव, मंत्रालय, मुंबई.
३. मा. मंत्री, मदत व पुनर्वसन, मंत्रालय, मुंबई यांचे खाजगी सचिव
४. मा. राज्यमंत्री, मदत व पुनर्वसन, मंत्रालय, मुंबई यांचे खाजगी सचिव
५. मा. राज्यमंत्री, नगर विकास विभाग, मंत्रालय, मुंबई यांचे खाजगी सचिव
६. मा. मुख्य सचिव, महाराष्ट्र शासन
७. अपर मुख्य सचिव (वित्त), मंत्रालय, मुंबई.
८. अपर मुख्य सचिव (नियोजन), मंत्रालय, मुंबई
९. प्रधान सचिव (१), नगर विकास विभाग, मंत्रालय, मुंबई
१०. प्रधान सचिव (२), नगर विकास विभाग, मंत्रालय, मुंबई
११. प्रधान सचिव (वने), मंत्रालय, मुंबई
१२. उपाध्यक्ष तथा व्यवस्थापकीय संचालक, शहर व औद्योगिक विकास महामंडळ (महाराष्ट्र) मर्यादित (सिडको), नरिमन पॉईन्ट, मुंबई
१३. विभागीय आयुक्त, कोकण विभाग, नवी मुंबई.
१४. आयुक्त, नवी मुंबई महानगरपालिका
१५. महासंचालक, माहिती व जनसंपर्क महासंचालनालय, मंत्रालय, मुंबई
१६. जिल्हाधिकारी रायगड
१७. जिल्हाधिकारी ठाणे
१८. निवड नस्ती (कार्यासन र-३)

Executive Engineer
(Airport-II)

महाराष्ट्र शासन

Email-cidcoud१०@gmail.com

क्रमांक : सिआयडी-१८१२/प्र.क्र.२७४/नवि-१०
नगर विकास विभाग,
मंत्रालय, मुंबई-४०० ०३२.
दिनांक : ११ ऑगस्ट, २०१४.

प्रति,

व्यवस्थापकीय संचालक,
शहर व औद्योगिक विकास महामंडळ (महाराष्ट्र) मर्या. (सिडको),
निर्मल, नरिमन पॉईन्ट, मुंबई - ४०० ०२१.

विषय :- नवी मुंबई प्रकल्पासाठी संपादित होणाऱ्या जमिनीबद्दल दि.१.३.१४ च्या समक्रमांकाच्या शासन निर्णयान्वये नुकसान भरपाईपोटी व स्थलांतरीत होणाऱ्या बांधकामाच्या पुन:स्थापनेसाठी देण्यात येणाऱ्या विकसित भूखंडास भाडेपट्ट्याची रक्कम आकारावयाची नाही ही धारणा पक्की करण्याबाबत

संदर्भ :- १) शासन निर्णय समक्रमांक दिनांक १ मार्च २०१४
२) शासन निर्णय समक्रमांक दिनांक २८ मे २०१४
३) आपले पत्र क्र. सिडको/नमुआवि/संपादन/व्य.सं./२०१४/१३८ दि. ५/६/२०१४.

महोदय,

आपल्या उपरोक्त संदर्भीय क्र. ३ वरील पत्रात नमूद केलेली धारणा विचारात घेवून विषयांकीत प्रकरणी मला आपणास पुढीलप्रमाणे कळविण्याचे निदेश आहेत :-

" शासन निर्णय समक्रमांक दि. १.३.२०१४ अन्वये संमती निवाड्याअंतर्गत संबंधितांना सिडकोकडून वाटप करण्यात येणा-या भूखंडांसाठी अधिमुल्य न आकारता लाक्षणिक वार्षिक भाडेपट्टयापोटी प्रति वर्षास प्रति भूखंडास रु. १/- या नाममात्र वार्षिक भाडेपट्टयाची आकारणी करण्यास सिडको संचालक मंडळाने त्यांच्या स्तरावर निर्णय घेतल्यास त्यास शासनाची तत्वत: संमती आहे."

कृपया वरीलप्रमाणे शासन मान्यतेस अनुसरुन नियमानुरुप पुढील आवश्यक ती कार्यवाही करण्यात यावी.

आपला,
११.८.२०१४
(एस. के. सालीमठ)
शासनाचे उप सचिव

प्रत : निवड नस्ती, नवि-१०.

ANNEXURE-XI
CWPRS TECHNICAL REPORT NO. 5815

[Additional Review of Storm Water Drainage studies for Navi Mumbai International Airport (NMIA), Navi Mumbai Dated June 2020]

भारत सरकार
केंद्रीय जल तथा विद्युत अनुसंधान शाला
पुणे- 411024

GOVERNMENT OF INDIA
CENTRAL WATER AND POWER RESEARCH STATION
PUNE – 411 024

नदी तथा जलाशय प्रणाली प्रतिमानन

RIVER AND RESERVOIR SYSTEM MODELLING

आपदा प्रबंधन योजना प्रभाग

DISASTER MANAGEMENT PLANNING DIVISION

तकनीकी रिपोर्ट संख्या . 5814

जून, 2020

TECHNICAL REPORT NO. 5814

JUNE, 2020

नवी मुंबई अंतर्राष्ट्रीय हवाई अड्डा (NMIA), नवी मुंबई के लिए तूफान जल निकासी प्रणाली अध्ययन की अतिरिक्त समीक्षा

Additional Review of Storm Water Drainage studies for Navi Mumbai International Airport (NMIA), Navi Mumbai

REPORT DOCUMENTATION SHEET

Technical Report No.: 5814 Month and Year: June, 2020

TITLE: ADDITIONAL REVIEW OF STORM WATER DRAINAGE STUDIES FOR NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA), NAVI MUMBAI

Officers responsible for conducting the studies:

Shri P. Vijayagopal, Scientist 'C', Shri S. Naveed Ali, Scientist 'B', Shri A. G. Golandaj, Assistant Research Officer and Shri Amit Kumar, Research Assistant under the supervision of Shri R.S.Jagtap, Ex. Joint Director and Dr. (Mrs) Neena Issac, Scientist 'E'.
Shri C. Srishailam Scientist 'C' & Shri N. Vivekanandan, Scientist 'B', HMET Division have carried out Rainfall Analysis part of the study under the supervision of Shri R.S.Jagtap, Ex.Joint Director.

Name and address of organization conducting the studies:

Disaster Management Planning Division (DMP)
River and Reservoir System Modelling Group
Central Water & Power Research Station, Khadakwasla, Pune 411024

Name and address of authority sponsoring the studies:

Shri Charudatta Deshmukh,
Director, Urban Planning,
Navi Mumbai International Airport Pvt Ltd,
Chhatrapati Shivaji International Airport
1st Floor, Terminal 1B Santacruz (E)
Mumbai - 400099, India

Synopsis

A new Greenfield airport known as the Navi Mumbai International Airport (NMIA) is being developed under City and Industrial Development Corporation of Maharashtra Limited (CIDCO), as Nodal Agency. M/s Navi Mumbai International Airport Private Limited (NMIAPL) has been entrusted with the construction and development of infrastructural facilities for NMIA by CIDCO. M/s Navi Mumbai International Airport Private Limited (NMIAPL) had referred CWPRS, study for review of 'Storm Water Drainage System Report (June 2018) for NMIA, Navi Mumbai' on which CWPRS had submitted Final Technical Report No.5724 in July 2019. Meanwhile, M/s NMIAPL has prepared and submitted a revised SWD system report (June 2019) vide email dated 20.06.2019 and requested CWPRS vide email dated 03.07.2019 to carry out additional review study of SWD report (2019) of M/s NMIAPL. Accordingly, an additional review of the Storm Water Drainage system prepared by M/s NMIAPL was carried out by CWPRS and observations have been reported. Additionally, mathematical model runs have been carried for some identified drainage channels adjacent to the runways and aprons in order to examine their sufficiency. The HEC-RAS Beta 4.1.0 version software was used for the computation of water level for these studies. Keeping present requirements in view, hydrodynamic studies for water flow simulation were adopted. The drains adjacent / near runway and aprons were identified and schematized from the starting node up to the outfall location and simulated in mathematical model. The catchment wise results were calculated. These modeling results show spilling over at some portions of drainage channels, but nevertheless as seen from the cross sectional results, the runways and aprons may not be flooded even for discharge resulting from 100 year return period rainfall.

Key words: 1-D mathematical model, 100 year return period, Cross-section of channel, Flood routing, HEC-RAS, Inundation.

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1.0 INTRODUCTION

The Government of Maharashtra has identified and entrusted City and Industrial Development Corporation of Maharashtra Limited (CIDCO), as Nodal Agency to undertake the development of the new Greenfield airport known as the Navi Mumbai International Airport (NMIA). The proposed Navi Mumbai International Airport (NMIA) near Panvel, Navi Mumbai is to be built through Public Private Partnership (PPP). It is reported that concession agreement has been executed between CIDCO and the Concessionaire, Navi Mumbai International Airport Private Limited (M/S NMIAPL) of Gunupati Venkata Krishna Reddy (GVK), a Hyderabad-based leading Infrastructure Conglomerate, for development of the Greenfield airport at Navi Mumbai. M/S NMIAPL had referred CWPRS, study for review of 'Storm Water Drainage System Report (June 2018) for NMIA, Navi Mumbai'. CWPRS had submitted the Technical Report No. 5724 dated July 2019 for the said study. Meanwhile M/S NMIAPL made modifications in SWD system of proposed NMIA and prepared a revised SWD system report (June 2019). M/S NMIAPL submitted revised SWD system report (June 2019) and requested CWPRS vide email dated 03.07.2019 to carry out additional review study for SWD report. M/S NMIAPL submitted the final revised SWD report (November 2019) vide email dated 21/11/2019 incorporating some minor modifications. The additional review study has been carried out for M/S NMIAPL revised SWD report (November 2019). The data required for carrying out review study was submitted by M/S NMIAPL to CWPRS vide email dated 13/01/2020. The additional review study of Storm Water Drainage system prepared by M/S NMIAPL for revised SWD report (November 2019) has been carried out by CWPRS. The observations have been presented in this Technical Report. Moreover, mathematical model runs have been carried for some identified drainage channels adjacent to the runways and aprons in order to examine their adequacy.

2.0 SCOPE OF WORK

The scope of present study was decided as follows:

(i) Additional Review of Storm Water Drainage (SWD) system (November 2019) Report prepared by NMIAPL.

(ii) Review of hydraulic design of SWD system for proposed drainage channels.

(iii) Submission of Final Technical Report.

3.0 METHODOLOGY

The methodology adopted for the study is given below.

(i) Review and analysis of available information in the form of maps, reports prepared by M/S NMIAPL, meteorological and hydrological data, literature, satellite images, general layout plan of NMIA etc having bearing on the hydrology and water regime of the NMIA.

(ii) Site inspection and reconnaissance survey and identification of data requirement.

(iii) Review of drainage scheme prepared by M/S NMIAPL considering topography, HFL at the outfall or nearby natural stream where storm water is to be discharged with appropriate 1D Mathematical Model.

(iv) Review of hydraulic design of cross sections for proposed storm water drainage channels.

(v) Discussions with project authorities.

(vi) Submission of final technical report.

4.0 DATA USED FOR THE STUDY

Basically the Storm Water Drainage Master Plan Report[1] of November 2019 prepared by M/S NMIAPL had been reviewed and following drawings / figures provided by the project authority have been utilized for carrying out the studies

1) Drawing No. NMIAL-CH2M-DRNG-CV-DRN-012.
2) Drawing No. NMIAL-CH2M-DRNG-CV-DRN-013.
3) Drawing No. NMIAL-CH2M-DRNG-CV-DRN-031.
4) Drawing No. NMIAL-CH2M-DRNG-CV-DRN-032.
5) Drawing No. NMIAL-CH2M-DRNG-CV-DRN-033.
6) Drawing No. NMIAL-CH2M-DRNG-CV-DRN-034.

5.0 STUDY AREA

The proposed NMIA is located at Kopre – Panvel area, in geographical centre of Navi Mumbai, having longitude of 73^{o} 4’ 18” E and latitude of 18^{o} 59’ 33” N approximately at a distance of 35 km from existing airport in Mumbai. The National Highway 4B (NH4B) is the main road access to the proposed Airport site from East, whereas the Aamra Marg provides road access to Airport site from the West. It is reported that Airport site is also accessible from the existing Mankhurd – Belapur – Panvel commuter rail corridor from Khandeshwar Railway Station on the Nerul – Uran Railway line currently being developed. Figure 1 shows location map of NMIA.

M/S NMIAPL informed that the development of NMIA is being undertaken in accordance with the overall requirement of Draft Concession Agreement as well as overall requirement as per conditions laid down by Government of India, The Ministry of Environment, Forest and Climate Change (MoEFCC) approval, consent to establishment from MPCB and ICAO & DGCA CAR'S standard requirements. As reported, development of NMIA will be undertaken in a phased manner i.e. 20 MPPA, 40 MPPA and 60 MPPA capacities. M/S CH2M has used the ultimate master plan submitted by M/S NMIAPL in May 2018, included in updates to the Initial Engineering Drainage concepts.

Figure 1: Location of Navi Mumbai International Airport (NMIA)

6.0 SITE VISIT

CWPRS officials along with NMIAPL officials carried out a site visit to Navi Mumbai International Airport, Mumbai on 6th September, 2019. Discussions were held in order to get information regarding the Strom Water Drainage studies for Navi Mumbai International Airport. The details of site visit are given below.

- The officials from CWPRS reached NMIAPL Office which is located on the Northern side of NMIA. The meeting was held with M/S NMIAPL and they explained the total project in brief using drawings and maps.

- The team then headed towards the NMIA project site. At project office, first a presentation regarding Safety norms to be followed on site was held for CWPRS officials. Shri Rajagopal Anilraja, Sr. Vice President briefed about the project and guided CWPRS officials on how to proceed for a Site Visit.

- Shri Sanatnu Ghosh, Asst. Vice President and Shri Gajanan Kashinath Gandewar, Deputy General Manager accompanied CWPRS officials on a site visit. First point visited was an Outlet Location W1 located on Northwest Corner of Airport Area, then a guided tour of internal area of Airport was carried out, showing the cutting and filling locations. One more Outlet location C1 was also visited which is at the centre North side of Airport area.

- Some of the photos of Site visit are given below :

Photo 1 : Discussion at NMIA Site Office

Photo 2 : Outfall Location Number 1

Photo 3 : Outfall Location Number 3

Photo 4 : Reclaimed Ground Level Area of NMIA Filled upto 5.5 m RL.

7.0 RAINFALL ANALYSIS

The Extreme Value Analysis (EVA) of rainfall carried out using statistical frequency analysis for different return periods is described in this section.

7.1 Availability of Rainfall Data

The daily and hourly rainfall data availability pertaining to Santacruz and Colaba sites used for the study is given in Table 1. Some of the data have been provided by the project authority, as obtained from IMD and other data was taken from CWPRS TR No. 4665 of October 2009.

Table 1: Data Availability of Daily and Hourly Rainfall

S. No.	Site	Rainfall Data	Period of Data Availability
1	Santacruz	Annual 1-day maximum (CWPRS TR No. 4665)	1950 to 2005
		Daily rainfall (IMD)	2005 to 2016
		Annual 1-hour maximum (CWPRS TR No. 4665)	1969 to 2005
		Hourly rainfall (IMD)	2006 to 2009, 2011, 2014 to 2017
2	Colaba	Annual 1-day maximum (CWPRS TR No. 4665)	1901 to 2004
		Daily rainfall (IMD)	2005 to 2016
		Annual 1-hour maximum (CWPRS TR No. 4665)	1969 to 2004
		Hourly rainfall (IMD)	2005 to 2010, 2013

The Annual 1-Day Maximum Rainfall (ADMR) and Annual 1-Hour Maximum Rainfall (AHMR) series were extracted from the daily and hourly rainfall data respectively, which is given in Tables 1(a) and 1(b).

Table 1(a): Observed ADMR and AHMR of Santacruz

Year	ADMR (mm)	AHMR (mm)	Year	ADMR (mm)	AHMR (mm)
1950	154.9	Not Available	**1984**	240.1	67.5
1951	129.5		**1985**	223.6	63.7
1952	308.6		**1986**	194.5	36.0
1953	310.6		**1987**	125.7	48.0
1954	256.0		**1988**	144.9	46.7
1955	183.4		**1989**	192.1	43.5
1956	175.8		**1990**	150.2	55.3
1957	161.5		**1991**	399.0	92.5
1958	241.2		**1992**	215.4	41.0
1959	176.0		**1993**	312.4	94.0
1960	121.2		**1994**	157.2	70.0
1961	157.8		**1995**	180.0	80.0
1962	212.4		**1996**	171.7	44.9

Year	ADMR (mm)	AHMR (mm)	Year	ADMR (mm)	AHMR (mm)
1963	192.6		**1997**	346.2	93.0
1964	137.8		**1998**	211.5	153.0
1965	372.9		**1999**	134.4	60.9
1966	291.3		**2000**	351.5	67.5
1967	201.1		**2001**	161.0	52.0
1968	173.8		**2002**	186.0	45.0
1969	201.4	93.0	**2003**	192.9	43.5
1970	194.0	45.0	**2004**	187.4	51.4
1971	244.6	58.1	**2005**	944.2	**189.0***
1972	203.0	57.5	**2006**	231.0	65.0
1973	163.2	27.0	**2007**	256.6	89.0
1974	375.2	57.3	**2008**	161.7	56.4
1975	223.4	63.5	**2009**	274.1	54.0
1976	264.7	43.1	**2010**	158.2	NA
1977	136.8	68.9	**2011**	232.6	68.3
1978	156.9	43.8	**2012**	185.3	NA
1979	139.1	45.5	**2013**	215.6	NA
1980	151.1	60.8	**2014**	207.0	65.0
1981	318.2	43.0	**2015**	283.4	43.6
1982	275.6	47.0	**2016**	142.6	15.5
1983	253.4	42.5	**2017**	NA	90.0

∗ Note: Observed value of AHMR for the year 2005 is not available. The observed ADMR for the year 2005 is 944.2 mm whereas the hourly rainfall data during 26th and 27th July 2005 corresponding to very high rainfall event in the region are found missing. The AHMR for the year 2005 has been taken from CWPRS TR No-4665 of October 2009.

Descriptive statistics of ADMR				**Descriptive statistics of AHMR**			
Average (mm)	224.3	Kurtosis	26.010	Average (mm)	59.3	Kurtosis	5.006
Std. Dev. (mm)	111.6	Minimum (mm)	121.2	Std. Dev. (mm)	23.0	Minimum (mm)	15.5
Skewness	4.293	Maximum (mm)	944.2	Skewness	1.622	Maximum (mm)	189.0
ADMR: Annual 1-day Maximum Rainfall				AHMR: Annual 1-Hour Maximum Rainfall			

Table 1(b): Observed ADMR and AHMR of Colaba

Year	ADMR (mm)	AHMR (mm)	Year	ADMR (mm)	AHMR (mm)	Year	ADMR (mm)	AHMR (mm)
1901	144.3	Not available	**1940**	163.1	Not available	**1979**	206.2	57.5
1902	151.6		**1941**	105.2		**1980**	125.9	48.6
1903	127.8		**1942**	178.6		**1981**	241.9	80.0
1904	86.4		**1943**	203.5		**1982**	180.9	56.8
1905	82.3		**1944**	181.1		**1983**	173.4	64.6
1906	119.1		**1945**	246.4		**1984**	544.3	68.3
1907	254.5		**1946**	217.4		**1985**	345.5	89.0
1908	129.3		**1947**	265.4		**1986**	128.7	58.8
1909	120.1		**1948**	172.7		**1987**	153.9	42.6
1910	304.0		**1949**	432.8		**1988**	138.2	53.3
1911	111.3		**1950**	147.8		**1989**	183.3	39.0
1912	164.3		**1951**	138.4		**1990**	421.2	113.0
1913	201.9		**1952**	156.7		**1991**	477.6	48.3
1914	178.1		**1953**	173.7		**1992**	175.9	53.5
1915	248.9		**1954**	249.9		**1993**	206.9	40.0
1916	165.6		**1955**	149.4		**1994**	148.6	37.4
1917	148.6		**1956**	222.3		**1995**	162.8	46.5
1918	135.6		**1957**	158.2		**1996**	165.4	52.3
1919	277.4		**1958**	233.4		**1997**	244.2	46.0
1920	182.4		**1959**	134.1		**1998**	261.9	100.0
1921	216.2		**1960**	238.3		**1999**	233.0	40.0
1922	215.1		**1961**	144.5		**2000**	243.7	40.0

Year	ADMR (mm)	AHMR (mm)	Year	ADMR (mm)	AHMR (mm)	Year	ADMR (mm)	AHMR (mm)
1923	304.8		**1962**	199.0		**2001**	184.9	73.5
1924	85.6		**1963**	189.1		**2002**	138.3	34.5
1925	116.8		**1964**	112.1		**2003**	147.7	44.2
1926	147.1		**1965**	249.4		**2004**	159.6	38.0
1927	216.9		**1966**	158.5		**2005**	217.0	52.6
1928	250.7		**1967**	179.7		**2006**	213.3	54.9
1929	170.9		**1968**	58.6		**2007**	279.4	59.0
1930	548.1		**1969**	109.6	28.3	**2008**	249.7	43.2
1931	242.8		**1970**	288.8	48.7	**2009**	194.0	31.9
1932	174.0		**1971**	291.2	86.2	**2010**	210.0	80.0
1933	153.2		**1972**	175.6	40.0	**2011**	210.9	NA
1934	118.9		**1973**	171.6	38.3	**2012**	112.6	NA
1935	148.3		**1974**	575.6	89.0	**2013**	218.6	59.0
1936	133.9		**1975**	417.2	110.0	**2014**	228.4	NA
1937	93.5		**1976**	123.5	43.0	**2015**	208.8	NA
1938	181.1		**1977**	184.4	66.2	**2016**	165.6	NA
1939	231.6		**1978**	175.7	50.5			

Descriptive statistics of ADMR				**Descriptive statistics of AHMR**			
Average (mm)	201.4	Kurtosis	5.244	Average (mm)	56.9	Kurtosis	0.765
Std. Dev. (mm)	91.6	Minimum (mm)	58.6	Std. Dev. (mm)	20.8	Minimum (mm)	28.3
Skewness	2.030	Maximum (mm)	575.6	Skewness	1.164	Maximum (mm)	113.0

The plots of observed ADMR and AHMR series for Santacruz and Colaba sites are shown in Figures 2(a) to 2(d).

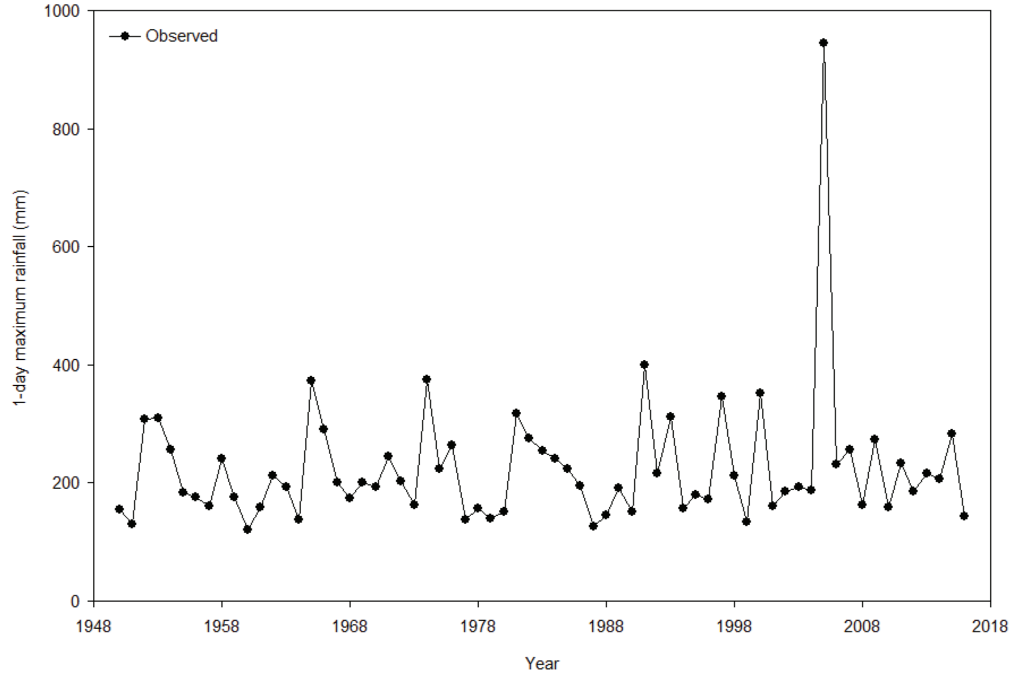

Figure 2(a): 1-day Maximum Rainfall of Santacruz for the Period 1950 to 2016

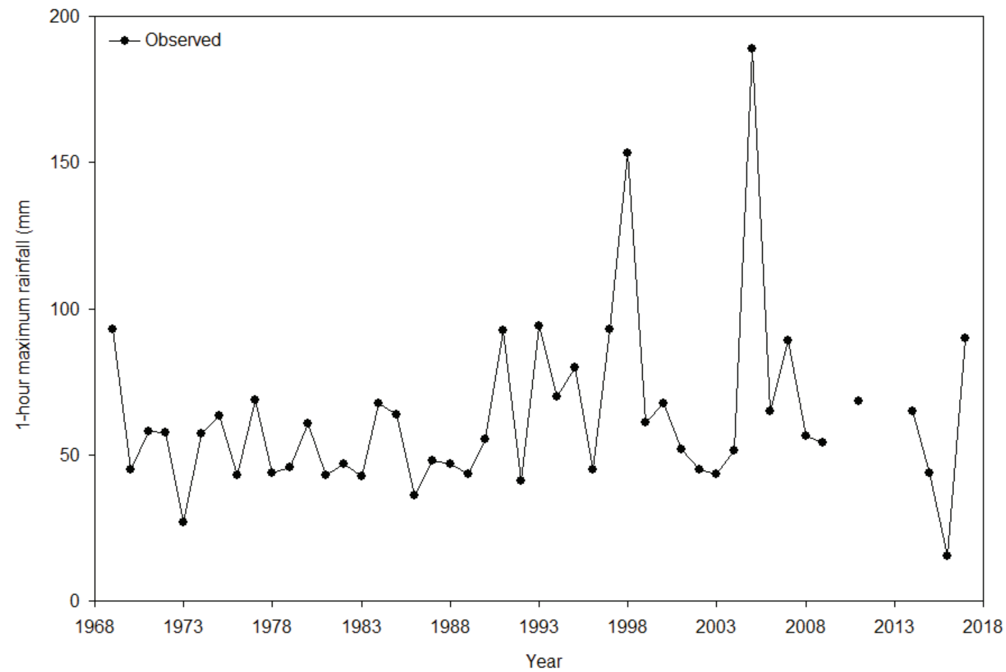

Figure 2(b): 1-hour Maximum Rainfall of Santacruz for the Period 1969 to 2017
(AHMR value for the year 2005 taken as 189 mm from CWPRS TR No. 4665 as actual value is not available with IMD)

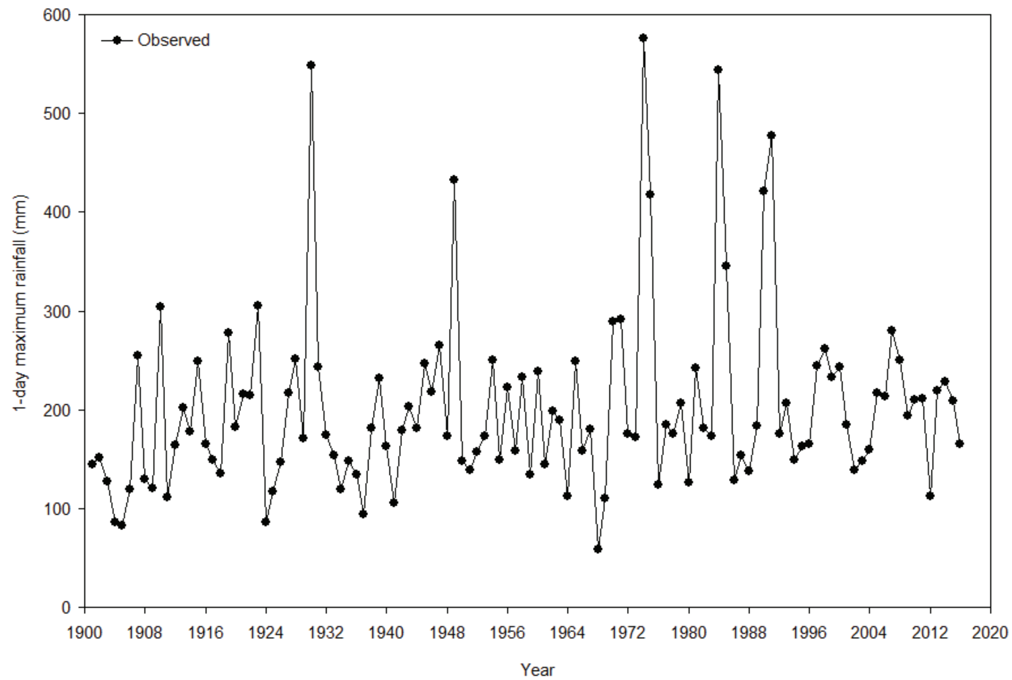

Figure 2(c): 1-day Maximum Rainfall of Colaba for the Period 1901 to 2016

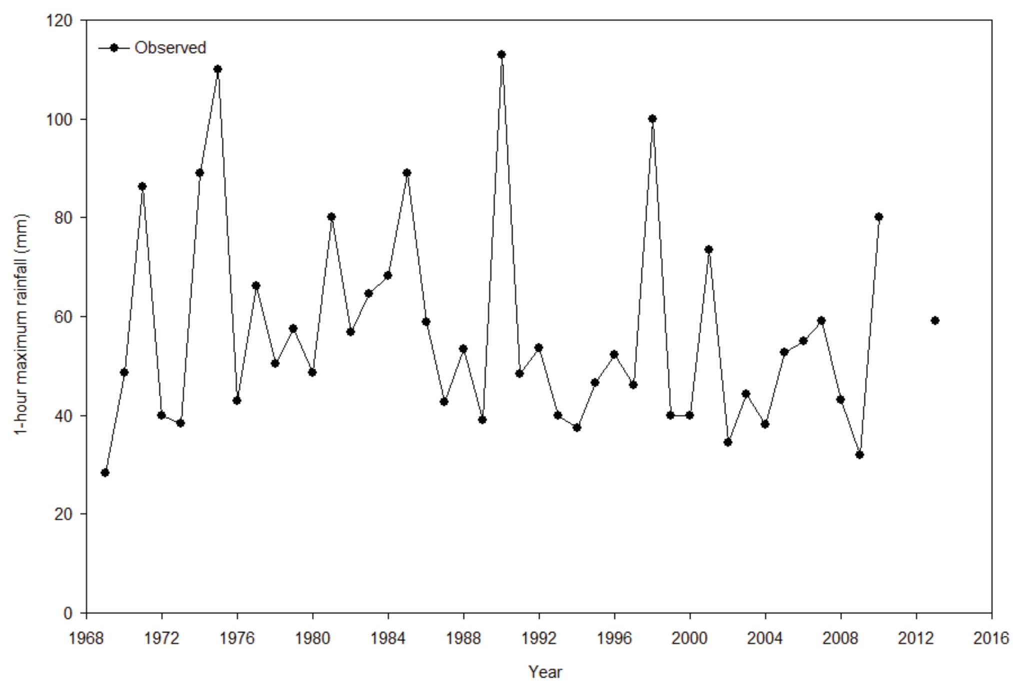

Figure 2(d): 1-hour Maximum Rainfall of Colaba for the Period 1969 to 2013

The EVA of daily and hourly rainfall for Santacruz and Colaba sites has been carried out for the cases given in Table 2.

Table 2: Annual Series for EVA of Daily and Hourly Rainfall

Site	Estimated variable	Data used for EVA	No. of years (n)
Santacruz	1-day maximum rainfall (mm)	ADMR data for the period 1950 to 2016.	67
	1-hour maximum rainfall (mm)	i) AHMR data for the period 1969 to 2009, 2011, 2014 to 2017. ii) AHMR of 189.0 mm for the year 2005 is considered. iii) Missing data for the years 2010, 2012 and 2013 is not considered.	46
Colaba	1-day maximum rainfall (mm)	ADMR data for the period 1901 to 2016.	116
	1-hour maximum rainfall (mm)	i) AHMR data for the period 1969 to 2010, 2013. ii) Missing data for the years 2011 to 2012 is not considered.	43

7.2 Selection of Probability Distribution

In hydrological practices, Gumbel distribution is generally adopted for EVA of rainfall whereas Log Normal and Log Pearson Type-3 (LP3) distributions for flood estimation and Weibull distribution for assessment of low-flows (Bobee and Ashkar, 1991; Naghavi et al., 1993; CWC, 2010). However, in the present study, Gumbel and LP3 distributions are adopted for EVA of rainfall so as to maintain compatibility with earlier CWPRS TR No. 4665 of October 2009. Parameters of the Gumbel and LP3 distributions are determined by Maximum Likelihood Method (MLM) and further used for estimation of Extreme Rainfall (ER) for different return periods.

7.2.1 Gumbel (or Extreme Value Type-I) Distribution

The Probability Density Function [PDF: f(r)] and Cumulative Distribution Function [CDF: F(r)] of Gumbel distribution is given as below:

$$f(r;\alpha,m) = \frac{e^{-(r-m)/\alpha} e^{-e^{-(r-m)/\alpha}}}{\alpha} \quad \text{and} \quad F(r;\alpha,m) = e^{-e^{-(r-m)/\alpha}}, \ \alpha>0,\ r>0 \qquad \text{... (1)}$$

where, α and m are the scale and location parameters of the distribution (Gumbel, 1960). The parameters are estimated by MLM from Eqs. (2 and 3), and are used to estimate the ER (R_T) for a return period (T) computed from the relation $R_T = \hat{m} + \hat{\alpha}(Y_T)$ with Y_T=-ln(-ln(1-(1/T))), where

$$\hat{m} = -\hat{\alpha}\ln\left[\sum_{i=1}^{N}\exp(-r_i/\hat{\alpha})\Big/N\right] \quad \text{... (2)}$$

$$\hat{\alpha} = \overline{R} - \left[\sum_{i=1}^{N} r_i \exp(-r_i/\hat{\alpha})\Big/\sum_{i=1}^{N}\exp(-r_i/\hat{\alpha})\right] \quad \text{... (3)}$$

where, r_i is the observed AMR value of i^{th} year, $\overline{R}$ is the average of observed values and N is the sample size. The Standard Error (SE) on the estimated ER (R_T) for a return period (T) can be computed from Eq. (4), which is given as:

$$SE(R_T) = \left(\hat{\alpha}/\sqrt{N}\right)\left(1.15894 + 0.19187Y_T + 1.1Y_T^2\right)^{0.5} \quad \text{... (4)}$$

7.2.2 Log Pearson Type-3 Distribution

The PDF and CDF of LP3 distribution is given by:

$$f(r;m,\alpha,\beta) = \frac{1}{\alpha r \Gamma\beta}\left(\frac{\ln r - m}{\alpha}\right)^{\beta-1} e^{-\left(\frac{\ln r - m}{\alpha}\right)};\ \alpha,\beta > 0, r > 0 \quad \text{... (5)}$$

$$F(r) = \int_0^r f(x;m,\alpha,\beta)\,dx \quad \text{... (6)}$$

where, m, α and β are the location, scale and shape parameters of the LP3 distribution (Rao and Hamed, 2000). The parameters are estimated by MLM from Eq. (8), and are used to estimate the ER (R_T) for a return period (T) from the relation given as below:

$$R_T = \text{Exp}((m + \alpha\beta) + K_P\alpha\sqrt{m}) \quad \text{... (7)}$$

The system of MLM equations is given below:

$$\left.\begin{aligned} &\sum_{i=1}^{N}(\ln(r_i) - m) = N\alpha\beta \\ &N\psi(\beta) = \sum_{i=1}^{N}\ln\left[(\ln(r_i) - m)/\alpha\right] \\ &N = \alpha(\beta - 1)\sum_{i=1}^{N}\left[1/(\ln(r_i) - m)\right] \end{aligned}\right\} \quad \text{... (8)}$$

where, $\psi(\beta) = \Gamma'(\beta)/\Gamma(\beta)$ is called a digamma function. The SE on the estimated extreme events adopting LP3 distribution using MLM has been computed through Eq. (9), which is as follows:

$$SE(R_T) = \frac{\alpha}{N}\left\{1 + KC_S + \left(\frac{K^2}{2}\right)\left(\frac{3C_S^2}{4} + 1\right) + 3K\frac{\partial K}{\partial C_S}\left(\frac{C_S^3}{4} + C_S\right) + 3\left(\frac{\partial K}{\partial C_S}\right)^2\left(2 + 3C_S^2 + 5C_S + \frac{5C_S^4}{9}\right)\right\} \quad \text{... (9)}$$

where, $\frac{\partial K}{\partial C_S} \cong \left(\frac{Z^2 - 1}{6}\right) + \frac{4(Z^3 - 6Z)}{6^3}C_S - \frac{3(Z^2 - 1)}{6^3}C_S^2 + \frac{4Z}{6^4}C_S^3 - \frac{10}{6^6}C_S^4$.

Here, Z is the standard normal variate at 1.96σ level and C_S is coefficient of skewness of log-transformed series of the observed data.

7.2.3 Estimation of Confidence Interval Limits

The lower and upper confidence limits (LCL and UCL) of the estimated ER are computed from Eq. (10) using normal approximation method, which is given as below:

LCL = ER-(1.96)SE and UCL=ER+(1.96)SE ... (10)

By applying the procedures as described above, parameters of Gumbel and LP3 probability distributions were determined and used for estimation of ER for different return periods from 1.01-year to 1,000-year. The EVA results of Santacruz and Colaba sites giving the estimated ER and 95% confidence limits for different return periods obtained from Gumbel and LP3 distributions are given in Tables 3(a) to Table 3(d) and respective plots in Figures 3(a) to 3(h) respectively. One can also go for liberal estimate of design values by considering upper confidence limit depending on cost benefit and other considerations.

Table 3(a): Estimated 1-day Maximum Rainfall (mm) with 95% Confidence Limits for Different Return Periods by Gumbel and LP3 Distributions for Santacruz

Return period (year)	Gumbel (using MLM)			LP3 (using MLM)		
	1-day maximum rainfall	Confidence Limits		1-day maximum rainfall	Confidence Limits	
		Lower	Upper		Lower	Upper
1.01	99.9	81.9	117.9	184.1	102.2	265.9
2	207.6	191.7	223.6	230.2	173.4	287.1
5	272.1	247.5	296.6	304.9	238.1	371.6
10	314.7	283.3	346.1	375.7	285.0	466.5
20	355.6	317.1	394.1	462.4	328.5	596.4
25	368.6	327.8	409.3	494.3	345.2	643.4
50	408.6	360.7	456.4	607.7	410.4	805.0
100	**448.2**	393.3	503.2	**746.7**	485.5	1007.8
200	487.8	425.6	549.9	917.0	560.0	1274.0
250	500.5	436.0	565.0	979.7	580.3	1379.0
500	539.9	468.2	611.6	1202.7	650.2	1755.2
1000	579.3	500.4	658.3	1476.1	734.8	2217.4

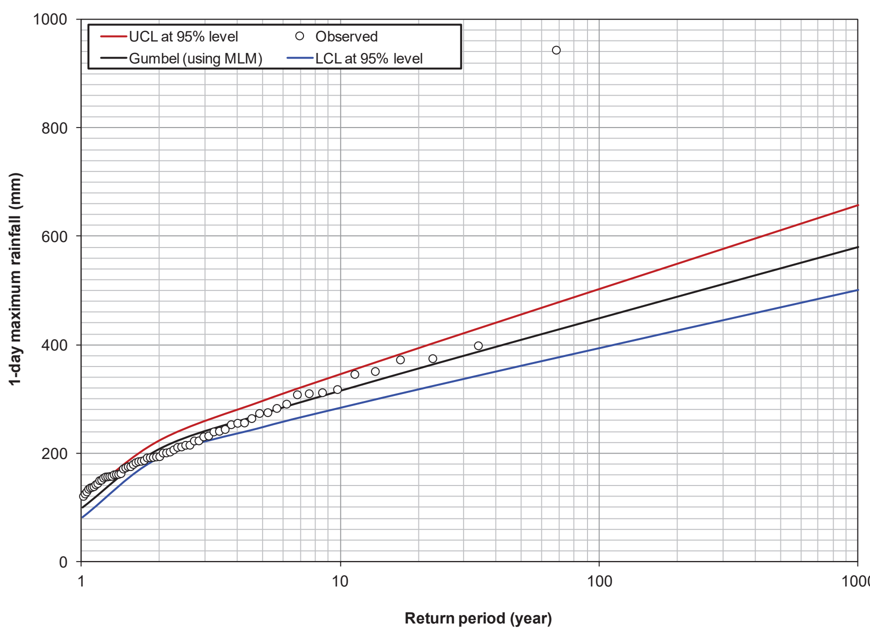

Figure 3(a): Estimated 1-day Maximum Rainfall With 95% Confidence Limits by Gumbel Distribution with Observed Data for Santacruz

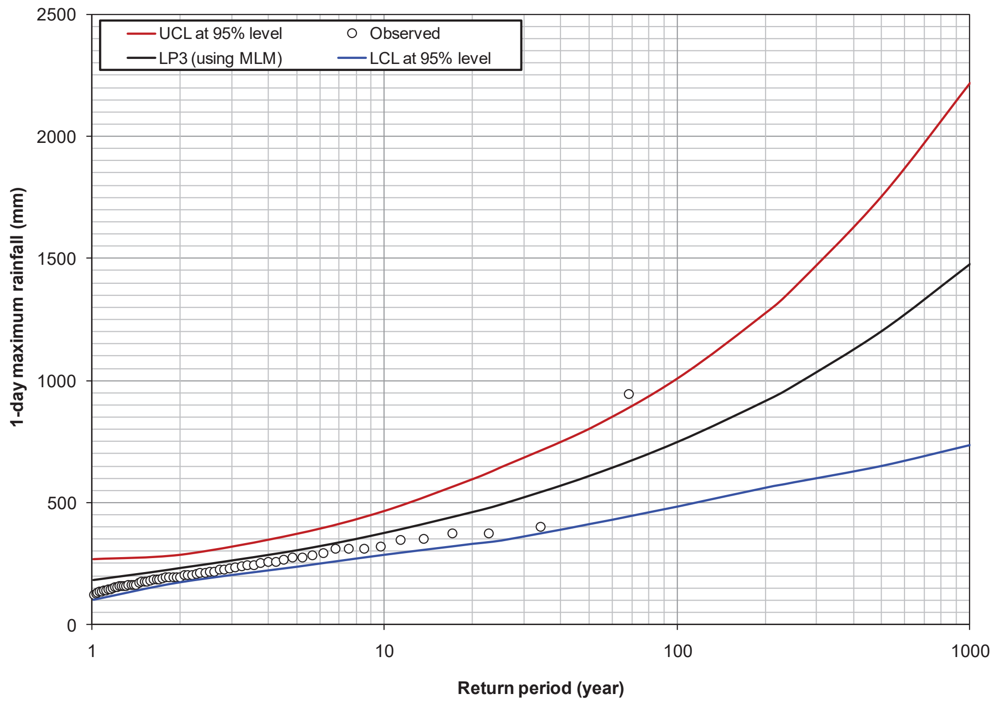

Figure 3(b): Estimated 1-day Maximum Rainfall With 95% Confidence Limits by LP3 Distribution with Observed Data for Santacruz

Table 3(b): Estimated 1-hour Maximum Rainfall (mm) with 95% Confidence Limits for Different Return Periods by Gumbel and LP3 Distributions for Santacruz

Return period (year)	Gumbel (using MLM)			LP3 (using MLM)		
	1-hour maximum rainfall	Confidence Limits		1-hour maximum rainfall	Confidence Limits	
		Lower	Upper		Lower	Upper
1.01	21.6	14.3	28.9	26.5	19.2	33.8
2	58.1	51.6	64.6	57.5	50.1	64.9
5	79.9	69.9	89.9	81.0	71.0	90.9
10	94.4	81.5	107.3	96.8	85.4	108.3
20	108.2	92.5	123.9	112.3	97.2	127.3
25	112.6	95.9	129.3	117.2	101.0	133.4
50	126.2	106.6	145.8	132.6	111.4	153.7
100	**139.6**	117.1	162.1	**148.1**	121.4	174.8
200	153.0	127.5	178.5	163.9	132.2	195.7
250	157.3	131.0	183.6	169.1	136.2	202.0
500	170.6	141.4	199.8	185.4	147.5	223.3
1000	184.0	151.7	216.3	202.1	159.9	244.3

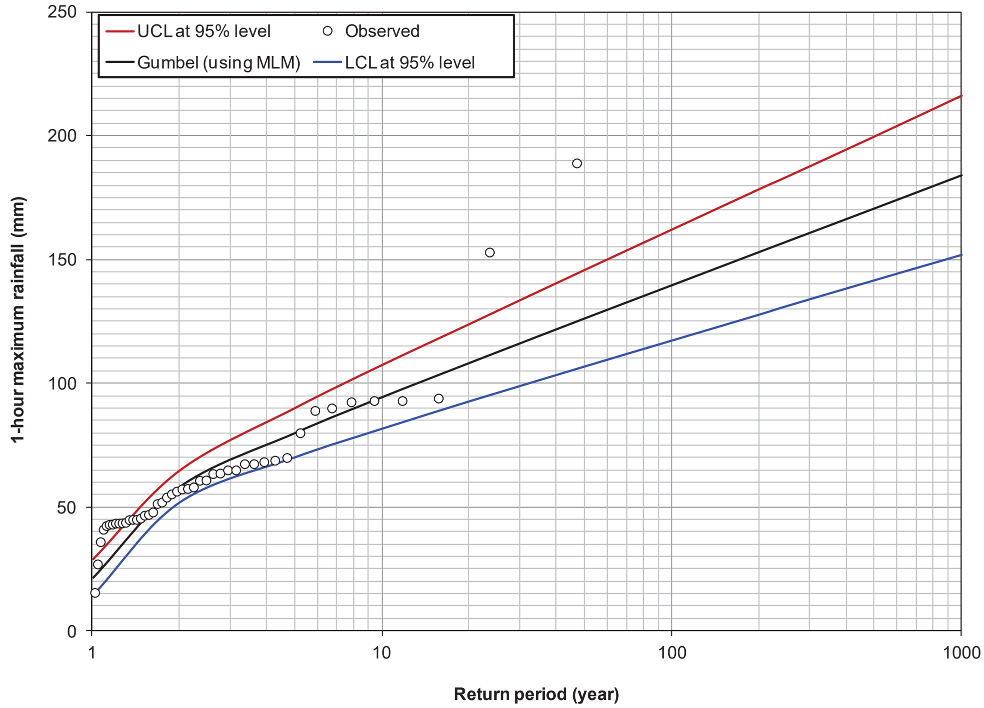

Figure 3(c): Estimated 1-hour Maximum Rainfall With 95% Confidence Limits by Gumbel Distribution with Observed Data for Santacruz

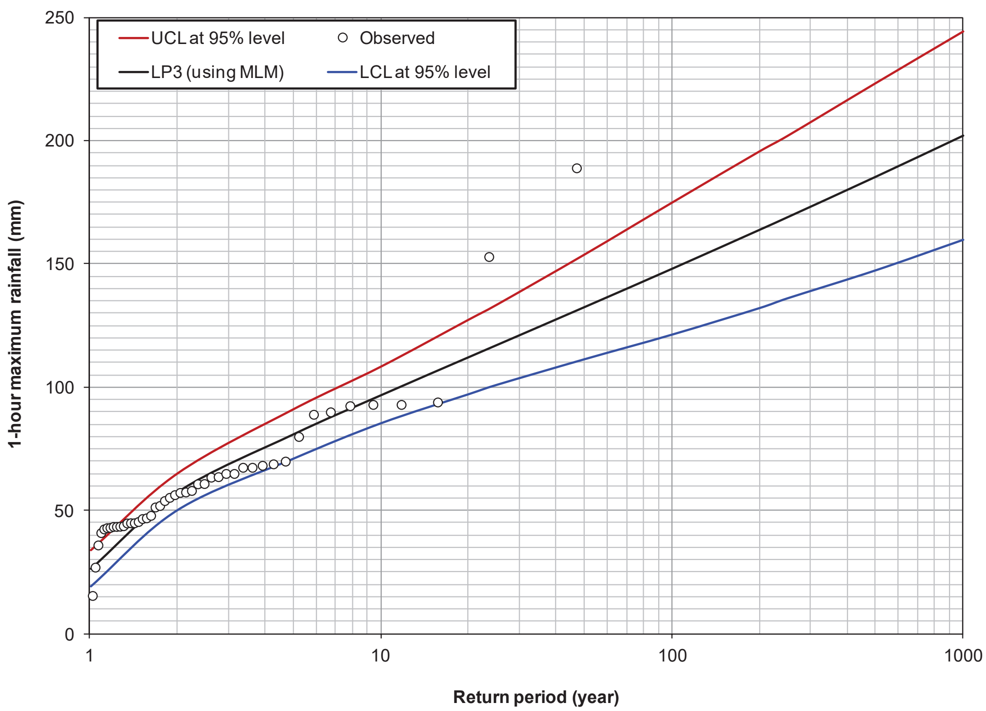

Figure 3(d): Estimated 1-hour Maximum Rainfall With 95% Confidence Limits by LP3 Distribution with Observed Data for Santacruz

Table 3(c): Estimated 1-day Maximum Rainfall (mm) with 95% Confidence Limits for Different Return Periods by Gumbel and LP3 Distributions for Colaba

Return period (year)	Gumbel (using MLM)			LP3 (using MLM)		
	1-day maximum rainfall	Confidence Limits		1-day maximum rainfall	Confidence Limits	
		Lower	Upper		Lower	Upper
1.01	73.0	58.7	87.3	80.8	70.2	91.4
2	186.4	173.7	199.1	182.2	168.1	196.3
5	254.3	234.7	273.9	256.5	230.0	283.1
10	299.2	274.1	324.3	310.1	275.3	344.9
20	342.3	311.5	373.1	364.7	315.2	414.2
25	356.0	323.5	388.5	382.7	330.4	435.0
50	398.1	359.9	436.3	440.4	380.0	500.9
100	439.9	395.8	484.0	501.3	425.2	577.4
200	481.5	431.7	531.3	565.9	480.5	651.2
250	494.9	443.4	546.4	587.5	500.2	674.8
500	536.4	479.0	593.8	657.5	560.1	754.9
1000	577.9	514.8	641.0	732.1	620.4	843.8

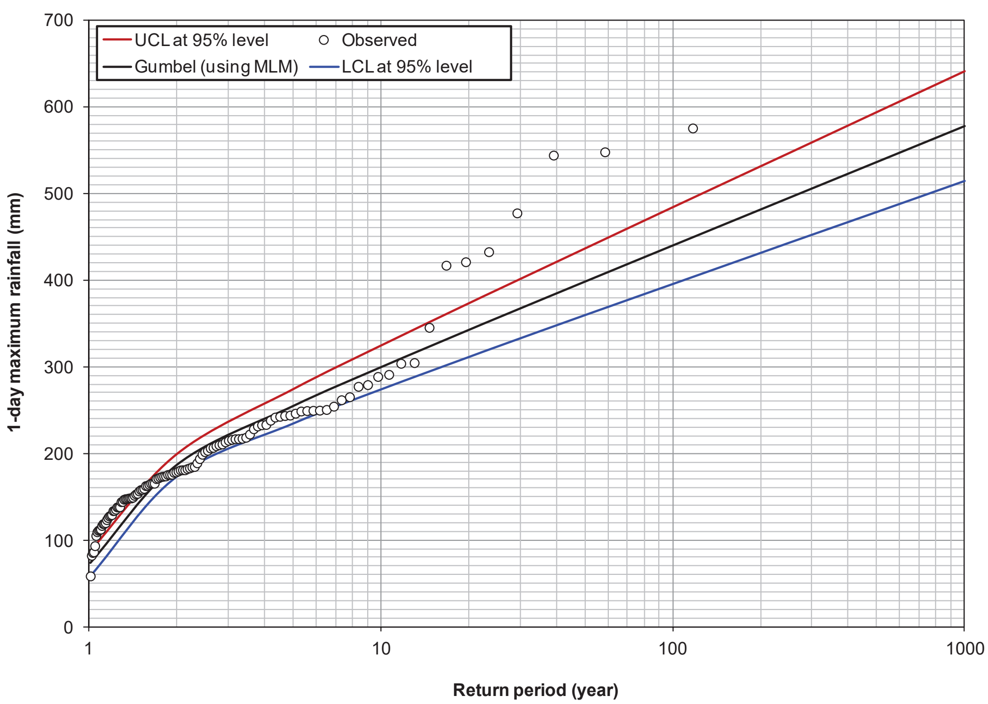

Figure 3(e): Estimated 1-day Maximum Rainfall With 95% Confidence Limits by Gumbel Distribution with Observed Data for Colaba

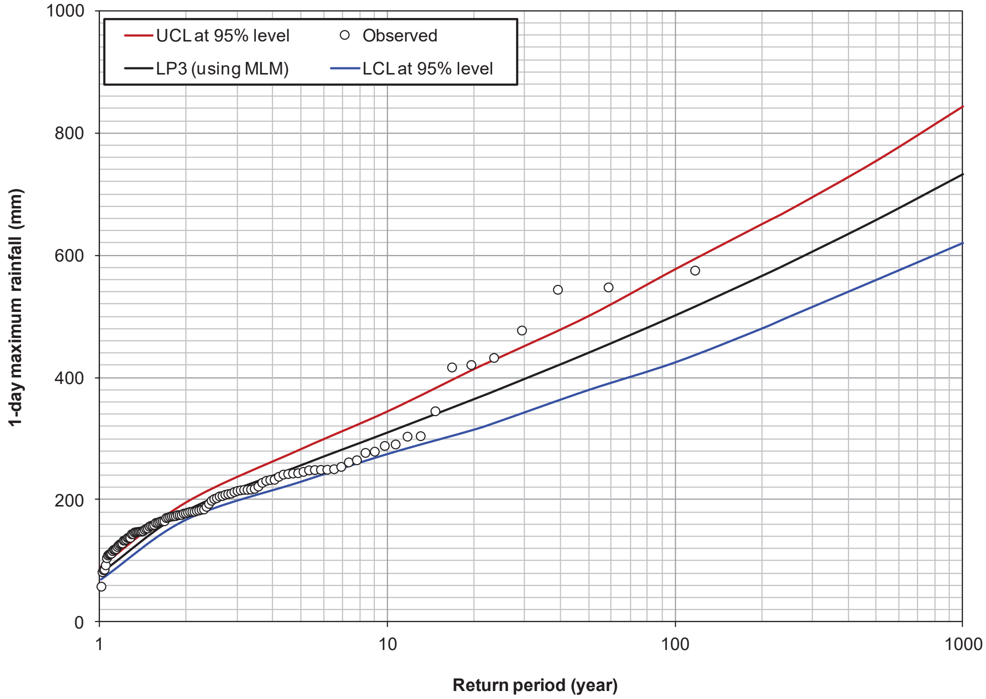

Figure 3(f): Estimated 1-day Maximum Rainfall With 95% Confidence Limits by LP3 Distribution with Observed Data for Colaba

Table 3(d): Estimated 1-hour Maximum Rainfall (mm) with 95% Confidence Limits for Different Return Periods by Gumbel and LP3 Distributions for Colaba

Return period (year)	Gumbel (using MLM)			LP3 (using MLM)		
	1-hour maximum rainfall	Confidence Limits		1-hour maximum rainfall	Confidence Limits	
		Lower	Upper		Lower	Upper
1.01	25.8	20.1	31.5	29.2	21.0	37.4
2	53.2	48.1	58.3	51.7	47.5	56.0
5	69.6	61.8	77.4	70.0	61.4	78.6
10	80.4	70.4	90.4	83.8	71.3	96.3
20	90.8	78.6	103.0	98.5	80.5	116.4
25	94.1	81.2	107.0	103.4	83.2	123.6
50	104.2	89.1	119.3	119.6	91.8	147.4
100	114.3	96.9	131.7	137.2	102.9	171.6
200	124.4	104.6	144.2	156.6	112.0	201.1
250	127.6	107.2	148.0	163.2	115.2	211.1
500	137.6	114.9	160.3	185.0	122.3	247.7
1000	147.6	122.5	172.7	209.0	130.5	287.5

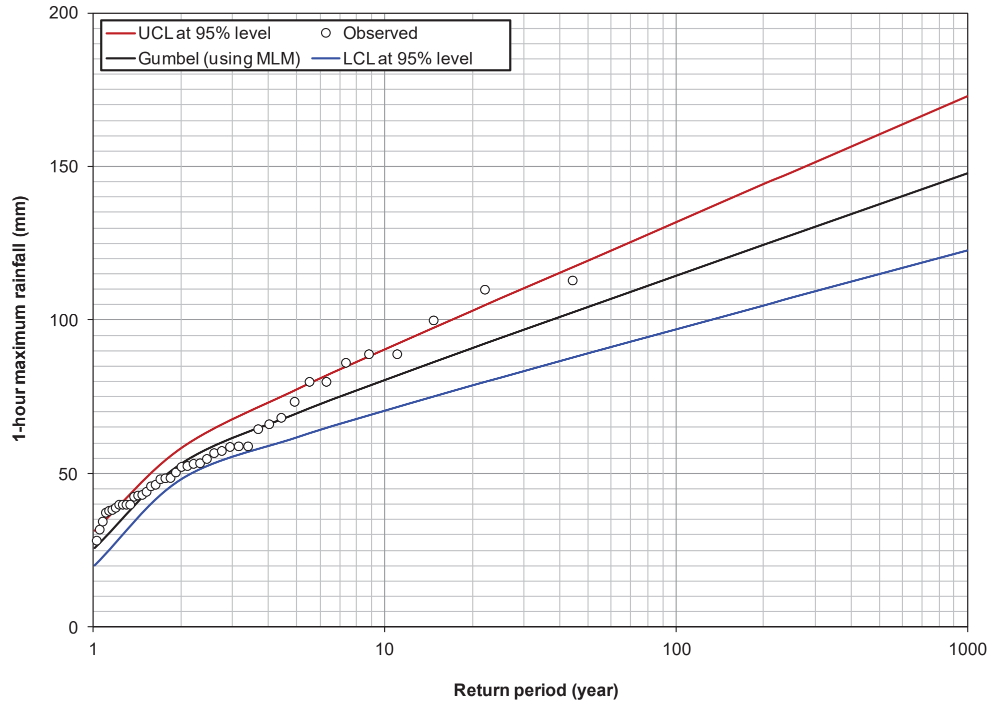

Figure 3(g): Estimated 1-hour Maximum Rainfall With 95% Confidence Limits by Gumbel Distribution with Observed Data for Colaba

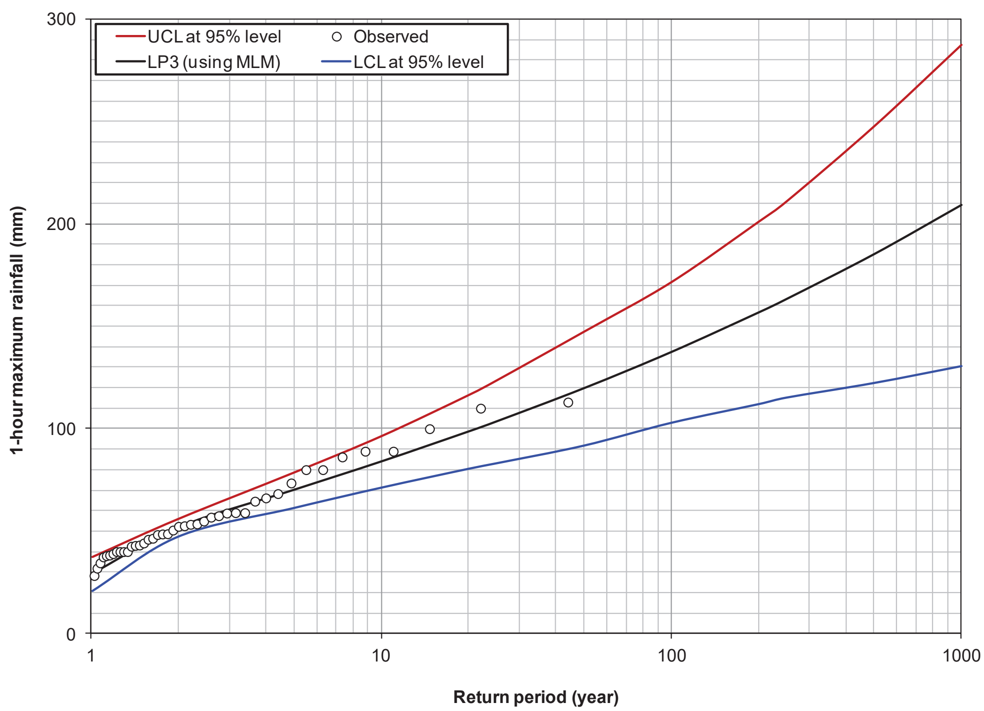

Figure 3(h): Estimated 1-hour Maximum Rainfall With 95% Confidence Limits by LP3 Distribution with Observed Data for Colaba

7.3 Goodness-of-Fit Test

A^2 test is applied for checking the adequacy of fitting of Gumbel and LP3 distributions to the ADMR and AHMR series. Theoretical description of A^2 statistic is as follows:

$$A^2 = (-N) - (1/N) \sum_{i=1}^{N} \{(2i-1)\ln(Z_i) + (2N+1-2i)\ln(1-Z_i)\} \quad \text{... (11)}$$

Here, $Z_i = F(r_i)$ for i=1,2,3,…,N with $r_1<r_2<….<r_N$ and $F(r_i)$ is the CDF of r_i (Zhang, 2002). The A^2 test results for EVA of daily and hourly rainfall pertaining to Santacruz and Colaba sites are given in Table 4.

Table 4: Computed Values of A^2 Statistic by Gumbel and LP3 Distributions

Site	Gumbel		LP3	
	1-day	1-hour	1-day	1-hour
Santacruz	0.685	0.924	1.083	0.872
Colaba	0.804	0.554	0.923	0.627

From Table 4, it is noted that the computed values of A^2 statistic for the 1-hour and 1-day rainfall series of Santacruz and Colaba by Gumbel and LP3 distributions are less than the theoretical value viz., 0.757 at 5% significance level or 1.038 at 1% significance level except for 1-day rainfall series of Santacruz using LP3. Additionally, the fit was assessed qualitatively by using fitted curves and other aspects. Due to common usefulness of Gumbel and LP3 distributions in EVA, all the data series were taken further in design values considerations.

7.4 Results of EVA of Rainfall

EVA of daily and hourly rainfall pertaining to Santacruz and Colaba sites adopting Gumbel and LP3 distributions (using MLM) was carried out. The adequacy of fitting of Gumbel and LP3 distributions to ADMR and AHMR series were evaluated through A^2 test and by the fitted curves of estimated ER. The outlier like event of July 2005 observed at Santacruz site clearly shows impact on the whole EVA. Based on EVA results of daily and hourly rainfall, the estimated 1-day and 1-hour maximum rainfall for different return periods viz. 10-year, 50-year, 100-year and 1000-year obtained for Santacruz and Colaba sites adopting Gumbel and LP3 distributions are summarized in Table 5.

Table 5: Estimated 1-day and 1-hour Maximum Rainfall for Different Return Periods for Santacruz and Colaba Sites

Parameter	Site	Extreme rainfall (mm)							
		10-year		50-year		100-year		1000-year	
		Gumbel	LP3	Gumbel	LP3	Gumbel	LP3	Gumbel	LP3
1-day maximum rainfall	Santacruz	314.7	375.7	408.6	607.7	448.2	746.7	579.3	1476.1
	Colaba	299.2	310.1	398.1	440.4	439.9	501.3	577.9	732.1
1-hour maximum rainfall	Santacruz	94.4	96.8	126.2	132.6	**139.6**	**148.1**	184.0	202.1
	Colaba	80.4	83.8	104.2	119.6	114.3	137.2	147.6	209.0

8.0 CWPRS REVIEW AND OBSERVATIONS ON REPORT PREPARED BY M/S NMIAPL

Following are point-wise review and observations carried out by CWPRS of the report 'Storm Water Drainage system for Navi Mumbai International Airport NMIA (Revised November 2019)' of M/s NMIAPL.

Analysis of Hydrological Data for Drainage Scheme

Design storm is a crucial factor in deciding the size of drainage channel. There are not much standard guidelines available in Indian context for adopting design storm for airport drainage system.

- U.S Federal Aviation Administration (FAA) provide some general guidance on typical design parameters related to ponding [Section 2-2.5 of FAAAC 150 / 5320-5D] and states the following:

  "Center 50 percent of Runways (RWYs); the center 50 percent of Taxiways (TWYs) serving these RWYs; and helipad surfaces along the centerline should be free from ponding resulting from storms of a 10-yr frequency and intensity determined by the geographic location".

- CIDCO DPR document Chapter 5.3 recommends 10 year return period design criteria.

- Ministry of Environment and Forests vide their F.No 10-53/2009-IA.III dated 22.11.2010, 7. I (vi) mentioned that

  "*The entire system shall be studied as one composite system with appropriate boundary conditions to reflect the worst conditions – minimum 100 years to be specified and compliance ensured such as – flooding, surface runoff…… "*.

Therefore considering MoEF recommendation, 100 year return period rainfall has been considered by M/S CH2M for design of airport drainage system.

CWPRS has earlier analyzed hydrological data supplied by CIDCO for the Development of Navi Mumbai International Airport and studies reported vide CWPRS Technical Report (TR) No. 4665 of October 2009. This analysis was done with rainfall data upto year 2004 for Santacruz rain-gauge station. It was felt that the rainfall analysis is to be refined with up to date rainfall data. The analysis of updated rainfall data has been carried out at CWPRS, and the detailed analysis is given in Section 7. The rainfall intensity for 100 year return period has been estimated as 139.6 mm/hr using Gumbel Distribution and 148.1 mm/hr using LP III Distribution.

For design of storm water drainage system, CH2M has adopted rainfall intensity as 148.1 mm/hr for 100 year return period value. Further short duration intensity has been estimated by M/S CH2M using IRC-SP-42 method. Table 6 shows Time Intensity Depth analysis pertaining to 148.1 mm/hr intensity of Rainfall.

Table 6: Time-Intensity and Time-Depth values

S.No	Time, Min	Intensity mm/hr	Depth, mm	S.No	Time, Min	Intensity mm/hr	Depth, mm
1	5	273.2	22.77	19	95	114.6	181.42
2	10	253.7	42.29	20	100	111.0	185.00
3	15	236.8	59.20	21	105	107.6	188.36
4	20	222.0	74.00	22	110	104.5	191.53
5	25	208.9	87.06	23	115	101.5	194.51
6	30	197.3	98.67	24	120	98.7	197.33
7	35	186.9	109.05	25	125	96.0	200.00
8	40	177.6	118.40	26	130	93.5	202.53
9	45	169.1	126.86	27	135	91.1	204.92
10	50	161.5	134.55	28	140	88.8	207.20
11	55	154.4	141.57	29	145	86.6	209.37
12	60	148.1	148.00	30	150	84.6	211.43
13	65	142.1	153.92	31	155	82.6	213.40
14	70	136.6	159.38	32	160	80.7	215.27
15	75	131.6	164.44	33	165	78.9	217.07
16	80	126.9	169.14	34	170	77.2	218.78
17	85	122.5	173.52	35	175	75.6	220.43
18	90	118.4	177.60	36	180	74.0	222.00

Derivation of Hydrographs

Unit Hydrograph is a conventional method for determination of design flood. Different types of unit hydrographs like Synthetic unit hydrograph, Instantaneous unit hydrograph are referred in literature along with traditional concept of unit hydrograph. M/S CH2M has adopted Soil Conservation System (SCS) design method for calculating storm runoff. The SCS method has been used interchangeably with Natural Resources Conservation Services (NRCS), a division of U.S. Department of Agriculture. This involves use of Hydrological Modeling Software Sewer-GEMS version V8i (Select Series 4) for modeling of Watersheds within the airport boundary. Sewer GEMS Software model is capable of generating complete runoff hydrograph using NRCS methodology. Coefficient of Runoff has been adopted as 1.

For the hydraulic design of drainage channel conventional Manning's Equation have been used

$$Q = (1/n)\, AR^{2/3}S^{1/2}$$

Where,

Q = Discharge capacity of the drain in m^3/s
n =Manning's roughness coefficient (channel roughness) depending on drain type
A = Flow area in m^2
R = A/P = hydraulic radius in m
P = Wetted perimeter in m
S = Hydraulic gradient

Manning's roughness 'n' has been considered as per IRC SP42:2014 between 0.013 and 0.015 for concrete drains.

<u>Watershed delineation and Outfall locations</u>

For watershed delineation CH2M had followed the given master plan, phasing and outfall constraints. Figure 4 below shows the total airport area of 1160 ha divided into 6 numbers of catchments and their respective outlets. Outfall locations towards Ulwe recourse channel and Moha creek have been avoided by M/S NMIAPL as per norms laid down by MoEF in their clearance.

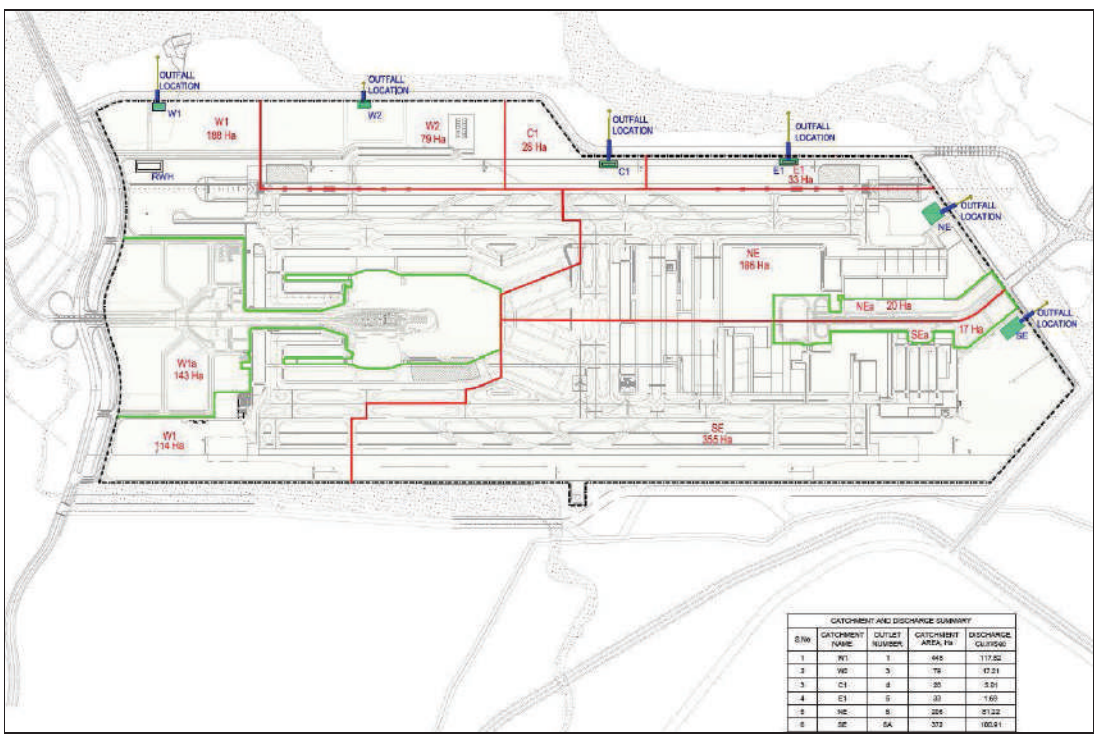

Figure 4: Storm water sub drainage area and proposed outlets as per M/S NMIAPL/ M/S CH2M master plan report (November 2019)

Soil Curve Number (SCN) Method

The NRCS Soil Curve Number (SCN) Method has been adopted to determine rainfall losses in each sub watershed and catchment drainage area in the SewerGEMS model. It depends on the watersheds, hydrologic soil group and land use map. Land use maps, based on the Master Plan issued by M/S NMIAPL, had been used in SWD report. Curve numbers for each ground cover type within a particular watershed had been selected according to tables in NRCS TR-55, “Technical Release 55 - Urban Hydrology for Small Watersheds”, United States Department of Agriculture.

Time of Concentration

Time of concentration (Tc) is the time required for runoff to travel from the hydraulically most distant point of the watershed to the point of interest. Standard methods for calculation of Tc are described in TR-55. These methods are built in to SewerGEMS software. The NRCS method differentiates surface runoff into three general types of flow: sheet or overland flow, shallow concentrated flow, and channel flow. Minimum Time of concentration of 15 min considered in airside network i.e. network between Runway and Taxiway (or) between taxiways and 10 min considered for drainage network in Apron portion.

Runoff Calculation

The NRCS method calculates peak flow as a function of drainage basin area, potential watershed storage, and the time of concentration. An easy to use graphical approach to this method can be found in the TR-55 document. This rainfall-runoff relationship separates total rainfall into direct runoff, retention, and initial abstraction to yield the following equations for rainfall runoff given in Table 7 below. Empirical studies found that storage retention (Sr) is related to soil type, land cover, and the in-situ moisture condition of the basin. These are represented by the runoff curve number, CN, which is used to estimate soil retentions Sr.

Table 7: Rainfall Runoff Equations (NRCS Method)

Eq. No	Parameter	Equations	Description of Parameters
1	Direct Run off	$Qd = (P - 0.2Sr)^2 / (P + 0.8Sr)$	Qd = depth of direct runoff, inch P = depth of 3-hour precipitation, inch. Sr = Soil retention, inch
2	Soil Retention	$Sr = (1000 / CN) - 10$	CN = Curve Number depends on landuse and soil type
3	Peak Flow	Qp = Qu. Ak. Qd	Qp = peak flow, ft^3/s Qu = unit peak flow, ft^3/s Ak = basin area, mi^2 Qd= runoff depth, in

<u>SewerGEMS Modelling</u>

CH2M has used SewerGEMS model version V8i (Select Series 4) from Bentley Systems, Inc for hydrologic modeling of watersheds within the airport boundary. The model is capable of generating peak flows and hydrographs for design storms.

<u>Rainfall Input</u> : For all durations (considered for modeling), i.e., 5 min, 10 min, 15 min … etc rainfall intensities were estimated using IRC SP-42 method, considering the 100 year return period intensity of rainfall as 148.1 mm/hr.

<u>Hydraulic design criteria</u>

The hydraulic design of drainage network includes the following criteria to be met.

- Velocity Criteria - Maximum allowable velocity is 6.0 m/s and
  Minimum velocity is 0.6 m/s.

Comments on the SewerGEMS Modeling results

M/S CH2M has presented catchment wise (W1,W2, C1, E1, NE, SE) modeling results for proposed open drain as well as box drain for the runoff generated from rainfall corresponding to 100 years return period. The results have been critically examined. It could be observed from mathematical model results that highest water level in the upstream side of drainage sub-catchments will spill over the drains and will be above the ground level for the runoff generated from 100 years return period rainfall. Catchment wise re-testing / analysis of SWD parameters considered for SewerGEMS model was carried out at CWPRS in association with M/S CH2M and M/S NMIAPL.

<u>Catchment W1</u>

Figures 5 and 6 show open drain and box drain node details respectively for catchment W1. Node to Node modeling results for 100 year return period condition obtained by M/S CH2M using SewerGEMS are presented in Table 8. It was observed from the drainage profiles results for W1, the maximum water level at the upstream side was about +8.126 m, whereas paved edge level is about +8.37 m for the runoff generated from 100 years return period rainfall. However, at some locations, the drainage channel is showing surcharge (spill over) as per M/S NMIAPL / M/S CH2M SWD Master Plan Report of November 2019.

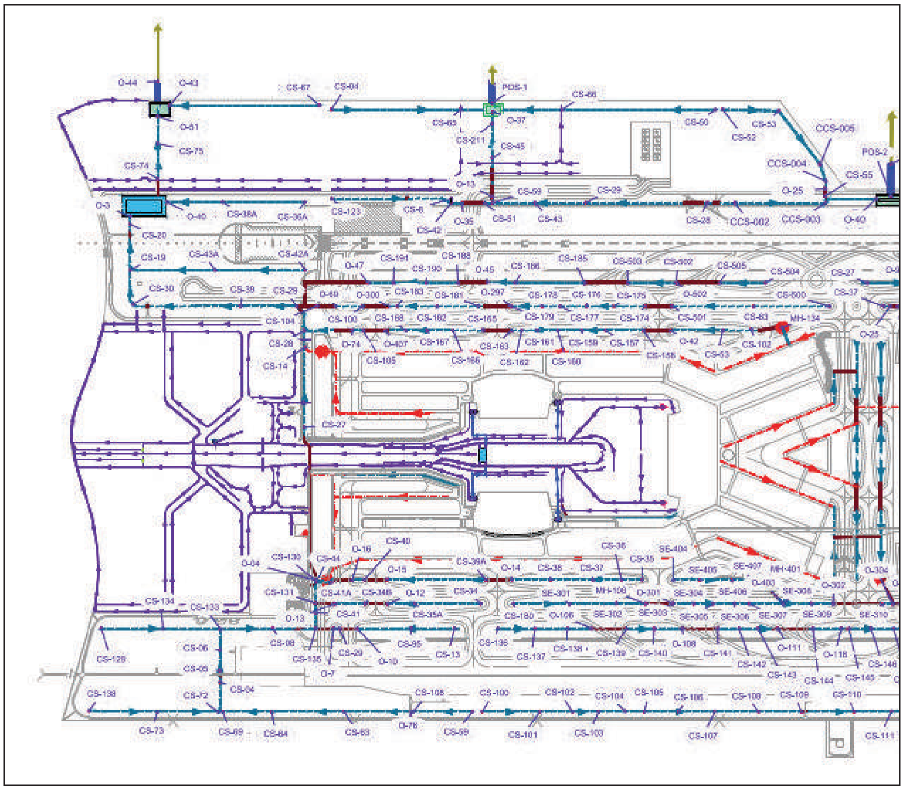

Figure 5: Open drain node to node details for catchment W1

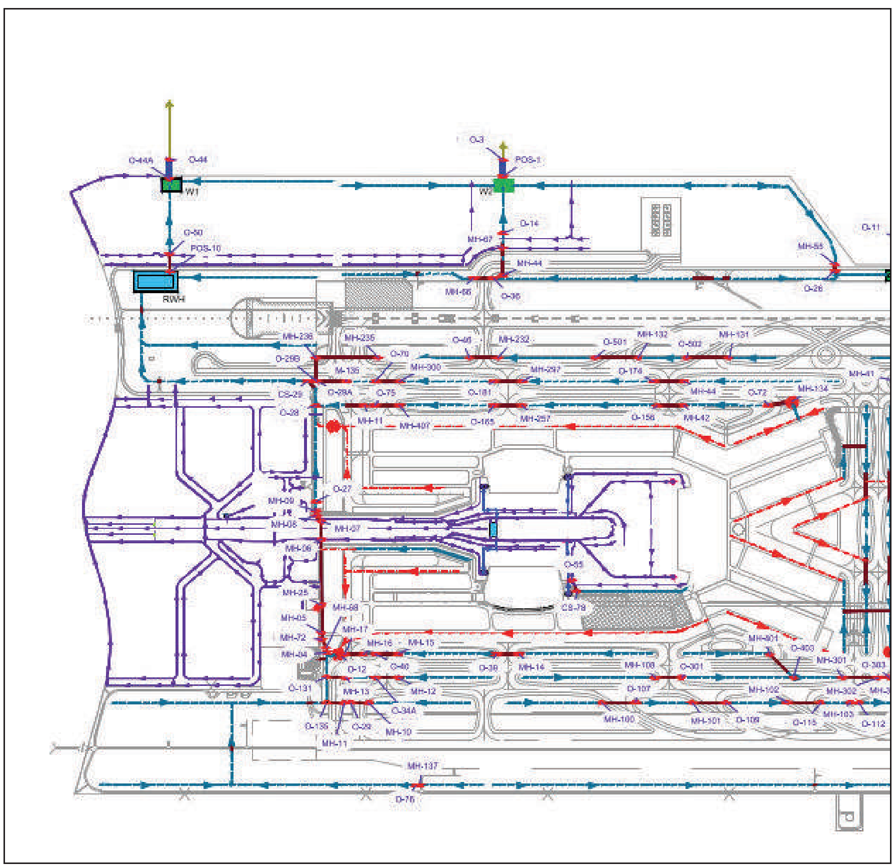

Figure 6: Box drain node to node details for catchment W1

Table 8: Catchment W1 Drain Details with Predicted Water Levels for 100 Year Return Period Rainfall

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-138	CS-73	8.00	7.27	6.25	6.15	8.120	255.8	2.5	0.962	-	-	Open
CS-73	CS-72	8.00	7.24	6.15	6.07	8.083	228.2	2.5	1.069	-	-	Open
CS-59	CS-108	8.10	8.22	6.62	6.49	8.290	241.6	1.5	1.59	-	-	Open
O-76	CS-63	8.02	0.00	6.49	6.36	8.205	238.4	-	-	-	-	Open
CS-63	CS-64	8.14	8.11	6.36	6.21	8.168	260.7	1.5	1.752	-	-	Open
CS-64	CS-69	8.00	7.97	6.21	6.10	8.095	192.5	1.5	1.818	-	-	Open
CS-69	CS-72	8.00	7.22	6.10	6.07	8.034	8.1	1.5	1.172	-	-	Open
CS-72	CS-4	7.68	7.21	6.07	6.01	8.016	110.9	2.5	1.135	-	-	Open
CS-4	CS-5	8.00	8.85	6.01	6.00	7.947	18	2.5	1.234	-	-	Open
CS-5	CS-6	8.00	9.07	5.99	5.95	7.906	89.5	2.5	1.273	-	-	Open
CS-6	CS-133	8.00	8.63	5.95	5.90	7.888	79.2	2.5	1.348	-	-	Open
CS-128	CS-134	8.20	7.10	6.38	6.24	7.986	230.1	1.5	0.933	-	-	Open
CS-134	CS-133	8.20	7.15	6.24	5.90	7.955	212.5	1.5	1.178	-	-	Open
CS-133	CS-8	7.80	7.29	5.90	5.77	7.888	197.5	3	1.424	-	-	Open
CS-8	CS-135	8.76	7.44	5.77	5.66	7.833	158.7	3	1.676	-	-	Open
CS-135	CS-41	8.80	8.20	5.66	5.62	7.784	58.9	3	2.537	-	-	Open
CS-41	CS-131	8.87	8.20	5.62	5.60	7.748	37.3	3	2.58	-	-	Open
CS-131	CS-130	8.89	8.20	5.60	5.55	7.723	69	3	2.601	-	-	Open
CS-130	MH-04	8.93	7.80	5.55	5.54	7.699	14.8	3	3.119	-	-	Open
MH-04	MH-68	8.94	8.54	5.53	5.54	7.669	23.9	-	-	2400x 2400	2	Box-Conc
MH-68	MH-72	9.20	8.89	5.50	5.53	7.644	36.7	-	-	2400x 2400	2	Box-Conc
MH-72	MH-05	9.24	9.21	5.49	5.50	7.620	25.5	-	-	2400x 2400	2	Box-Conc
MH-05	MH-25	9.26	9.22	5.42	5.49	7.595	103	-	-	2400x 2400	2	Box-Conc
MH-25	MH-06	9.27	9.24	5.25	5.42	7.571	243.1	-	-	2400x 2400	2	Pipe
MH-06	MH-07	9.39	9.53	5.19	5.25	7.504	68.8	-	-	2400x 2400	3	Box-Conc
MH-07	MH-08	9.00	9.63	5.15	5.19	7.480	31.3	-	-	2400x 2400	3	Box-Conc
MH-08	MH-09	9.22	9.72	5.14	5.15	7.455	17.8	-	-	2400x 2400	3	Box-Conc
MH-09	O-27	8.96	8.60	5.10	5.14	7.431	34.7	-	-	2700x 2400	3	Box-Conc
CS-27	CS-14	8.89	8.04	5.10	4.91	7.403	282	15	4.478	-	-	Open
CS-14	CS-28	8.25	8.00	4.91	4.86	7.364	77.9	15	2.937	-	-	Open
CS-28	O-29	7.84	8.00	4.86	4.80	7.266	90.1	15	2.98	-	-	Open
CS-29	CS-39	8.66	7.27	4.80	4.64	7.241	237.7	15	2.932	-	-	Open
CS-39	CS-30	8.09	7.26	4.64	4.37	7.111	411.3	15	3.093	-	-	Open
CS-30	CS-19	7.07	6.67	4.37	4.28	7.019	134.5	15	3.999	-	-	Open
CS-19	CS-20	6.98	6.67	4.28	4.16	6.940	171.6	15	2.237	-	-	Open
CS-20	O-3	6.90	6.67	4.16	4.14	6.897	29.8	15	2.346	-	-	Open

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
POS-10	O-50	7.50	7.50	3.99	4.14	6.500	60	-	-	5000x 2000	3	Box-Conc
CS-74	CS-75	8.00	6.50	3.99	3.96	7.392	137.1	15	3.01	-	-	Open
CS-75	O-51	8.00	6.50	3.96	3.93	7.286	101.3	15	4.392	-	-	Open
CS-13	CS-95	8.68	7.72	5.95	5.87	7.979	162.5	1.5	1.778	-	-	Open
CS-95	O-10	9.07	7.61	5.87	5.79	7.912	198.6	1.5	1.748	-	-	Open
MH-10	O-29	8.68	8.37	5.73	5.77	7.839	66.8	-	-	1200x 900	1	Box-Conc
CS-29a	O-11	8.66	8.36	5.72	5.72	7.809	20	1.5	2.694	-	-	Open
MH-11	O-135	8.69	7.62	4.90	4.95	7.612	173.7	-	-	2100x 1800	3	Box-Conc
CS-34	CS-35a	8.64	7.81	6.12	6.07	7.876	247.4	1.5	1.677	-	-	Open
CS-35a	O-12	8.37	7.57	6.07	5.89	7.845	99	1.5	1.466	-	-	Open
MH-12	O-34a	8.36	8.14	5.79	5.89	7.790	85.2	-	-	1200x 900	1	Box-Conc
CS-34b	O-13	8.36	8.14	5.79	5.71	7.763	108.8	1.5	2.281	-	-	
MH-13	O-131	8.62	8.25	5.60	5.71	7.736	70.3	-	-	1200x 900	1	Box-Conc
CS-35	CS-36	8.37	7.53	6.44	6.37	8.126	75	2	1.1	-	-	Open
CS-36	CS-37	8.37	7.46	6.37	6.29	8.114	107.5	2	1.217	-	-	Open
CS-37	CS-38	8.28	7.46	6.29	6.15	8.089	157.8	2	1.429	-	-	Open
CS-38	O-14	8.28	7.43	6.15	6.02	8.053	146.8	3	1.74	-	-	Open
MH-14	O-39	8.15	7.47	5.97	6.02	7.992	97.8	-	-	3000x 1500	1	Box-Conc
CS-39a	O-15	8.09	7.26	5.97	5.72	7.964	364.6	15	3.093	-	-	Open
MH-15	O-40	8.17	7.97	5.67	5.72	7.864	86.1	-	-	3000x 1500	1	Box-Conc
CS-40	O-16	8.15	7.93	5.67	5.64	7.836	43.8	2	2.161	-	-	Open
MH-16	MH-17	8.16	7.93	5.59	5.64	7.815	67.7	-	-	1500x 900	1	Box-Conc
MH-17	O-41	8.42	8.32	5.58	5.59	7.790	12.8	-	-	3000x 1500	1	Box-Conc
CS-41a	CS-42	8.87	8.21	5.80	5.91	7.763	77.9	3	2.426	-	-	Open
CS-44	O-04	8.94	8.41	5.55	5.54	7.699	4.6	3	3.119	-	-	Open
MH-134	0-72	8.16	7.93	5.69	5.75	8.022	112.8	-	-	900x9 00	1	Box-Conc
CS-102	CS-53	8.18	7.59	5.69	5.64	8.022	105.6	-	-	-	-	Open
CS-53	O-42	8.15	7.51	5.64	5.54	8.009	196	-	-	-	-	Open
MH-42	O-156	8.00	7.54	5.50	5.54	7.942	85.2	-	-	1200x 900	2	Box-Conc
CS-156	CS-157	8.01	7.65	5.50	5.42	7.915	153.1	-	-	-	-	Open
CS-157	CS-159	8.17	7.60	5.42	5.37	7.894	89.4	-	-	-	-	Open
CS-159	CS-160	8.17	7.61	5.37	5.33	7.857	90.6	-	-	-	-	Open
CS-160	CS-161	8.17	7.61	5.33	5.29	7.833	75.4	-	-	-	-	Open
CS-161	CS-162	8.17	7.62	5.29	5.26	7.808	58.6	-	-	-	-	Open
CS-162	CS-163	8.05	7.62	5.26	5.24	7.784	44.5	-	-	-	-	Open
MH-257	O-165	7.77	7.54	5.19	5.24	7.729	87.6	-	-	1500x 1500	2	Box-Conc
CS-165	CS-166	7.75	7.56	5.19	5.13	7.702	118.2	-	-	-	-	Open

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-166	CS-167	8.17	7.65	5.13	5.09	7.362	95.6	-	-	-	-	Open
CS-167	CS-168	8.17	7.66	5.09	5.05	7.222	79.3	-	-	-	-	Open
CS-168	O-407	8.11	7.68	5.05	5.01	7.182	69.9	-	-	-	-	Open
MH-407	O-75	7.66	7.73	4.97	5.01	6.897	76.9	-	-	1800x 1800	4	Box-Conc
CS-105	0-74	8.10	7.50	4.97	4.95	8.089	41.2	-	-	-	-	Open
MH-11	O-28	8.69	7.62	4.90	4.95	7.612	173.7	-	-	2100x 1800	3	Box-Conc
CS-500	CS-63	7.90	7.55	6.80	6.49	7.851	285	-	-	-	-	Open
CS-63	CS-501	8.14	8.11	6.36	6.21	7.813	260.7	1.5	1.752	-	-	Open
CS-501	O-44	7.84	7.54	6.15	6.06	7.729	6.5	-	-	-	-	Open
MH-44	O-174	7.84	7.54	6.01	6.06	7.668	92.2	-	-	1500x 900	1	Box-Conc
CS-174	CS-175	7.77	7.51	6.01	5.94	7.641	117.6	3	1.481	-	-	Open
CS-175	CS-176	8.09	7.50	5.94	5.91	7.625	100.7	3	1.559	-	-	Open
CS-176	CS-177	8.09	7.50	5.91	5.87	7.595	99.4	3	1.596	-	-	Open
CS-177	CS-178	8.09	7.50	5.87	5.83	7.571	67.4	3	1.631	-	-	Open
CS-178	CS-179	8.07	7.50	5.83	5.80	7.546	114.7	3	1.668	-	-	Open
CS-179	O-297	7.55	7.48	5.80	5.74	7.522	9.1	3	1.706	-	-	Open
MH-297	O-181	7.51	7.46	5.68	5.74	7.485	110.6	-	-	2100x 1500	1	Box-Conc
CS-181	CS-182	7.95	7.49	5.68	5.59	7.452	156.5	3	1.81	-	-	Open
CS-182	CS-183	8.09	7.50	5.59	5.55	7.430	148.4	3	1.902	-	-	Open
CS-183	O-300	7.94	7.50	5.55	5.50	7.388	35.2	3	1.945	-	-	Open
MH-300	O-70	7.56	7.59	5.26	5.50	7.345	87.4	-	-	2400x 1800	1	Box-Conc
CS-100	O-69	7.76	7.49	5.25	5.02	7.314	95.3	3	2.8	-	-	
MH-135	O-73	7.41	7.52	4.88	5.01	7.290	65.1	-	-	2400x 1800	1	
CS-104	O-29a	7.38	7.51	4.87	4.84	7.260	45	4	3	-	-	Open
CS-504	CS-505	7.88	7.29	5.90	5.80	7.659	156.6	2	1.517	-	-	Open
CS-505	O-131	7.78	7.12	5.80	5.64	7.641	24.8	2	1.333	-	-	Open
MH-131	O-502	7.84	7.35	5.53	5.64	7.599	146.3	-	-	1500x 900	1	Box-Conc
CS-502	CS-503	8.01	7.54	5.53	5.48	7.553	177.5	2	1.976	-	-	Open
CS-503	O-502	7.65	7.14	5.48	5.48	7.525	14.8	2	1.864	-	-	Open
MH-132	O-501	7.63	7.26	5.36	5.48	7.483	139.6	-	-	2100x 900	1	Box-Conc
CS-185	CS-186	8.08	7.18	5.36	5.28	7.443	272.1	2	1.755	-	-	Open
CS-186	O-45	8.09	7.12	5.28	5.23	7.403	101.6	2	1.845	-	-	Open
MH-232	O-46	7.92	7.11	5.17	5.23	7.342	108.5	-	-	2400x 1200	1	Box-Conc
CS-188	CS-190	7.95	7.11	5.17	5.11	7.309	118.4	3	1.939	-	-	Open
CS-190	CS-191	8.09	7.11	5.11	5.05	7.294	122.9	3	2.004	-	-	Open
CS-191	O-47	8.09	7.13	5.05	5.00	7.263	121.8	3	2.079	-	-	Open
MH-235	MH-236	7.96	7.18	4.95	5.00	7.221	90.4	-	-	3000x 1500	1	Box-Conc

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
MH-236	O-29b	7.95	7.83	4.84	4.88	7.166	83.5	-	-	3000x 1500	1	Box-Conc
CS-42a	CS-43a	8.17	7.93	5.56	5.55	7.748	34.3	3	2.784	-	-	Open
CS-43a	CS-19	8.17	7.50	6.07	4.28	7.041	316.7	3	2.9	-	-	Open
CS-36a	CS-38a	7.70	7.56	6.00	5.89	6.854	307	3	1.693	-	-	Open
CS-38a	0-40	7.69	7.19	5.89	4.17	6.849	208.5	3	1.794	-	-	Open
CS-67	O-43	7.82	8.00	5.38	3.94	7.790	560.6	3	3.625	-	-	Open

Catchment SE

Figures 7 and 8 show open drain and box drain node details respectively for catchment SE. Node to Node modeling results for 100 year return period condition obtained by M/S CH2M using SewerGEMS are presented in Table 9. Similar conditions like in W1 were observed for catchment SE also, where the maximum water at the upstream side is about +8.06m, whereas paved edge level is about +8.06m for the runoff generated from 100 years return period rainfall. However, at some locations, the drainage channel is showing surcharge (spillover above ground surface) as per M/S NMIAPL / M/S CH2M SWD Master Plan Report of November 2019.

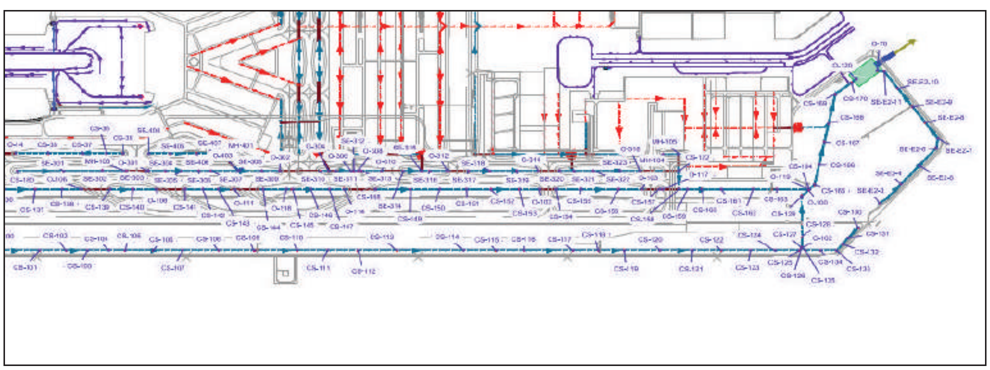

Figure 7: Open drain node to node details for catchment SE

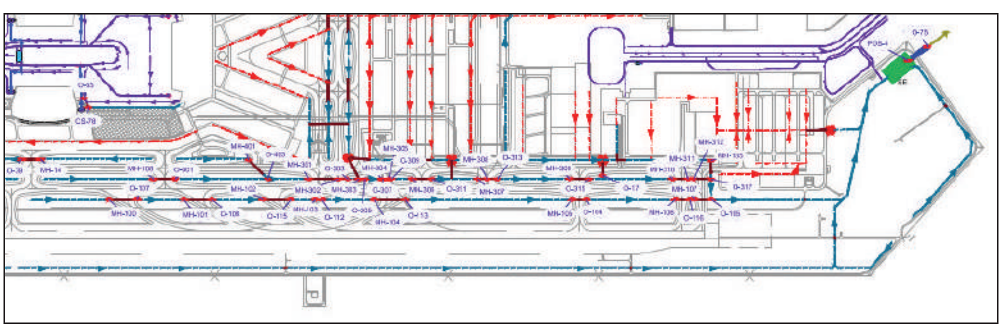

Figure 8: Box drain node to node details for catchment SE

Table 9: Catchment SE Drain Details with Predicted Water Levels for 100 Year Return Period Rainfall

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-100	CS-101	8.69	8.20	6.38	6.29	8.20	216	-	-	2574	-	-
CS-101	CS-102	8.57	7.96	6.29	6.23	8.13	121	-	-	2048	-	-
CS-102	CS-103	8.43	7.84	6.23	6.18	8.10	101	-	-	2061	-	-
CS-103	CS-104	8.30	7.74	6.18	6.14	8.08	96	-	-	2081	-	-
CS-104	CS-105	8.09	7.64	6.14	6.10	8.05	73	-	-	2076	-	-
CS-105	CS-106	8.05	7.60	6.10	6.04	8.03	127	-	-	2050	-	-
CS-106	CS-107	7.95	7.60	6.04	5.98	7.99	135	-	-	2076	-	-
CS-107	CS-108	7.95	7.48	5.98	5.90	7.96	163	-	-	2089	-	-
CS-108	CS-109	7.90	7.33	5.90	5.82	7.91	161	-	-	1990	-	-
CS-109	Cs-110	7.90	7.66	5.82	5.72	7.87	197	-	-	2072	-	-
CS-110	CS-111	7.78	7.21	5.72	5.65	7.82	139	-	-	2068	-	-
CS-111	Cs-112	7.77	7.21	5.65	5.59	7.78	138	-	-	2060	-	-
CS-112	CS-113	7.71	7.20	5.59	5.50	7.74	176	-	-	2072	-	-
CS-113	CS-114	7.70	7.21	5.50	5.36	7.70	304	-	-	2069	-	-
CS-114	CS-115	7.69	7.22	5.36	5.28	7.61	149	-	-	2041	-	-
CS-115	CS-116	7.75	7.43	5.28	5.22	7.53	125	-	-	2049	-	-
CS-116	CS-117	7.76	7.59	5.22	5.11	7.47	223	-	-	2060	-	-
CS-117	CS-118	7.76	7.62	5.11	5.06	7.28	115	-	-	2050	-	-
CS-118	CS-119	7.78	7.78	5.06	5.10	7.21	118	-	-	-2744	-	-
CS-119	CS-120	7.79	7.62	5.10	4.92	7.15	164	-	-	914	-	-
CS-120	CS-121	7.80	7.62	4.92	4.85	7.08	149	-	-	2040	-	-
CS-121	CS-122	7.80	7.62	4.85	4.79	7.02	130	-	-	2067	-	-
CS-122	CS-123	7.80	7.80	4.79	4.72	7.10	132	-	-	2068	-	-
CS-123	CS-124	7.80	7.62	4.72	4.67	6.79	113	-	-	2049	-	-
CS-124	CS-125	7.80	7.62	4.67	4.62	6.76	111	5	3	2255	-	-
CS-125	CS-126	7.80	7.62	4.62	4.61	6.72	14	5	3	2360	-	-
CS-126	CS-127	7.80	7.71	4.61	4.61	6.70	5	5	3	1292	-	-
CS-127	CS-128	7.80	7.76	4.61	4.77	6.68	54	-	-	321	-	-
CS-128	CS-129	7.80	7.80	4.77	4.72	6.65	206	5	3	3744	-	-
CS-129	O-100	7.80	7.80	4.72	4.66	6.60	48	5	3	787	-	-
CS-130	CS-131	7.90	7.90	6.79	6.76	7.13	69	1	1	2302	-	-
CS-131	CS-132	7.90	7.63	6.76	6.74	7.09	39	1	1	2279	-	-
CS-132	CS-133	7.90	7.64	6.74	6.72	7.06	43	1	1	1882	-	-
CS-133	CS-134	7.90	7.62	6.72	6.69	7.03	72	1	1	2396	-	-
CS-134	CS-135	7.90	7.62	6.69	6.66	6.96	70	1	1	2196	-	-
CS-135	O-102	7.90	7.62	6.66	6.65	6.87	21	1	1	4163	-	-
CS-136	CS-137	8.61	8.39	6.55	6.46	8.10	190	-	-	2067	-	-
CS-137	CS-138	9.20	7.71	6.46	6.40	8.04	123	-	-	2080	-	-

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-138	O-106	9.20	7.70	6.40	6.35	8.01	76	-	-	1465	-	-
MH-100	O-107	8.59	8.45	6.35	6.32	7.99	141	-	-	4283	2100x 900	1
CS-139	CS-140	8.64	8.07	6.32	6.27	7.95	104	-	-	2361	-	-
CS-140	O-108	8.80	7.60	6.27	6.23	7.93	93	-	-	2321	-	-
MH-101	O-109	8.80	8.16	6.23	6.17	7.90	142	-	-	2147	2100x 900	1
CS-141	CS-142	8.80	7.94	6.17	6.13	7.86	81	-	-	2142	-	-
CS-142	CS-143	8.80	7.42	6.13	6.10	7.84	70	-	-	2185	-	-
CS-143	O-111	8.70	7.33	6.10	6.07	7.82	61	-	-	2099	-	-
MH-102	O-115	8.12	7.85	6.07	6.00	7.79	141	-	-	2176	2400x 1200	1
CS-144	O-118	8.01	7.43	6.00	5.96	7.75	104	-	-	2129	-	-
MH-103	O-112	8.01	8.01	5.96	5.94	7.72	28	-	-	2020	2400x 1200	1
CS-145	CS-146	8.04	8.04	5.94	5.90	7.70	82	-	-	2008	-	-
CS-146	CS-147	8.23	7.31	5.90	5.86	7.68	85	-	-	1986	-	-
CS-147	O-114	8.23	7.31	5.86	5.83	7.65	65	-	-	2086	-	-
MH-104	O-113	8.01	7.73	5.83	5.76	7.63	143	-	-	2107	1500x 1500	2
CS-148	CS-149	8.08	7.64	5.76	5.68	7.59	157	-	-	2094	-	-
CS-149	CS-150	8.23	7.11	5.68	5.62	7.51	135	-	-	2079	-	-
CS-150	CS-151	8.23	8.18	5.62	5.56	7.40	122	-	-	2110	-	-
CS-151	CS-152	8.13	7.51	5.56	5.51	7.37	111	-	-	2096	-	-
CS-152	CS-153	8.30	7.61	5.51	5.45	7.34	129	-	-	2120	-	-
CS-153	O-102	8.30	7.73	5.45	5.40	7.30	91	-	-	2059	-	-
MH-105	O-104	8.07	7.82	5.40	5.37	7.28	76	-	-	2097	1800x 1500	2
CS-154	CS-155	8.11	7.83	5.37	5.31	7.25	112	-	-	2118	-	-
CS-155	CS-156	8.32	7.62	5.31	5.23	7.22	171	-	-	2088	-	-
CS-156	O-103	8.32	7.60	5.23	5.18	7.18	105	-	-	2108	-	-
MH-106	O-116	8.09	7.83	5.18	5.14	7.14	79	-	-	2128	1800x 1800	2
CS-157	O-117	8.06	7.60	5.14	5.14	7.12	12	-	-	2952	-	-
MH-107	O-105	8.06	7.60	5.14	5.10	7.10	77	-	-	2070	1800x 1800	2
CS-180	SE-301	8.35	8.31	6.76	6.67	8.32	226	-	-	2310	-	-
SE-301	SE-302	8.40	7.81	6.67	6.57	8.26	176	-	-	1855	-	-
SE-302	MH-108	8.40	7.81	6.57	6.50	8.21	109	-	-	1657	-	-
MH-108	O-301	8.40	8.27	6.50	6.47	8.18	98	-	-	2647	2100x 900	1
SE-303	SE-304	8.36	7.92	6.47	6.42	8.15	79	-	-	1802	-	-
SE-304	SE-305	8.50	7.52	6.42	6.38	8.13	74	-	-	1847	-	-
SE-305	SE-306	8.50	7.51	6.38	6.34	8.11	79	-	-	1826	-	-
SE-306	SE-307	8.50	7.51	6.34	6.33	8.08	57	-	-	3765	-	-
SE-307	SE-308	8.50	7.52	6.33	6.10	8.06	126	-	-	561	-	-
SE-404	SE-405	8.066	7.93	6.35	6.30	8.13	109	-	-	2188	-	-

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
SE-405	SE-406	8.28	7.80	6.30	6.24	8.10	121	-	-	2010	-	-
SE-406	SE-407	8.06	7.82	6.24	6.22	8.07	59	-	-	2680	-	-
SE-407	MH-401	8.06	7.83	6.22	6.20	8.04	43	-	-	2379	-	-
MH-401	O-403	8.10	7.98	6.20	6.10	8.02	124	-	-	1240	3000x 1200	1
SE-308	SE-309	8.50	7.52	6.10	6.10	8.02	103	-	-	20638	-	-
SE-309	O-302	8.50	7.52	6.10	6.08	8.00	80	-	-	6690	-	-
MH-301	MH-302	8.18	7.95	6.08	6.02	7.97	134	-	-	2153	2100x 1200	2
MH-302	O-303	8.26	8.26	6.02	6.00	7.93	50	-	-	2077	2100x 1200	2
SE-310	O-304	8.10	7.90	6.00	5.98	7.91	39	-	-	2286	-	-
MH-303	O-305	7.90	7.71	5.98	5.97	7.89	29	-	-	2252	2100x 1200	2
SE-311	O-306	7.90	7.73	5.97	5.93	7.86	73	-	-	2216	-	-
MH-304	O-307	7.90	7.73	5.93	5.93	7.84	9	-	-	2351	2100x 1200	2
SE-312	O-308	7.90	7.72	5.93	5.92	7.81	22	-	-	2167	-	-
MH-305	O-309	7.90	7.74	5.92	5.91	7.79	14	-	-	2306	2100x 1200	2
SE-313	O-310	7.90	7.75	5.91	5.87	7.76	89	-	-	2221	-	-
MH-306	O-311	8.10	7.78	5.87	5.83	7.74	97	-	-	2265	2400x 1500	3
SE-314	SE-315	7.90	7.82	5.83	5.79	7.72	82	-	-	2221	-	-
SE-315	SE-316	8.20	7.79	5.79	5.78	7.63	39	-	-	2303	-	-
SE-316	O-312	8.20	7.79	5.78	5.74	7.52	72	-	-	2179	-	-
MH-307	MH-308	8.27	7.96	5.74	5.72	7.49	51	-	-	2202	3000x 1500	4
MH-308	O-313	8.51	8.51	5.72	5.70	7.47	51	-	-	2046	3000x 1500	4
SE-317	SE-318	8.40	7.68	5.70	5.64	7.44	98	-	-	1842	-	-
SE-318	SE-319	8.20	7.74	5.64	5.61	7.36	125	-	-	3475	-	-
SE-319	O-314	8.20	7.52	5.61	5.51	7.32	88	-	-	878	-	-
MH-309	O-315	8.29	7.86	5.51	5.45	7.30	101	-	-	1836	3000x 1500	4
SE-320	SE-321	8.29	7.85	5.45	5.42	7.27	64	-	-	2140	-	-
SE-321	SE-322	8.20	7.62	5.42	5.37	7.25	89	-	-	1713	-	-
SE-322	SE-323	8.30	7.62	5.37	5.30	7.22	122	-	-	1768	-	-
SE-323	O-316	8.30	7.60	5.30	5.25	7.19	88	-	-	1787	-	-
MH-310	MH-311	8.32	7.90	5.25	5.21	7.17	69	-	-	1802	3000x 1800	4
MH-311	MH-312	8.30	8.13	5.21	5.20	7.14	27	-	-	1896	3000x 1800	4
MH-312	O-317	8.30	7.80	5.20	5.16	7.12	83	-	-	1845	3000x 1800	4
CS-122	CS-158	8.30	8.10	5.16	5.10	7.10	93	10	3	1780	-	-
CS-158	CS-159	7.70	7.70	5.10	5.07	7.07	36	-	-	1237	-	-
CS-159	CS-160	7.70	7.70	5.07	5.02	6.97	66	12	2	1260	-	-
CS-160	CS-161	7.75	7.75	5.02	4.95	6.92	90	12	3	1253	-	-

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-161	CS-162	7.75	7.75	4.95	4.84	6.85	144	12	3	1248	-	-
CS-162	CS-163	7.76	7.76	4.84	4.75	6.74	108	12	3	1244	-	-
CS-163	O-119	7.75	7.75	4.75	4.66	6.66	146	12	3	1625	-	-
CS-164	CS-165	7.75	7.75	4.66	4.64	6.57	33	12	3	1573	-	-
CS-165	CS-166	7.75	7.75	4.64	4.55	6.34	106	15	3	1187	-	-
CS-166	CS-167	7.76	7.76	4.55	4.45	6.26	114	15	3	1211	-	-
CS-167	CS-168	7.75	7.75	4.45	4.35	6.15	99	15	3	947	-	-
CS-168	CS-169	7.76	7.76	4.35	4.25	6.05	152	15	3	1462	-	-
CS-169	CS-170	7.75	7.75	4.25	4.15	5.74	94	15	4	943	-	-
CS-170	O-120	7.52	7.52	4.15	4.02	5.51	26	15	3	214	-	-
SE-E2-3	SE-E2-4	7.90	7.87	6.23	6.12	6.62	142	2	2	1330	-	-
SE-E2-4	SE-E2-5	7.90	7.86	6.12	6.02	6.53	125	2	2	1232	-	-
SE-E2-5	SE-E2-6	7.91	7.87	6.02	5.92	6.48	117	2	2	1248	-	-
SE-E2-6	SE-E2-7	7.91	7.86	5.92	5.88	6.42	50	2	2	1249	-	-
SE-E2-7	SE-E2-8	7.91	7.87	5.88	5.80	6.40	101	2	2	1251	-	-
SE-E2-8	SE-E2-9	7.93	7.89	5.80	5.73	6.38	97	2	2	1249	-	-
SE-E2-9	SE-E2-10	7.95	7.89	5.73	5.63	6.24	115	2	2	1251	-	-
SE-E2-10	SE-E2-11	7.95	7.85	5.63	5.55	6.11	106	2	2	1261	-	-
SE-E2-11	O-72	7.72	7.72	5.55	5.50	5.94	33	2	2	661	-	-
POS-04	O-75	7.75	7.50	4.05	3.99	4.65	70	-	-	1875	3050x 1500	7

Catchment NE, W2, C1 and E1

Figures 9 and 10 show open drain and box drain node details for catchment NE whereas Figures 11 and 12 show open drain and box drain node details for catchment W2, C1 and E1. Node to Node modeling results for 100 year return period condition obtained by M/S CH2M using SewerGEMS are presented in Tables 10 and 11. As per model results shown from SewerGEMS there is not much surcharge expected for runoff from these catchments as per M/S NMIAPL / M/S CH2M SWD Master Plan Report of November 2019.

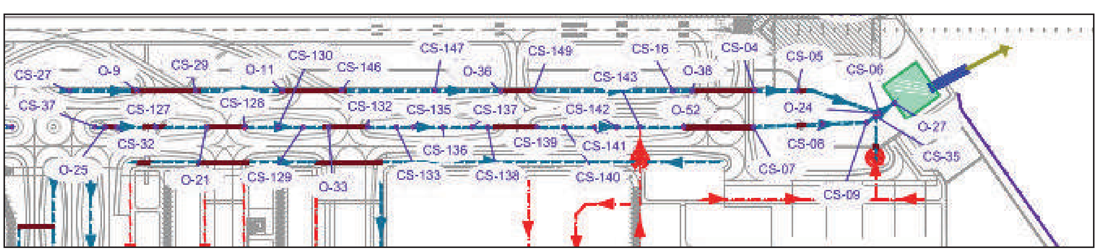

Figure 9: Open drain node to node details for catchment NE

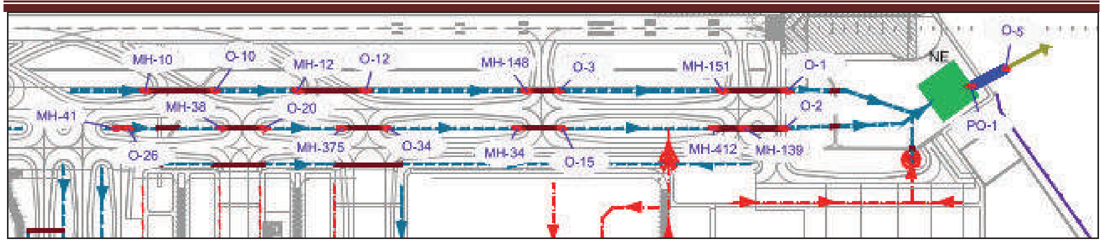

Figure 10: Box drain node to node details for catchment NE

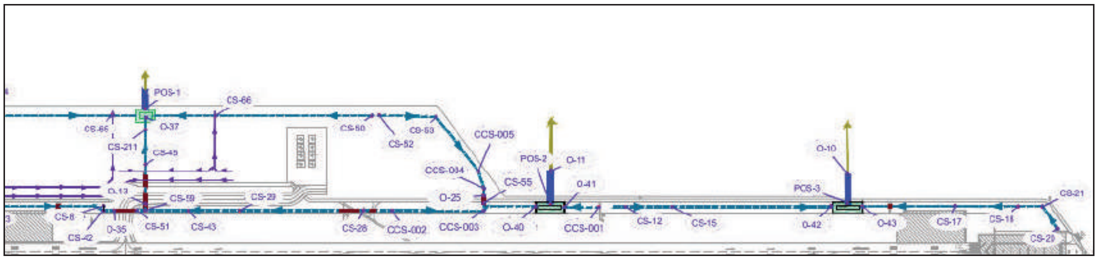

Figure 11: Open drain node to node details for catchment W2,C1 & E1

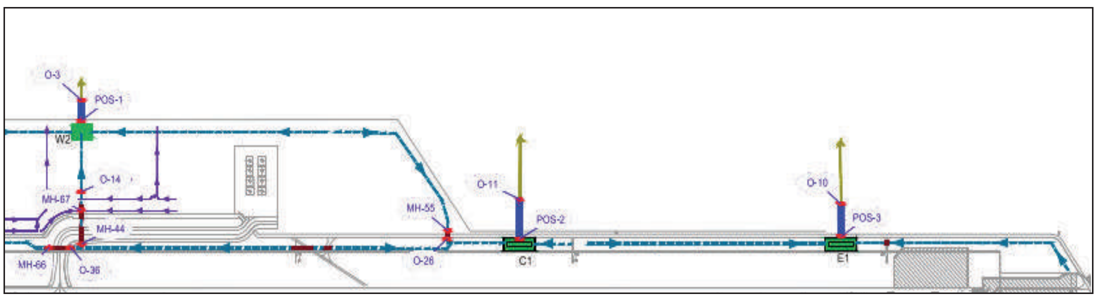

Figure 12: Box drain node to node details for catchment W2,C1 & E1

Table 10: Catchment NE Drain Details with Predicted Water Levels for 100 Year Return Period Rainfall

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-27	O-9	7.76	7.31	6.029	5.881	7.43	164.40	4	1.4	-	-	Open
MH-10	O-10	7.38	7.20	5.881	5.770	7.38	139.00	-	-	1200x 1200	2	Box-Conc
CS-29	O-11	7.38	7.15	5.770	5.600	7.34	212.30	4	2.854	-	-	Open
MH-12	O-12	7.81	7.59	5.600	5.487	7.28	140.50	-	-	1200x 1200	2	Box-Conc
CS-146	CS-147	7.69	7.39	5.487	5.305	7.23	228.10	4	3.425	-	-	Open
CS-147	O-36	8.09	7.12	5.305	5.176	7.20	161.40	4	3.306	-	-	Open
MH-148	O-3	7.30	7.14	5.176	5.114	7.12	77.60	-	-	2100x 1200	3	Box-Conc
CS-149	CS-16	7.35	7.35	5.114	4.842	7.09	339.60	4	3.73	-	-	Open

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-16	O-38	8.77	7.13	4.842	4.805	7.04	46.30	4	3.799	-	-	Open
MH-151	O-1	7.45	7.28	4.805	4.684	6.97	151.00	-	-	2100x 1500	3	Box-Conc
CS-4	CS-5	7.54	7.43	4.684	4.601	6.92	104.00	4	4.176	-	-	Open
CS-5	O-24	7.65	7.38	4.601	4.435	6.88	207.40	6	3.8	-	-	Open
CS-37	O-25	7.86	7.54	5.965	5.947	8.004	22.40	4	3.088	-	-	Open
MH-41	O-26	7.99	7.56	5.947	5.925	7.99	27.90	-	-	2100x 2100	2	Box-Conc
CS-32	CS-127	7.99	7.56	5.925	5.849	7.96	95.40	4	3.126	-	-	Open
CS-127	O-21	8.09	7.56	5.849	5.749	7.94	125.00	4	3.203	-	-	Open
MH-38	O-20	7.75	7.58	5.749	5.676	7.900	91.10	-	-	3000x 2100	2	Box-Conc
CS-128	CS-130	7.73	7.56	5.676	5.611	7.873	81.40	4	3.34	-	-	Open
CS-130	CS-129	7.99	7.53	5.611	5.562	7.858	61.20	4	3.657	-	-	Open
CS-129	O-33	8.00	7.53	5.562	5.512	7.83	61.60	4	3.459	-	-	Open
MH-375	O-34	7.65	7.52	5.512	5.437	7.803	94.10	-	-	2100x 2100	2	Box-Conc
CS-132	CS-133	7.60	7.53	5.437	5.382	7.775	69.50	4	3.592	-	-	Open
CS-133	CS-135	8.00	7.53	5.382	5.348	7.76	41.60	4	3.639	-	-	Open
CS-135	CS-136	8.09	7.53	5.348	5.290	7.74	72.80	4	3.68	-	-	Open
CS-136	CS-137	8.09	7.53	5.290	5.233	7.71	71.70	4	3.734	-	-	Open
CS-137	CS-138	8.00	7.54	5.233	5.203	7.69	37.50	4	3.797	-	-	Open
MH-34	O-15	7.91	7.49	5.191	5.108	7.63	103.40	-	-	3000x 2100	2	Box-Conc
CS-139	CS-140	7.60	7.51	5.108	5.056	7.598	66.20	4	3.921	-	-	Open
CS-140	CS-141	7.99	7.54	5.056	4.996	7.58	74.10	4	3.977	-	-	Open
CS-141	CS-142	8.09	7.54	4.996	4.952	7.56	55.30	4	4.034	-	-	Open
CS-142	CS-143	8.09	7.54	4.952	4.907	7.53	56.30	4	4.078	-	-	Open
CS-143	O-52	8.09	7.54	4.907	4.822	7.51	106.30	7	4.129	-	-	Open
MH-412	MH-139	7.55	7.53	4.822	4.766	7.47	70.10	-	-	3000x 2100	2	Box-Conc
MH-139	O-2	7.70	7.70	4.766	4.689	7.45	96.20	-	-	2100x 2100	2	Box-Conc
CS-7	CS-8	7.72	7.54	4.689	4.552	7.35	171.00	7	4.36	-	-	Open
CS-8	CS-9	7.69	7.30	4.552	4.466	7.14	107.00	7	3.662	-	-	Open
CS-9	CS-35	7.69	7.23	4.466	4.444	6.84	27.70	7	3.411	-	-	Open
CS-35	CS-6	7.69	7.15	4.444	4.435	6.77	11.30	7	3.27	-	-	Open
CS-6	O-27	7.69	7.11	4.435	4.220	6.74	44.10	9	4	-	-	Open
POS-1	O-5	8.01	3.56	4.220	4.000		111.20	-	-	2700x 1500	7	Box-Conc

Table 11: Catchment W2, C1 and E1 Drain Details with Predicted Water Levels for 100 year Return Period Rainfall

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-20	CS-21	7.780	7.780	6.290	6.260	6.831	98.4	2	2.06	-	-	Open
CS-21	CS-18	7.780	7.715	6.260	6.240	6.820	88.8	2	1.49	-	-	Open
CS-18	CS-17	7.839	7.839	6.240	6.160	6.809	231.2	2	1.6	-	-	Open
CS-17	O-43	7.770	7.657	6.160	6.030	6.778	320.1	2	1.59	-	-	Open
POS3	O-10	7.800	7.800	4.440	4.450	4.500	109.4	-	-	1800 x 1500	2	Box
CS-12	CS-15	7.770	7.447	6.650	6.510	7.544	171.4	1.5	0.8	-	-	Open
CS-15	O-42	7.770	7.451	6.510	6.040	7.495	582.8	1.5	0.94	-	-	Open
CCS-001	O-41	7.770	7.445	6.650	6.550	7.130	98.5	1.5	0.8	-	-	Open
POS2	O11	7.800	7.800	4.100	4.200	4.500	121.3	-	-	1800x 1500	1	Box
CCS-002	CCS-003	7.770	7.448	6.600	6.510	7.634	337.7	1.5	0.85	-	-	Open
CCS-003	O-40	7.770	7.504	6.510	6.490	7.536	192.3	4	0.99	-	-	Open
CS-52	CS-53	8.000	7.827	6.860	6.750	7.990	192.7	3	1.07	-	-	Open
CS-53	CCS-005	8.000	7.538	6.750	6.600	7.742	276.7	3	1.16	-	-	Open
CCS-005	CCS-004	8.000	7.500	6.600	6.560	7.634	66	4	1.02	-	-	Open
CCS-004	O-25	8.000	7.500	6.560	6.540	7.609	28.9	4	0.94	-	-	Open
MH-55	O-26	7.820	7.533	6.540	6.530	7.585	21.5	-	-	1500x 900	1	Box
CS-55	CCS-003	7.770	7.695	6.530	6.510	7.560	27.2	4	0.97	-	-	Open
CS-4	CS-65	7.990	7.781	6.480	6.020	7.929	483.9	3	1.29	-	-	Open
CS-123	CS-8	7.720	7.650	7.030	6.500	7.298	450.2	2	0.72	-	-	Open
CS-8	CS-42	7.750	7.647	6.500	6.480	7.211	15.7	2	1.25	-	-	Open
CS-42	O-35	7.750	7.677	6.480	6.420	7.193	41	2	1.27	-	-	Open
MH-66	O-36	7.750	7.676	6.420	6.350	7.168	78.6	-	-	1800x 1200	1	Box
CS-51	CS-59	7.750	7.666	6.350	6.330	7.144	29.3	2	1.36	-	-	Open
CS-28	CS-29	7.770	7.461	6.760	6.510	7.611	454.2	2	0.70	-	-	Open
CS-29	CS-43	7.770	7.449	6.510	6.430	7.289	188.2	2	0.99	-	-	Open
CS-43	CS-59	7.770	7.466	6.430	6.330	7.174	160.2	2	1.13	-	-	Open
CS-59	O-13	7.770	7.635	6.330	6.310	7.125	23.7	2	1.35	-	-	Open
MH-44	O-14	7.770	7.701	6.310	6.160	7.101	84.3	-	-	2100x 1200	1	Box
CS-45	CS-211	8.327	8.327	6.070	5.970	7.028	127.2	2	1.95	-	-	Open
CS-211	O-37	8.000	7.972	5.970	5.940	6.732	23.9	2	1.79	-	-	Open

Start Node	Stop Node	Elevation (Critical Paved Edge) /Road Inner Edge Level(m)	Elevation (Drain Top) m	Invert (Start) (m)	Invert (Stop) (m)	HGL (m)	Length (Scaled) (m)	Bottom Width (m)	Height (m)	Size,	No.	Type of Drain
CS-50	CS-66	8.000	7.933	6.330	6.000	8.109	577.5	4	1.6	-	-	Open
POS1-	O3	8.000	7.800	4.100	4.200	5.940	73.7	-	-	3000x 1800	2	Box

As mentioned in the report submitted by M/S NMIAPL that in case of overtopping as seen in some cases, the spreading water level may not flood upto the pavements/ runway/Aprons etc. This flooding / spreading has been analysed using an alternate model (HECRAS) . This exercise was done by carrying out 1-D mathematical model study for some identified network of drains/channels. The same drainage channel size as adopted in SewerGEMS model was reproduced in 1-D mathematical model HEC-RAS[4]. The other input parameters were maintained as in the case of SewerGEMS model including Manning's roughness coefficient, upstream and downstream boundary conditions etc.

9.0 DISCUSSION OF 1-DIMENSIONAL MATHEMATICAL MODEL STUDY

The objective of carrying out mathematical model study was to predict highest water levels for the identified drainage channels in order to assess the effect of spreading. Simulations were taken with peak discharges resulting from 100 year return period rainfall. Studies have been carried out for the proposed storm water drainage scheme prepared and supplied by M/S NMIAPL / CH2M. These cross sections of drains were appropriately extended on both the sides up to highest ground levels (Ridge lines) using proposed grading contours provided by M/S NMIAPL. This would consider reproduction of topography of the drains up to highest over bank levels.

The choice of mathematical model for any prediction or simulation technique mostly depends on desired accuracy, extent and quality of data available for representing the prototype topography and boundary conditions. The HEC-RAS Beta 4.1.0 version for the computation of water level was used for this study. Keeping present requirements in view, hydrodynamic studies for water flow simulation was adopted.

The energy balance equation used for computing the water surface profile for a section of stream is given as below:

$$WS_2 + (\alpha_2 v_2^2 / 2g) = WS_1 + (\alpha_1 v_1^2 / 2g) + h_e$$

Where,

WS_1, WS_2 are water surface elevations at cross sections 1& 2

v_1, v_2 are average velocities (total discharge/total flow area) at section 1 & 2

α_1, α_2 are velocity weighing coefficients at sections 1 & 2

g is gravitational acceleration, and

h_e is energy head loss

The energy head loss between two cross sections comprises friction loss and contraction or expansion loss. The equation for energy head loss h_e is

$$h_e = LS_f + C\left|\{(\alpha_2 v_2^2 / 2g) - (\alpha_1 v_1^2 / 2g)\}\right|$$

Where,

L is discharge weighted reach length

S_f is representative friction slope between two sections and

C is expansion or contraction loss coefficient

Based on the above principles, Hydrologic Engineering Center (HEC), US Army Corps of Engineers (USACE), Davis, USA has developed one-dimensional model HEC-RAS. The model is designed to perform one-dimensional hydraulic computations for a network of natural, as well as constructed channels. The model can handle; a network of channels, a dendritic system, or a single channel reaches. The steady flow component is capable of modeling sub critical, supercritical and mixed flow regime water surface profiles. The computational procedure is based on the solution of the one-dimensional energy equation. The energy losses are evaluated by friction (Manning's Equation) and contraction/expansion. It can also model flood plain inundations. In the present study the steady flow in sub critical flow regime was considered so as to deal with the extreme flood conditions and model was used to perform hydraulic routing in steady state condition.

Water surface profile computations at all locations of interest for given flow value requires channel geometry and flow data. Boundary conditions for flow modeling in natural streams are specified in terms of measured stage and discharges at upstream and downstream locations. Cross sections are required at representative locations throughout the channel and at locations where changes occur in discharge, shape, slope aspect and roughness. The basic geometric data consists of establishing the connectivity of the drainage system; longitudinal and cross section data; reach lengths; energy loss coefficients (friction losses, contraction and expansion losses etc). The measured distances between cross sections referred to as reach lengths along the thalweg as well as the reach lengths for left over bank and right over bank are also required for modeling. In steady state flow modeling, the friction loss is modeled by Manning's equations. The selection of appropriate value of Manning's 'n' is significant to achieve accuracy of the computed water surface profiles. The manning's '*n*' roughness has been considered as 0.013 in the mathematical model study. The discharge data are the most important data input for the computation.

Predicted water levels from 1 D mathematical model

As mentioned above, the drains adjacent / near runway and aprons were identified and schematized from the starting node up to the outfall location and simulated in mathematical model. The catchment wise results are given below. The drainage channels flowing near or adjacent to Runway / Apron were critically examined. Model runs were carried out for the identified drainage channel for the conditions as described above. The catchment wise results for these identified channels are shown in Tables 12 to 15. The result shows that maximum water levels predicted by 1D Mathematical Model HEC-RAS are higher than those predicted by SewerGEM model. These modeling results show spilling over drainage channels, but nevertheless as seen from the cross sectional results, the runways and aprons may not be flooded even for discharge resulting from 100 year return period rainfall as can be seen from the figure 13 to figure 19. It is seen from the results that the predicted maximum velocity could be 4.69M/Sec, which is within the permissible limit for concrete drains.

Table 12: Comparison of Predicted Water Levels by different models for identified drains of SE for 100 Year Return Period Rainfall

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
CS-100	CS-101	6.375	6.291	8.200	8.195	8.440
CS-101	CS-102	6.291	6.232	7.960	8.134	8.410
CS-102	CS-103	6.232	6.183	7.840	8.103	8.400
CS-103	CS-104	6.183	6.137	7.740	8.079	8.400
CS-104	CS-105	6.137	6.102	7.640	8.054	8.400
CS-105	CS-106	6.102	6.040	7.600	8.030	8.400
CS-106	CS-107	6.040	5.975	7.600	7.993	8.400
CS-107	CS-108	5.975	5.897	7.480	7.957	8.390

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
CS-108	CS-109	5.897	5.816	7.330	7.914	8.390
CS-109	Cs-110	5.816	5.721	7.660	7.872	8.390
CS-110	CS-111	5.721	5.654	7.210	7.817	8.390
CS-111	Cs-112	5.654	5.587	7.210	7.780	8.390
CS-112	CS-113	5.587	5.502	7.200	7.744	8.390
CS-113	CS-114	5.502	5.355	7.210	7.695	8.390
CS-114	CS-115	5.355	5.282	7.220	7.609	8.380
CS-115	CS-116	5.282	5.221	7.430	7.531	8.380
CS-116	CS-117	5.221	5.113	7.590	7.470	8.370
CS-117	CS-118	5.113	5.057	7.620	7.275	8.360
CS-118	CS-119	5.057	5.000	7.780	7.209	8.340
CS-119	CS-120	5.100	4.921	7.620	7.154	8.340
CS-120	CS-121	4.921	4.848	7.620	7.084	8.330
CS-121	CS-122	4.848	4.785	7.620	7.020	8.310
CS-122	CS-123	4.785	4.721	7.800	7.096	7.010
CS-123	CS-124	4.721	4.666	7.620	6.785	7.100
CS-124	CS-125	4.666	4.617	7.620	6.755	7.090
CS-125	CS-126	4.617	4.611	7.620	6.724	7.060
CS-126	CS-127	4.611	4.680	7.710	6.700	7.060
CS-127	CS-128	4.607	4.660	7.760	6.676	7.060
CS-128	CS-129	4.774	4.719	7.800	6.651	7.020
CS-129	O-100	4.719	4.658	7.800	6.596	6.950
CS-164	CS-165	4.658	4.637	7.750	6.572	6.500
CS-165	CS-166	4.637	4.548	7.750	6.343	6.620
CS-166	CS-167	4.548	4.454	7.760	6.262	6.560
CS-167	CS-168	4.454	4.350	7.750	6.145	6.500
CS-168	CS-169	4.350	4.246	7.760	6.046	6.250
CS-169	CS-170	4.246	4.146	7.750	5.741	6.000
CS-170	O-120	4.146	4.024	7.520	5.513	5.560
CS-136	CS-137	6.554	6.462	8.390	8.095	8.370
CS-137	CS-138	6.462	6.403	7.710	8.041	8.380
CS-138	O-106	6.403	6.351	7.700	8.010	8.380
MH-100	O-107	6.351	6.318	8.450	7.986	8.360
CS-139	CS-140	6.318	6.274	8.070	7.949	8.330
CS-140	O-108	6.274	6.234	7.600	7.925	8.330

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
MH-101	O-109	6.234	6.168	8.160	7.900	8.320
CS-141	CS-142	6.168	6.130	7.940	7.864	8.270
CS-142	CS-143	6.130	6.098	7.420	7.839	8.270
CS-143	O-111	6.098	6.069	7.330	7.815	8.270
MH-102	O-115	6.069	6.004	7.850	7.791	8.260
CS-144	O-118	6.004	5.955	7.430	7.754	8.260
MH-103	O-112	5.955	5.941	8.010	7.724	8.200
CS-145	CS-146	5.941	5.900	8.040	7.699	8.180
CS-146	CS-147	5.900	5.857	7.310	7.675	8.200
CS-147	O-114	5.857	5.826	7.310	7.650	8.190
MH-104	O-113	5.826	5.758	7.730	7.626	8.150
CS-148	CS-149	5.758	5.683	7.640	7.589	8.090
CS-149	CS-150	5.683	5.618	7.110	7.506	8.090
CS-150	CS-151	5.618	5.560	8.180	7.400	7.960
CS-151	CS-152	5.560	5.507	7.510	7.370	7.960
CS-152	CS-153	5.507	5.446	7.610	7.339	7.860
CS-153	O-102	5.446	5.402	7.730	7.303	7.740
MH-105	O-104	5.402	5.366	7.820	7.278	7.670
CS-154	CS-155	5.366	5.313	7.830	7.254	7.650
CS-155	CS-156	5.313	5.231	7.620	7.224	7.560
CS-156	O-103	5.231	5.181	7.600	7.175	7.470
MH-106	O-116	5.181	5.144	7.830	7.144	7.350
CS-157	O-117	5.144	5.140	7.600	7.120	7.320
MH-107	O-105	5.140	5.103	7.600	7.096	7.270
CS-158	CS-159	5.103	5.074	7.700	7.071	7.130
CS-159	CS-160	5.074	5.022	7.700	6.969	7.110
CS-160	CS-161	5.022	4.950	7.750	6.919	7.070
CS-161	CS-162	4.950	4.835	7.750	6.852	7.020
CS-162	CS-163	4.835	4.748	7.760	6.742	6.940
CS-163	O-119	4.748	4.658	7.750	6.661	6.890
CS-164	CS-165	4.658	4.637	7.750	6.572	6.500
CS-165	CS-166	4.637	4.548	7.750	6.343	6.620
CS-166	CS-167	4.548	4.454	7.760	6.262	6.560
CS-167	CS-168	4.454	4.350	7.750	6.145	6.500
CS-168	CS-169	4.350	4.246	7.760	6.046	6.250

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
CS-169	CS-170	4.246	4.146	7.750	5.741	6.000
CS-170	O-120	4.146	4.024	7.520	5.513	5.560

Table 13: Comparison of Predicted Water Levels by different models for identified drains of NE for 100 Year Return Period Rainfall

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
CS-27	O-9	6.029	5.881	7.310	7.430	8.130
MH-10	O-10	5.881	5.770	7.200	7.380	8.130
CS-29	O-11	5.770	5.600	7.150	7.340	8.130
MH-12	O-12	5.600	5.487	7.590	7.280	8.130
CS-146	CS-147	5.487	5.305	7.390	7.230	8.120
CS-147	O-36	5.305	5.176	7.120	7.200	8.110
MH-148	O-3	5.176	5.114	7.140	7.120	8.110
CS-149	CS-16	5.114	4.842	7.350	7.090	8.100
CS-16	O-38	4.842	4.805	7.130	7.040	8.090
MH-151	O-1	4.805	4.684	7.280	6.970	8.080
CS-4	CS-5	4.684	4.601	7.430	6.920	8.060
CS-5	O-24	4.601	4.435	7.380	6.880	8.050
CS-6	O-27	4.435	4.220	7.110	6.740	6.650
POS-1	O-5	4.220	4.000	3.560	7.430	6.240

Table 14: Comparison of Predicted Water Levels by different models for identified drains of W2, C1 and E1 for 100 Year Return Period Rainfall

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
CS-123	CS-8	7.030	6.500	7.650	7.298	7.570
CS-8	CS-42	6.500	6.480	7.647	7.211	7.500
CS-42	O-35	6.480	6.420	7.677	7.193	7.490
MH-66	O-36	6.420	6.350	7.676	7.168	7.490

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
CS-51	CS-59	6.350	6.330	7.666	7.144	7.480
CS-59	O-13	6.330	6.310	7.635	7.125	7.390
MH-44	O-14	6.310	6.160	7.701	7.101	7.370
CS-45	CS-211	6.070	5.970	8.327	7.028	7.210
CS-211	O-37	5.970	5.940	7.972	6.732	6.890
POS1-	O3	4.100	4.200	7.800	5.940	6.650
CS-28	CS-29	6.760	6.510	7.461	7.611	7.730
CS-29	CS-43	6.510	6.430	7.449	7.289	7.660
CS-43	CS-59	6.430	6.330	7.466	7.174	7.590
CS-59	O-13	6.330	6.310	7.635	7.125	7.390
MH-44	O-14	6.310	6.160	7.701	7.101	7.370
CS-45	CS-211	6.070	5.970	8.327	7.028	7.210
CS-211	O-37	5.970	5.940	7.972	6.732	6.890
POS1-	O3	4.100	4.200	7.800	5.940	6.650
CCS-002	CCS-003	6.600	6.510	7.448	7.634	7.810
CCS-003	O-40	6.510	6.490	7.504	7.536	7.100
POS2	O11	4.100	4.200	7.800	4.500	6.020
CCS-001	O-41	6.650	6.550	7.445	7.130	7.200
POS2	O11	4.100	4.200	7.800	4.500	6.02
CS-12	CS-15	6.650	6.510	7.447	7.544	7.660
CS-15	O-42	6.510	6.040	7.451	7.495	6.530
POS3	O-10	4.440	4.450	7.800	4.500	5.400
CS-20	CS-21	6.290	6.260	7.780	6.831	6.890
CS-21	CS-18	6.260	6.240	7.715	6.820	6.890
CS-18	CS-17	6.240	6.160	7.839	6.809	6.890
CS-17	O-43	6.160	6.030	7.657	6.778	6.810
POS3	O-10	4.440	4.450	7.800	4.500	6.330

Table 15: Comparison of Predicted Water Levels by different models for identified drains of W1 for 100 Year Return Period Rainfall

Node		Invert Level		Ground Elevation (m)	Maximum Water Levels (m)	
Start (m)	Stop (m)	Start (m)	Stop (m)		SewerGEMS	HEC-RAS
CS-504	CS-505	5.900	5.800	7.290	7.659	7.740
CS-505	O-131	5.800	5.640	7.120	7.641	7.740
MH-131	O-502	5.640	5.530	7.350	7.599	7.740
CS-502	CS-503	5.530	5.480	7.540	7.553	7.710
CS-503	O-502	5.480	5.480	7.140	7.525	7.700
MH-132	O-501	5.480	5.360	7.260	7.483	7.700
CS-185	CS-186	5.360	5.280	7.180	7.443	7.690
CS-186	O-45	5.280	5.230	7.120	7.403	7.660
MH-232	O-46	5.230	5.170	7.110	7.342	7.650
CS-188	CS-190	5.170	5.110	7.110	7.309	7.640
CS-190	CS-191	5.110	5.050	7.110	7.294	7.620
CS-191	O-47	5.050	5.000	7.130	7.263	7.600
MH-235	MH-236	5.000	4.880	7.180	7.221	7.560
MH-236	O-29b	4.880	4.840	7.830	7.166	7.440
CS-29	CS-39	5.720	5.720	7.270	7.241	7.260
CS-39	CS-30	5.970	5.720	7.260	7.111	7.140
CS-30	CS-19	4.370	4.280	6.670	7.019	6.760
CS-19	CS-20	4.280	4.160	6.670	6.940	6.630
CS-20	O-3	4.160	4.140	6.670	6.897	6.460
POS-10	O-50	4.100	3.990	7.500	6.500	6.490
CS-74	CS-75	3.990	3.950	6.500	7.392	6.410
CS-75	O-51	3.950	3.930	6.500	7.286	6.180

Graphical results of some of the typical cross sections of drainage channel showing maximum predicted water level for flood discharge resulting from 100 year return period rainfall are represented vide their nodes as shown in Figures 13 to 19 with reference to the design of SWD submitted by M/S NMIAPL.

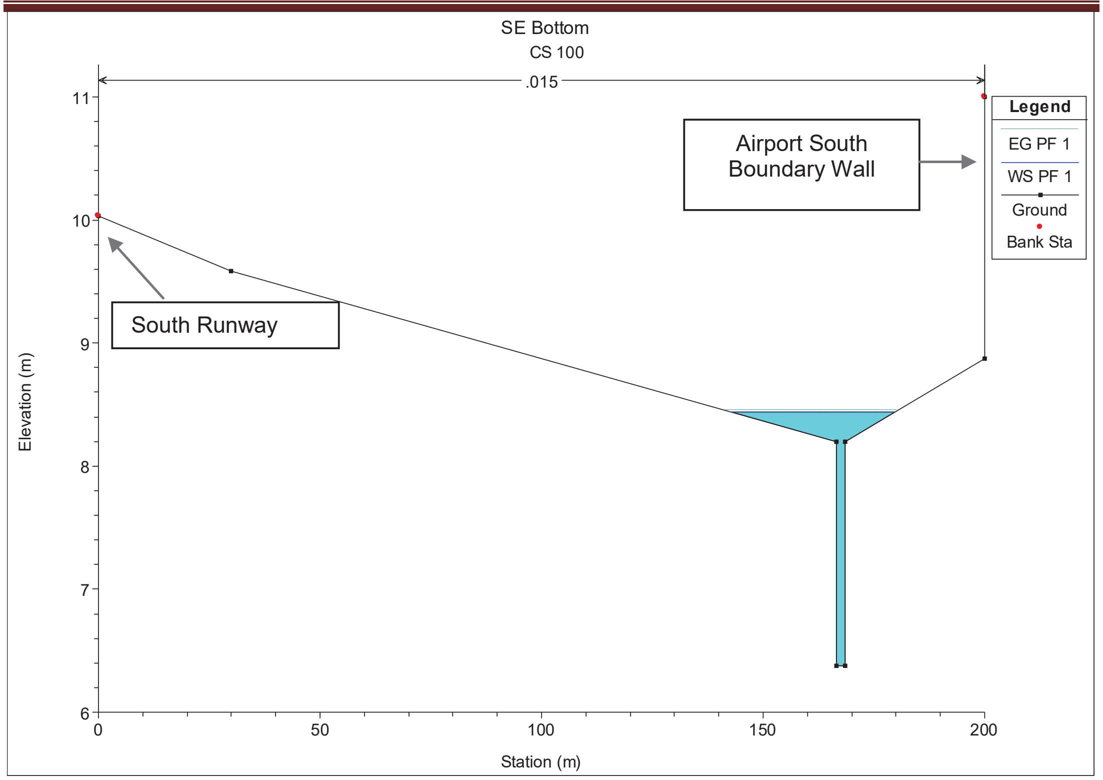

Figure 13: Cross Section of drain at Node CS-100 of SE Bottom Catchment Showing Maximum Predicted water level for 100 year return period rainfall

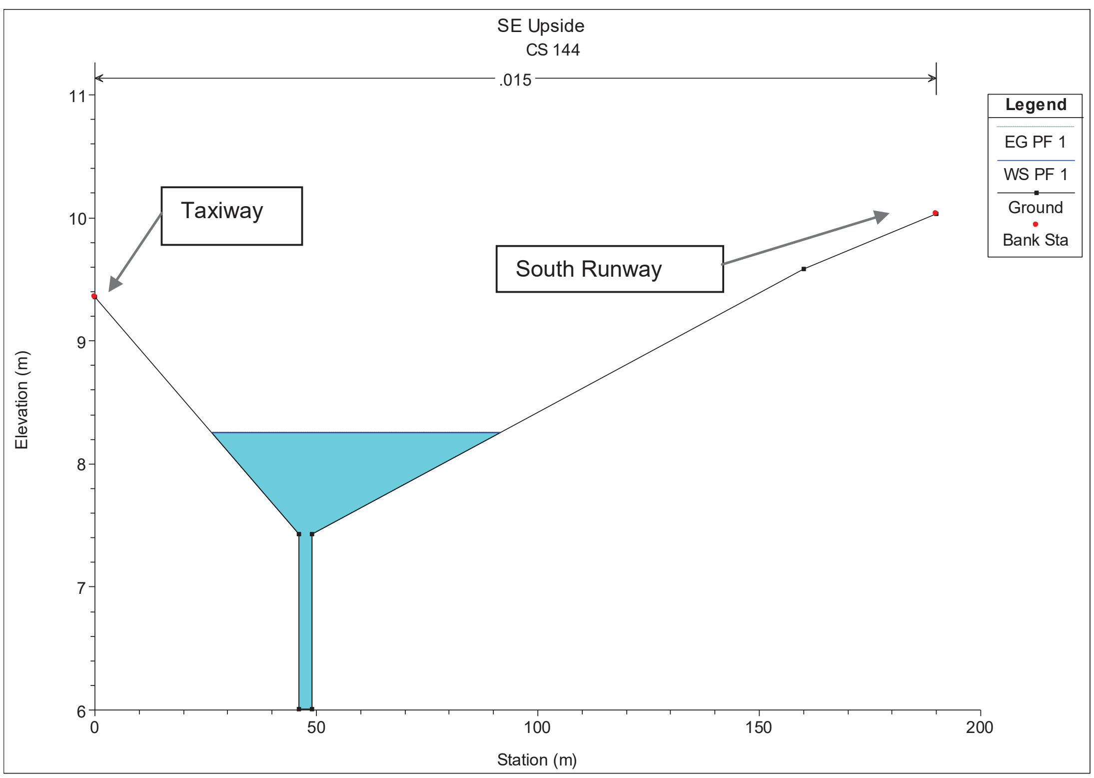

Figure 14: Cross Section of drain at Node CS-144 of SE Upside Catchment. Showing Maximum Predicted water level for 100 year return period rainfall

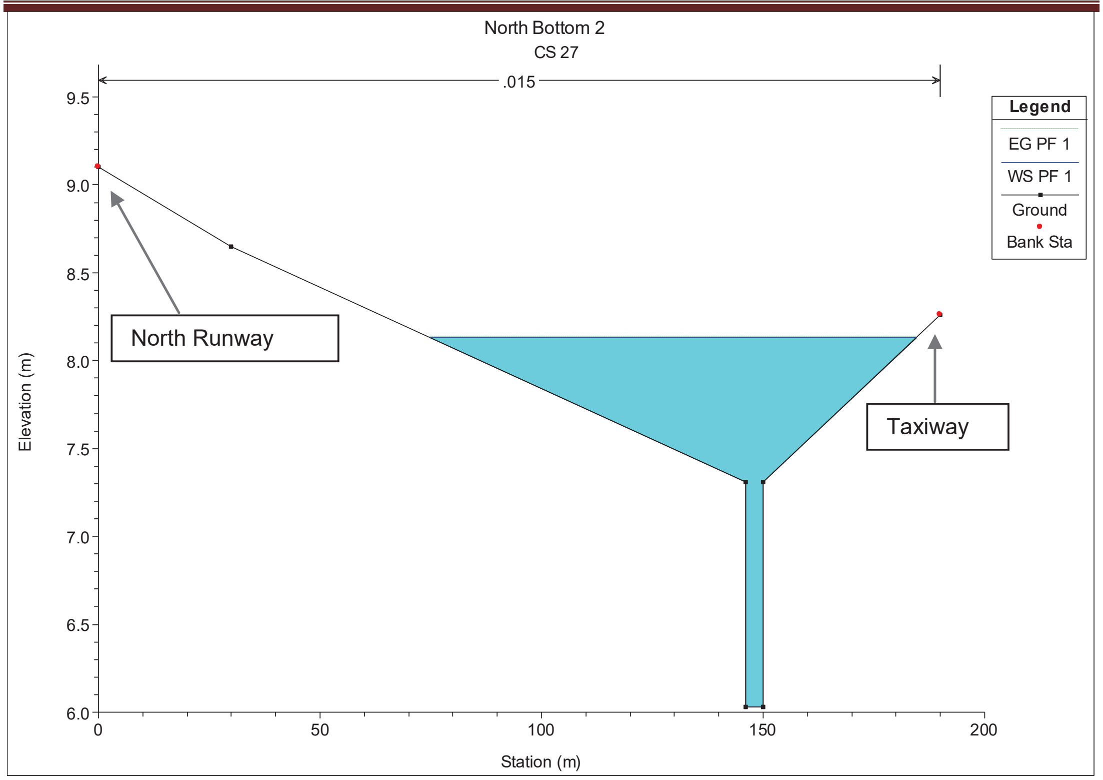

Figure 15: Cross Section of drain at Node CS-27 of NE Catchment. Showing Maximum Predicted water level for 100 year return period rainfall

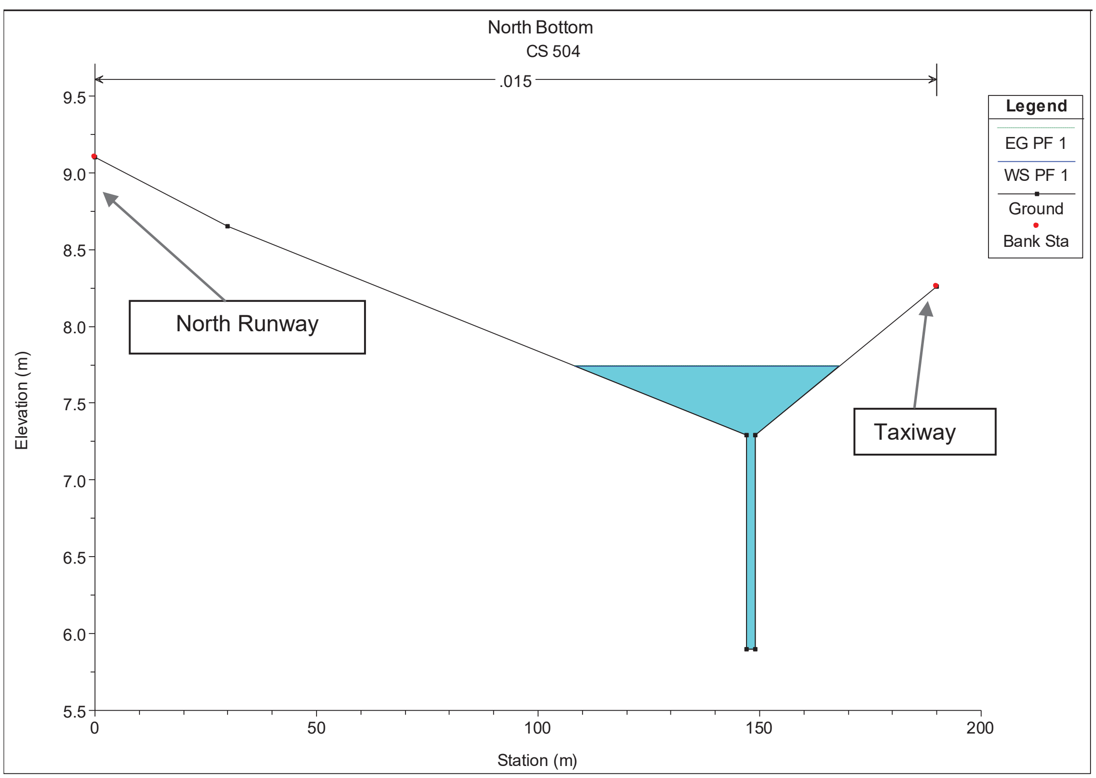

Figure 16: Cross Section of drain at Node CS-504 of W1 Catchment. Showing Maximum Predicted water level for 100 year return period rainfall

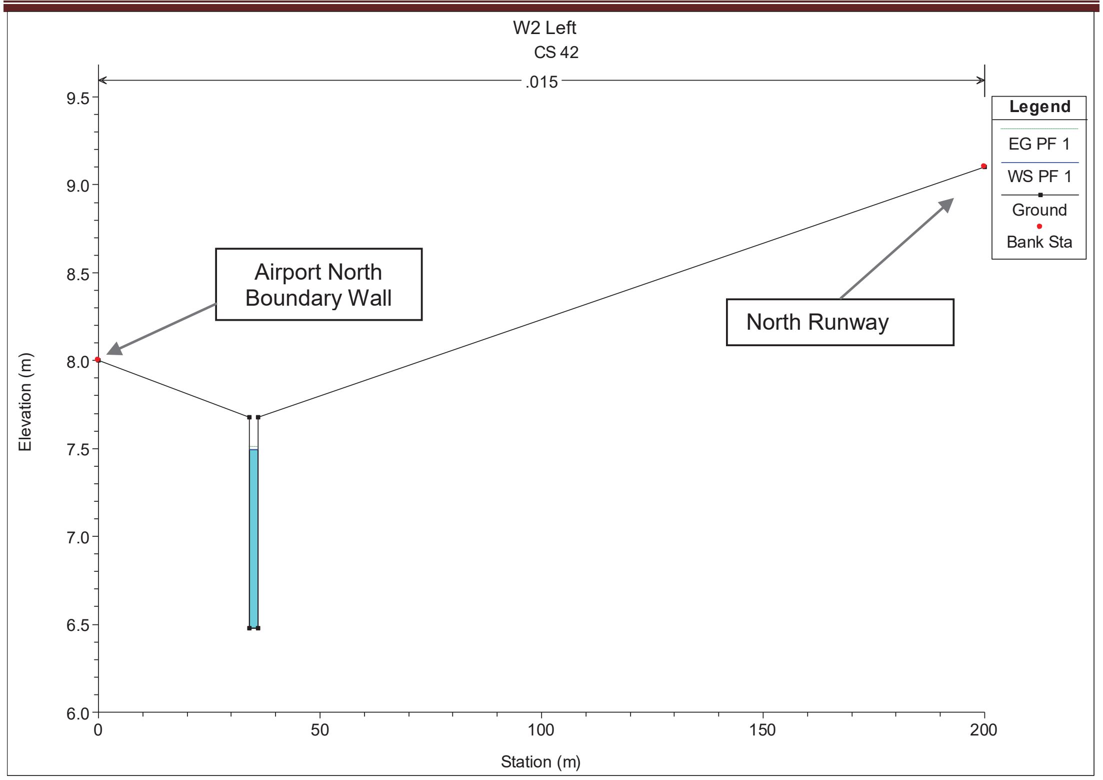

Figure 17: Cross Section of drain at Node CS-42 of W2 Catchment. Showing Maximum Predicted water level for 100 year return period rainfall

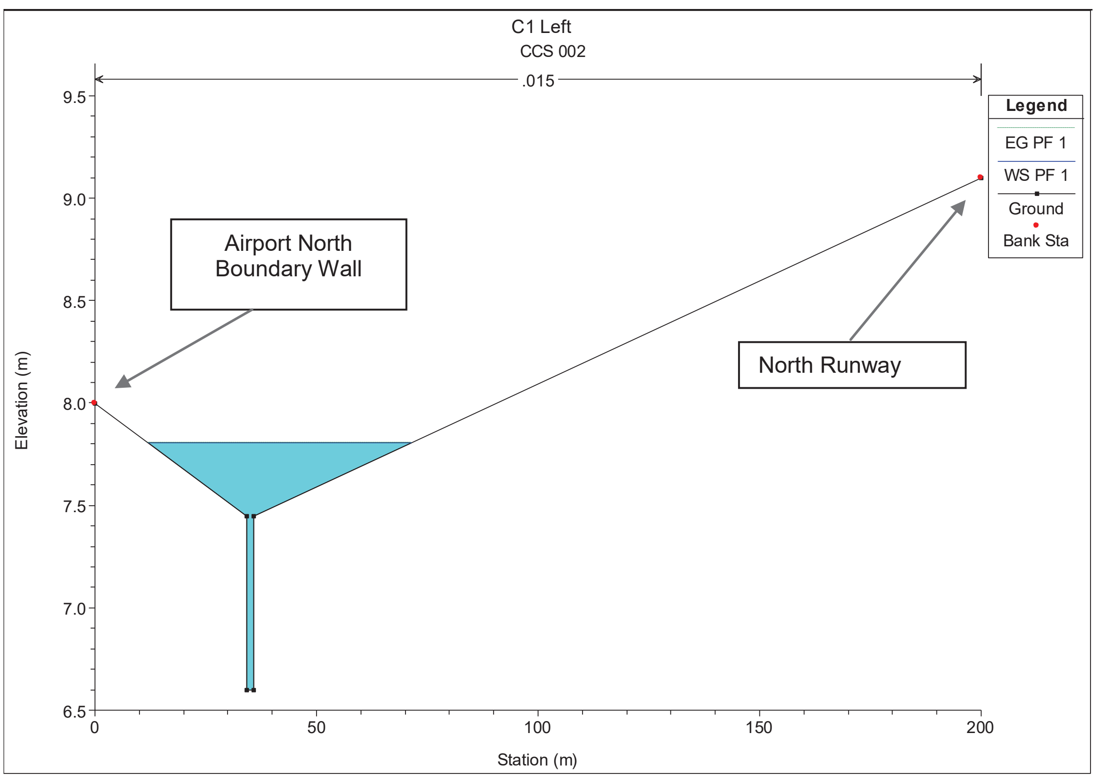

Figure 18: Cross Section of drain at Node CCS-002 of C1 Catchment. Showing Maximum Predicted water level for 100 year return period rainfall

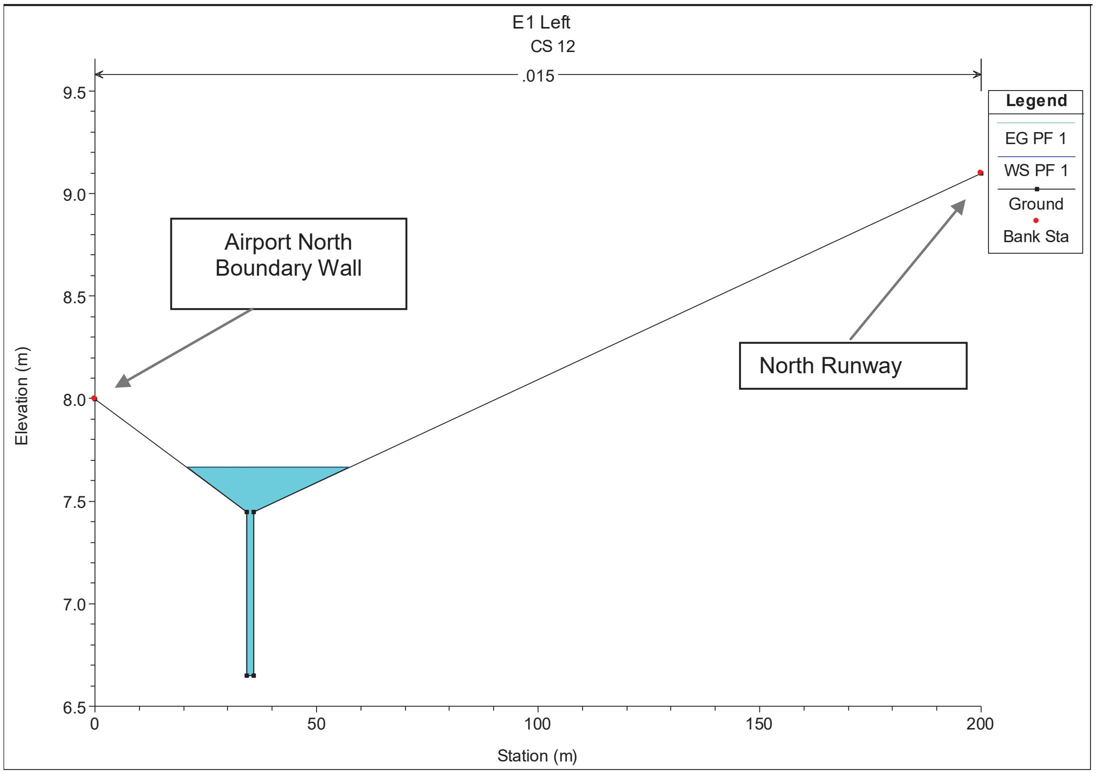

Figure 19: Cross Section of drain at Node CS-12 of E1 Catchment. Showing Maximum Predicted water level for 100 year return period rainfall

10.0 GENERAL LIMITATIONS

1. One-dimensional mathematical model has its own limitation of providing only depth and discharge as output at every computational cross section along the river. In order to obtain a two dimensional map of the flooding area, one dimensional model results needs to be converted into two dimensional maps by interpolating outputs between 1D model cross sections. The interpolation process may introduce errors in unsteady simulations, especially over relatively flat terrain. In the case of highly transient flows, the interpolation process does not respect the mass conservation principle. This is an inherent limitation of the model used for the study in addition to general assumptions made, that may creep in some amount of uncertainty and may affect reliability of the final estimated / predicted flood levels to some extent.
2. The review analysis and results in this report are based on rainfall intensity as 148.1 mm/hr whereas in the earlier report it was 134 mm/hr. Hence current report shall be used for implementation whereas earlier report shall be used for reference wherever required. Any changes occurring due to modification at site condition may affect partially or wholly the reliability of the storm water drainage system results.

3. 1D model study has been carried out with cross sections generated from the data provided by M/S CIDCO. The accuracy of the predicted model results depend upon the accuracy of input data.
4. The extreme value analysis of rainfall has been carried out by assuming the stationarity of data series. Nowadays, the effect of climate change and other anthropogenic factors on hydro-meteorological extremes is also being discussed in research works; which however requires variety of data, modeling facilities and so on. Climate change effect, cloud burst and other such events have not been considered in the present study; however design authorities may consider some percentage rise (free board) in design parameters, as feasible to arrive at liberal estimates.

11.0 RECOMMENDATION AND CONCLUSIONS

From the detailed review of Storm Water Drainage Master Plan Report and analysis of the results by carrying out mathematical modeling, following recommendations / conclusion are drawn:

1. The airport master plan prepared by M/S NMIAPL (updated in November 2019) has been used as basis for the development of initial Storm Water Drainage (SWD) scheme.
2. It is recommended that SWD development of NMIA may be undertaken in accordance with applicable codes, specific conditions and overall standard Airfield drainage requirement laid down by competent authorities viz. ICAO, DGCA CAR's, MoEF, MPCB etc.
3. Design storm is a crucial factor in deciding the size of drainage channel. There are not much standard guidelines available for adopting design storm for airport drainage system. As discussed in para 6, in accordance with the Ministry of Environment and Forests recommendation entire drainage system should be designed for minimum 100 year return period rainfall.
4. For storm water drainage system, M/S CH2M / M/S NMIAPL has adopted the rainfall intensity as 148.1 mm/hr using LP III Distribution for 100 year return period.
5. M/S CH2M / M/S NMIAPL has adopted the runoff coefficient as 1.0 for paved surface and 0.35 for unpaved areas within the airside which appears to be appropriate.
6. M/S CH2M / M/S NMIAPL has adopted Soil Conservation System (SCS) design method for calculating storm runoff. The SCS method has been used

interchangeably with Natural Resources Conservation Services (NRCS) a division of U.S. Department of Agriculture by use of Hydrological Modeling Software Sewer-GEMS version V8i (Select Series 4) for modeling of Watersheds within the airport boundary appears to be appropriate.

7. For the hydraulic design of drainage channel conventional Manning's Equation has been used. Manning's roughness 'n' has been considered as per IRC SP42:2014 to be between 0.013 and 0.015 for concrete drains. Time of concentration of 15 min considered in airside network i.e. network between Runway and Taxiway (or) between taxiways and 10 min considered for drainage network in Apron portion, are found to be appropriate.

8. Catchment wise (W1,W2, C1, E1, NE, SE) modeling results for proposed open drain as well as box drain for the runoff generated from rainfall corresponding to 100 years return period are presented in this report. It could be observed from mathematical model results that highest water level in the upstream side of drains will be above the ground level for the runoff generated from rainfall corresponding to 100 year return period rainfall, which will spill over adjoining ground surface.

9. The comparative results of predicted highest water (by HEC-RAS model and SewerGEMS model) for some of the identified drainage channels adjacent to the runways and aprons are presented in this report.

10. From the analysis of mathematical model results it is seen that there may be flooding / spreading on the over banks / ground in case of overtopping of drains / channels. However, the result shows that flooding water may not spread up to the proposed RL of runway/ Aprons corresponding to discharge / runoff resulting from 100 year return period rainfall.

11. From the results of mathematical model it is observed that the predicted maximum velocity could be 4.69 M/S, which is within the permissible limit for concrete drains.

12. Due to outfall constraint, the bed slope of maximum numbers of proposed drainage channels are mild hence low velocities are expected during non-monsoon period. Regular and periodic maintenance / cleaning of the complete drainage channel is essential.

13. There are inherent limitations associated with mathematical model which may creep in some amount of uncertainty and may affect reliability of the final estimated flood levels to some extent.

ACKNOWLEDGEMENT

We wish to express our deep sense of gratitude to Dr. (Mrs.) V. V. Bhosekar, Director, CWPRS for her constant encouragement and valuable suggestions during the course of this study. Our sincere thanks are due to Shri Charu Datta Deshmukh, Director - Urban Planning, Shri Gajanan K Gandewar DGM-Urban Planning, Navi Mumbai International Airport Pvt Ltd (M/S NMIAPL), Shri Sanatnu Ghosh, Asst. Vice President – Project Construction, NMIAPL and Shri Sreenivas A., Sr. Drainage Engineer, M/S JACOBS for discussions during the course of study. The support extended by Shri Gajanan K Gandewar and Shri Sreenivas A, during their visit to CWPRS Pune for working with SewerGEMS Model is acknowledged with thanks. Efforts extended in assisting data processing and preparation of report by staff members of Disaster Management Planning Division, CWPRS are also acknowledged.

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ANNEXURE-XII
ENERGY CONSERVATION BUILDING CODE (ECBC) 2017
COMPLIANCE REPORT OF NMIA

ECBC 2017 COMPLIANCE REPORT

ANNEXURE-XII
ECBC 2017 COMPLIANCE REPORT OF NMIA

Introduction

At the proposed Terminal 1 and Ancillary Buildings necessary Green Building measures will be followed for minimum conservation of energy in line with "Energy Conservation Building Code –2017", "National

Building Code 2016" and ASHRAE requirements. The Terminal is targeted to achieve LEED Certification Gold from the United States Green Building Council (USGBC), and all other building shall follow a minimum energy requirement as per ECBC. The building falls under the category of Assembly, and the energy conservation measures which will be adopted are described below. The report has an Annexure which can be referred for compliance

Building Envelope

Generally, the building envelope is comprised of a series of components and system that protect the interior space from the effects of the environment like precipitation, wind, temperature, humidity and ultraviolet radiation. Through the optimization of various building elements such as the roof, windows and openings, and building envelope, cost and emissions can be cut down while increasing indoor comfort. Reduced dependence on non-renewables by promoting daylight and natural ventilation plays a vital role in the reduction of annual energy consumption.

Fenestration, Walls & Roof

Building

The U value & SHGC shall be determined for the overall fenestration which shall include the sash and frame. The values considered for Terminal 1 facade are U – 2 W/m^2 K, Roof with a U value of 0.20 W/m^2 K and wall having a value of 0.40 W/m^2 K. The Solar heat gain Coefficient for Facade and Skylight shall be 0.25.

Daylight

Assembly buildings and other buildings where day lighting will interfere with the functions or processes of 50% (or more) of the building floor area is exempted from meeting the requirement as per Table 4-1 in ECBC 2017. Hence daylighting are not considered for all the areas.

COMFORT SYSTEM AND CONTROLS

Nowadays, due to the high demand for HVAC system installation in buildings, designing an effective controller to decrease the energy consumption of the devices while meeting the thermal comfort demands in buildings are the most important goals. The other factors are how efficiently we use the outside air for occupant wellbeing, bringing outside air can have an impact on the power consumption of the overall however there are controls to efficient modulate the outside air for energy reduction.

Ventilation

Habitat space is ventilated as per Ashrae 62.1 2010, and where cross-reference for spaces are not available in Ashrae 62.1 2010, NBC 2016 has been followed.

Buildings ventilated using mixed-mode mechanical ventilation has Demand Control ventilation which has been integrated with Carbon dioxide sensors ($C0_2$) to optimize the fresh air requirement based on the Outdoor and Indoor CO_2 level. This reduces the tonnage on the chiller based on diversified load, which has a considerable energy saving in the Air Handling Unit.

HVAC:

1. Ventilation

(a) All habitable spaces shall be ventilated with outdoor air in accordance with the requirements of ECBC 2017 Clause# 5.2.1 and guidelines specified in the National Building Code 2016 (Part 8: Building Services, Section 1: Lighting and Natural Ventilation, Subsection 5: Ventilation).

(b) Ventilated spaces shall be provided with outdoor air using one of the following:

i. Natural ventilation

ii. Mechanical ventilation

iii. Mixed mode ventilation

Compliance Strategy:

The project has only mechanical ventilated spaces and the air changes shall be between 4 to 8 ACH in all mechanical ventilation spaces.

1.1 Natural Ventilation Design Requirements

Naturally ventilated buildings or spaces in a mixed-mode ventilated buildings shall:

(a) Comply with guidelines provided for natural ventilation in NBC.
(b) Have minimum BEE 3-star rated ceiling fans, if provided with ceiling fans.
(c) Have exhaust fans complying with minimum efficiency requirements of fans in table below, if provided.

TABLE-1
MECHANICAL AND MOTOR EFFICIENCY REQUIREMENTS FORO FANC IN ECBC BUILDINGS

System Type	Fan Type	Mechanical Efficiency	Motor Efficiency (As per IS 12615)
Air-Handling Unit	Supply, return and exhaust	60%	IE-2

Compliance Strategy:

- There are no naturally ventilated spaces in the project.
- The ceiling fans shall have at least BEE 3-Star rating.
- All exhaust fan motors shall be in compliance with the ECBC norms of at least IE-2 efficiency.

1.2 Mechanical Ventilation Air Quantity Design Requirements

Buildings that are ventilated using a mechanical ventilation system or spaces in mixed-mode ventilated buildings that are ventilated with a mechanical system, either completely or in conjunction with natural ventilation systems, shall:

(a) Install mechanical systems that provide outdoor air change rate as per NBC; and
(b) Have a ventilation system controlled by CO sensors for basement carpark spaces with total car park space greater than or equal to 600 m^2.

Compliance Strategy:

- The outdoor air change rate shall be as per the NBC standard equivalent to 4 – 8 ACH.
- As there is no basement parking system in the project, providing CO sensors for basement car parks are not applicable.

1.3 Demand Control Ventilation

Mechanical ventilation systems shall have demand control ventilation if they provide outdoor air greater than 1,500 liters per second, to a space greater than 50 m^2, with occupant density exceeding 40 people per 100 m^2 of the space, and are served by one or more of the following systems:

(a) An air side economizer
(b) Automatic outdoor modulating control of the outdoor air damper

Compliance Strategy:

- CO_2 sensors shall be provided for complying the ECBC requirement along with the automatic outdoor modulating control for controlling the outdoor air damper.

2. Minimum Space Conditioning Equipment Efficiencies

2.1 Chillers

(a) Chillers shall meet or exceed the minimum efficiency requirements presented in table below under ANSI/ AHRI 550/ 590 conditions.

ECBC Building		
Chiller Capacity (kWr)	COP	IPLV
<260	4.7	5.8
≥260 & <530	4.9	5.9
≥530 & <1,050	5.4	6.5
≥1,050 & <1,580	5.8	6.8
≥1,580	6.3	7.0

Compliance Strategy:

- Water cooled centrifugal chillers are proposed with efficiency in compliance with the ECBC standard of COP equal to 6.3 and IPLV of 7.
- Air Cooled chillers are not proposed in the project

Water Cooled Chillers:

Equipment Efficiencies & Control

- Chiller shall comply with the requirement of ANSI/AHRI 550/590 Conditions.
- The cooling tower is provided with VFD, and the logic is based on the wet bulb conditions.
- All the Air handling units shall be with minimum 60% efficiency with VFD for fan control and space shall have pressure independent Variable Air Volume (VAV).
- The pumping system will be with primary constant speed and Secondary Variable speed integrated with a differential pressure sensor to achieve saving in part-load conditions by decreasing the water flow rate. Minimum efficiency of the pumps will be 70%

2.2 Variable Refrigerant Flow

Variable Refrigerant Flow (VRF) systems shall meet or exceed the efficiency requirements specified in Table below as per the ANSI/AHRI Standard 1230 while the Indian Standard on VRF is being developed. Standards and Labeling requirements for VRF shall take precedence over the current minimum requirement.

For Heating or cooling or both			
Type	**Size category (kWr)**	**EER**	**IEER**
VRF Air Conditioners, Air cooled	< 40	3.28	4.36
	>= 40 and < 70	3.26	4.34
	>= 70	3.02	4.07

NOTE: *The revised EER and IEER values as per Indian Standard for VRF corresponding to values in this table will supersede as and when the revised standards are published.*

Compliance Strategy:

- *VRF systems are not proposed in the project and hence the compliance to this section is not applicable*

2.3 Air Conditioning and Condensing Units Serving Computer Rooms

Air conditioning and condensing units serving computer rooms shall meet or exceed the energy efficiency requirements listed in Table below.

Equipment type	**Net Sensible Cooling Capacity a**	**Minimum SCOP-127b**	
		Down flow	**Up flow**
All types of computer room ACs Air/ Water/ Glycol	All capacity	2.5	2.5
a. Net Sensible cooling capacity = Total gross cooling capacity - latent cooling capacity – Fan power b. Sensible Coefficient of Performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheater and dehumidifier) at conditions defined in ASHRAE Standard 127-2012 Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners)			

Compliance Strategy:

- The air conditioning system proposed for serving the computer rooms and server rooms shall comply the ECBC norms of SCOP.

2.4 Controls

To comply with the Code, buildings shall meet the requirements of ECBC 2017 Clause# 5.2.3.1 through ECBC 2017 Clause# 5.2.3.5.

2.4.1 Time clock

Mechanical cooling and heating systems in Universities and Training Institutions of all sizes and all Shopping Complexes with built up area greater than 20,000 m^2 shall be controlled by time clocks that:

(a) Can start and stop the system under different schedules for three different day-types per week,
(b) Are capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and
(c) Include an accessible manual override that allows temporary operation of the system for up to 2 hours.

2.4.2 Temperature Controls

Mechanical heating and cooling equipment in all buildings shall be installed with controls to manage the temperature inside the conditioned zones. Each floor or a building block shall be installed with at least one control to manage the temperature. These controls should meet the following requirements:

(a) Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3.0°C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

(b) Where separate heating and cooling equipment serve the same temperature zone, temperature controls shall be interlocked to prevent simultaneous heating and cooling.

(c) Separate thermostat control shall be installed in each

i. Guest room of Resort and star hotel,
ii. Room less than 30 m^2 in business,
iii. Air-conditioned class room, lecture room, and computer room of educational,
iv. In-patient and out-patient room of healthcare

2.4.3 Occupancy Controls

Occupancy controls shall be installed to de-energize or to throttle to minimum the ventilation and/or air conditioning systems when there are no occupants in:

(a) Each guest room in a resort and star hotel
(b) Each public toilet in a star hotel or business with built up area more than 20,000 m^2
(c) Each conference and meeting room in a star hotel or business
(d) Each room of size more than 30 m^2 in educational buildings

2.4.4 Fan Controls

Cooling towers in buildings with built up area greater than 20,000 m^2, shall have fan controls based on wet bulb logic, with either:

(a) Two speed motors, pony motors, or variable speed drives controlling the fans, or

(b) Controls capable of reducing the fan speed to at least two third of installed fan power

2.4.5 Dampers

All air supply and exhaust equipment, having a Variable Frequency Drive (VFD), shall have dampers that automatically close upon:

(a) Fan shutdown, or,

(b) When spaces served are not in use

(c) Backdraft gravity damper is acceptable in the system with design outdoor air of the system is less than 150 liters per second in all climatic zones except cold climate, provided backdraft dampers for ventilation air intakes are protected from direct exposure to wind.

(d) Dampers are not required in ventilation or exhaust systems serving naturally conditioned spaces.

(e) Dampers are not required in exhaust systems serving

Compliance Strategy:

- As the project is operational round the clock throughout the year, providing timer clock, temperature controls, occupancy controls are not applicable.
- The Cooling tower fans are configured with Variable Frequency Drive (VFDs) for complying the ECBC norms.

As per ECBC 2017 Clause# 5.2.3.1 shall be address by building management system;

ECBC 2017 Clause# 5.2.3.2 - Thermostats are provided to comply the norms; and

ECBC 2017 Clause# 5.2.3.3 - Occupancy sensors shall be provide to meet the norms.

2.5 Piping and Ductwork

2.5.1 Piping Insulation

Piping for heating, space conditioning, and service hot water systems shall meet the insulation requirements listed in Table below. Insulation exposed to weather shall be protected by aluminum sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above, or be painted with water retardant paint.

Operating Temperature (°C)	**Pipe size (mm)**	
	<25	>=40
	Insulation R value (m2.K/W)	
Heating System		
94°C to 121°C	0.9	1.2
60°C to 94°C	0.7	0.7
40°C to 60°C	0.4	0.7
Cooling System		
4.5°C to 15°C	0.4	0.7
< 4.5°C	0.9	1.2
Refrigerant Piping (Split systems)		
4.5°C to 15°C	0.4	0.7
< 4.5°C	0.9	1.2

2.5.2 Ductwork and Plenum Insulation

Ductwork and plenum shall be insulated in accordance as per table below.

TABLE-2
DUCTWORK INSULATION (R VALUE IN m^2 k/m REQUIREMENT

Duct Location	Supply Ducts	Return Ducts
Exterior	R1.4	R-0.6
Unconditional Space	R-0.6	None
Buried	R-0.6	None

Compliance Strategy:

- The insulation materials used for piping, ductworks and in plenum spaces shall comply with the resistance value as specified in the ECBC norms.

2.6 System Balancing

2.6.1 General

System balancing shall be done for systems serving zones with a total conditioned area exceeding 500 m^2.

2.6.2 Air System Balancing

Air systems shall be balanced in a manner to first minimize throttling losses; then, for fans with fan system power greater than 0.75 kW, fan speed shall be adjusted to meet design flow conditions.

2.6.3 Hydronic System Balancing

Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions.

Compliance Strategy:

- The system balancing shall be done as per the ECBC requirement during the commissioning stage of the project.

2.7 Condensers

2.7.1 Condenser Locations

Condensers shall be located such that the heat sink is free of interference from heat discharge by devices located in adjoining spaces, and do not interfere with other such systems installed nearby.

Compliance Strategy:

- The condenser location shall be free from any interference by heat discharged from devices located in adjoining spaces.

2.8 Service Water Heating

2.8.1 Heating Equipment Efficiency

Service water heating equipment shall meet or exceed the performance and minimum efficiency requirements presented in available Indian Standards

(a) Solar water heater shall meet the performance/ minimum efficiency level mentioned in IS 13129 Part (1&2)
(b) Gas Instantaneous water heaters shall meet the performance/minimum efficiency level mentioned in IS 15558 with above 80% Fuel utilization efficiency.
(c) Electric water heater shall meet the performance/ minimum efficiency level mentioned in IS 2082.

2.8.2 Other Water Heating System

Supplementary heating system shall be designed to maximize the energy efficiency of the system and shall incorporate the following design features in cascade:

(a) Maximum heat recovery from hot discharge system like condensers of air conditioning units,
(b) Use of gas fired heaters wherever gas is available, and
(c) Electric heater as last resort.

2.8.3 Piping Insulation

Piping insulation shall comply with ECBC 2017 Clause# 5.2.6.1. The entire hot water system including the storage tanks, pipelines shall be insulated conforming to the relevant IS standards on materials and applications.

2.8.4 Heat Traps

Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a non-recirculating system shall have heat traps on both the inlet and outlet piping.

Compliance Strategy:

- Providing hot water system is not a part of contractor scope, hence this compliance is not applicable.
- ECBC 2017 Clause# 5.2.9 service water heating not applicable

2.9 Lighting and Controls

Lighting control systems serve to provide the right amount of light where and when it is needed. Lighting control systems are employed to maximize the energy savings from the lighting system, satisfy building codes, or comply with green building and energy conservation programs.

2.9.1 Interior and Exterior lighting and Control

The Interior lighting control for the Terminal will be equipped with automatic control devices like dimmable luminaires and time clock dependent based on daylight (PV) sensors. The back of the house like office will have an individual on/off control switch and the services areas will have occupancy sensor for Lighting Control. The Connected lighting power density requirement followed for Interior, and Exterior lighting shall be as per ASHRAE 90.1 2010. Exterior lighting shall be provided with automatic control.

The natural daylight will be integrated with the building to comply with the ECBC requirement.

2.9.2 Electrical and Renewable Energy System

Clean, renewable energy is one of the most important actions we can take to reduce our impact on the environment. Electricity production is our #1 source of greenhouse gases, more than all of our driving and flying combined. Clean energy also reduces harmful smog, toxic build-ups in our air and water, and the impacts caused by coal mining and gas extraction. Energy efficiency is a key step to reducing our impact on climate change and creating a sustainable energy future.

2.9.3 Lighting Control

- **Automatic Lighting Shutoff**

(a) 90% of interior lighting fittings in building or space of building larger than 300 m^2 shall be equipped with automatic control device.

(b) Additionally, occupancy sensors shall be provided in

i. All building types greater than 20,000 m^2 BUA, in

a. All habitable spaces less than 30 m^2, enclosed by walls or ceiling height partitions.

b. All storage or utility spaces more than 15 m^2 in all building types with BUA greater than 20,000 m^2.

c. Public toilets more than 25 m^2, controlling at least 80 % of lighting fitted in the toilet. The lighting fixtures, not controlled by automatic lighting shutoff, shall be uniformly spread in the area.

ii. In corridors of all Hospitality greater than 20,000 m^2 BUA, controlling minimum 70% and maximum 80% of lighting fitted in the public corridor. The lighting fixtures, not controlled by automatic lighting shut off, shall be uniformly spread in the area.

iii. In all business and all conference or meeting rooms.

(c) Automatic control device shall function on either:

i. A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m^2 and not more than one floor, or,

ii. Occupancy sensors that shall turn off the lighting fixtures within 15 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights when the space is occupied.

Compliance Strategy:

- Occupancy sensors shall be provided in all applicable areas as recommended in ECBC.
- Providing programmable timers is not applicable as the project is operational for 24 Hours.

- **Space Control**

Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant. Each control device shall

(a) Control a maximum of 250 m^2 for a space less than or equal to 1,000 m^2, and a maximum of 1,000 m2 for a space greater than 1,000 m2.

(b) Have the capability to override the shutoff control required in ECBC 2017 Clause# 6.2.1.1 for no more than 2 hours, and

(c) Be readily accessible and located

Compliance Strategy:

Occupancy sensors and manual switches shall be provided for complying the ECBC norms.

- **Control in Daylight Areas**

(a) Luminaires, installed within day lighting extent from the window as calculated in ECBC 2017 Clause# 4.2.3, shall be equipped with either a manual control device to shut off luminaires, installed within day lit area, during potential daylit time of a day or automatic control device that:

i. Has a delay of minimum 5 minutes, or,

ii. Can dim or step down to 50% of total power.

(b) Overrides to the daylight controls shall not be allowed.

Compliance Strategy:

Necessary control device for shutting down the luminaires located within the day light zone shall be provided as per the ECBC norms.

- **Exterior Lighting Control**

(a) Lighting for all exterior applications not exempted in table below shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required.

TABLE-3
EXTERIOR LIGHT APPLICATION

Parameter	Description
Exterior Light Application	Building entrance (with canopy)
	Building entrance (w/o canopy)
	Building exit
	Building façade
	Emergency signs, ATM kiosks, Security areas façade
	Driveways and parking (open/external)
	Pedestrian walkways
	Stairways
	Landscaping
	Outdoor sales area

Compliance Strategy:

- Astronomical time switch shall be provided for automatically turning off the exterior lighting when daylight is available or the lighting is not required;
- Lighting for all exterior applications, of Schools and Business with built up area greater than 20,000 m^2, shall have lamp efficacy not less than 80 lumens per watt, 90 lumens per watt, and 100 lumens per watt, for ECBC Buildings unless the luminaire is controlled by a motion sensor or exempt for emergency & security lighting; and

- The Lamp efficacy of the light fixtures proposed to be installed in the project shall be $\geq$ 80 lumens per watt.

- **Additional Control**

The following lighting applications shall be equipped with a control device to control such lighting independently of general lighting:

Display/ Accent Lighting. Display or accent lighting greater than 300 m^2 area shall have a separate control device.

Compliance Strategy:

- Necessary control device for independently controlling the display lights installed in the project shall be provided as per the ECBC requirement.
- Hotel Guest Room Lighting. Guest rooms and guest suites in a hotel shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.
- Task Lighting. Supplemental task lighting including permanently installed under shelf or under cabinet lighting shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device complies with ECBC 2017 Clause# 2.1.2.
- Nonvisual Lighting. Lighting for nonvisual applications, such as plant growth and food-warming, shall be equipped with a separate control device.
- Demonstration Lighting. Lighting equipment that is for sale or for demonstrations in lighting education shall be equipped with a separate control device accessible only to authorized personnel.
- Control device integral to the luminaires or a wall mounted control device shall be provided for controlling all task lightings.
- Internally-illuminated exit signs shall not exceed 5 Watts per face.

3.0 Electrical and Renewal Energy Systems

Energy Recovery

The energy recovery is through Enthalpy wheel which can recover the temperature and moisture load through exhaust from the conditioned zone, which otherwise would have been exhausted to the atmosphere without any recovery.

Electrical

Transformer considered shall be dry type and will be as per the ECBC norms. All the Motors used, whether, in HVAC, Fire Fighting or Public Health Services shall be energy efficient. Renewable energy in the form of Solar Panel will be provided on the roof of Terminal 1 with 5% of the total electrical load requirement.

3.1 Transformers

3.1.1 Maximum Allowable Power Transformer Losses

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating.

Permissible total loss values shall not exceed 5% of the maximum total loss values mentioned in IS 1180 for oil type transformers in voltage class above 11 kV but not more than 22 kV

Compliance Strategy:

- The Oil type transformers proposed to be installed in the project shall comply to the losses values as specified in the ECBC for both 50% and 100% load.
- 7.5% of the maximum total loss values mentioned in above IS 1180 for oil type transformers in voltage class above 22 kV and up to and including 33 kV

3.1.2 Measurement and Reporting of Transformer Losses

All measurement of losses shall be carried out by using calibrated digital meters of class 0.5 or better accuracy and certified by the manufacturer. All transformers of capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to requirements of Utilities so that periodic loss monitoring study may be carried out.

3.1.3 Voltage Drop

Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

Compliance Strategy:

The Voltage drop for feeders shall not exceed 2% at design load and shall not exceed 3% at design load in the branch circuit.

3.2 Energy Efficient Motors

Motors shall comply with the following:

(a) Three phase induction motors shall conform to Indian Standard (IS) 12615 and shall fulfil the following efficiency requirements:

ECBC Buildings shall have motors of IE 2 (high efficiency) class or a higher class

(b) All permanently wired polyphase motors of 0.375 kW or more serving the building and expected to operate more than 1,500 hours per year and all permanently wired polyphase motors of 50kW or more serving the building and expected to operate more than 500 hour per year, shall have a minimum acceptable nominal full load motor efficiency not less than levels specified in the latest version of IS 12615.

(c) Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.

(d) Motor horsepower ratings shall not exceed 20% of the calculated maximum load being served.

(e) Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor.

(f) Motor users should insist on proper rewinding practices for any rewound motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices. Rewinding practices from BEE guideline for energy efficient motors shall be followed.

(g) Certificates shall be obtained and kept on record indicating the motor efficiency. Whenever a motor is rewound, appropriate measures shall be taken so that the core characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts. After rewinding, a new efficiency test shall be performed and a similar record shall be maintained.

Compliance Strategy:

The efficiency of all motors (vertical multistage, hydro-pneumatic and monobloc pumps, HVAC motors) will be minimum IE-2 except for submersible pumps and motors as submersible pumps and motors are not categorised into IE classes as per global pump manufacturer’s standards.

3.2.1 Diesel Generator (DG) Sets

BEE star rated DG sets shall be used in all compliant buildings. DG sets in buildings greater than 20,000 m^2 BUA shall have minimum 3 stars rating in ECBC Buildings

Compliance Strategy:

- The Diesel Generator (DG) sets shall of minimum BEE 3 Star rating as per ECBC norms.

3.4 Check-Metering and Monitoring

(a) Services exceeding 1000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.

(b) Services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh).

(c) Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh).

(d) In case of tenant-based building, metering should be provided at a location from where each tenant could attach the services.

Compliance Strategy:

- Electrical meters for measuring the demand (kVA), energy (kWh), total power factor, current, voltage and Total Harmonic Distortions (THD) shall be provided for complying the ECBC requirement.
- Also metering for individually measuring the energy components like HVAC, Lighting, hot water system, plug loads and renewable energy shall be installed.

3.5 Power Factor Correction

All 3 phase shall maintain their power factor at the point of connection as follows:

- 0.97 for ECBC Building

Compliance Strategy:

All 3 Phase shall maintain power factor at the point of connection as 0.97 for complying the ECBC requirement.

3.6 Power Distribution Systems

The power cabling shall be sized so that the distribution losses do not exceed

(a) 3% of the total power usage in ECBC Buildings

Record of design calculation for the losses shall be maintained. Load calculation shall be calculated up to the panel level.

Compliance Strategy:

The power cabling shall be sized in such a way that the distribution losses shall not exceed 3% of the total power usage as per ECBC norms.

3.7 Uninterruptible Power Supply (UPS)

In all buildings, UPS shall meet or exceed the energy efficiency requirements listed in Table below. Any Standards and Labeling program by BEE shall take precedence over requirements listed in this section.

UPS Size	Energy Efficiency Requirements at 100% Load
kVA< 20	90.2%
20<=kVA <= 100	91.9%
kVA > 100	93.8%

Compliance Strategy:

The energy efficiency of the UPS shall meet or exceed the ECBC requirements as listed in the above table according to the UPS size.

3.8 Renewable Energy Systems

All buildings shall have provisions for installation of renewable energy systems in the future on rooftops or the site.

3.8.1 Renewable Energy Generating Zone (REGZ)

(a) A dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.

(b) The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone

Exception to ECBC 2017 Clause# 3.8.1: Projects with solar hot water and/ or solar power generation systems.

3.8.2 Main Electrical Service Panel

Minimum rating shall be displayed on the main electrical service panel. Space shall be reserved for the installation of a double pole circuit breaker for a future solar electric installation.

Compliance Strategy:

- Renewable Energy Generating Zone (REGZ) shall be provided for generating atleast 1% of the total peak demand of connected load of the building.
- The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone.
- The minimum rating shall be displayed on the main electric service panel along with a double pole circuit breaker for future solar electric installation.

ECBC-2017: MANDATORY COMPLIANCE REPORT

Terminal 1			
Section	**Category**	**Requirement- ECBC 2017**	**Compliance**
ECBC 4	**Building Envelope**	**Mandatory Requirement**	
		Fenestration U-factors and SHGC shall be determined for the overall fenestration product (including the sash and frame) in accordance with ISO-15099 by an accredited independent laboratory, and labelled or certified by the manufacturer.	U Value - 2 W/m2K SHGC - 0.25

ANNEXURE-XII
ECBC 2017 COMPLIANCE REPORT OF NMIA

Terminal 1			
Section	**Category**	**Requirement- ECBC 2017**	**Compliance**
		U-Value - 3 W/m2K SHGC - 0.27	
		Prescriptive Requirements	
		Roof - 0.33 W/m2K	Roof - 0.2 W/m2K
		Walls - 0.40 W/m2K	Walls - 0.40 W/m2K
		Skylight U - 4.25 W/m2K SHGC - 0.35	Skylight U - 4.25 W/m2K SHGC - 0.25
ECBC 5	Comfort System and Control	**Mandatory Requirement**	
		Mechanical Ventilation air quantity requirement as per NBC	Ventilation requirement as per ASHRAE 62.1 2010
		Demand Control Ventilation	CO2 sensor provided to monitor/control the outdoor/indoor carbon dioxide level which is used to modulate the fresh air Damper.
		Equipment efficiencies Table 5-1 Chiller COP - 6.3	Will be Complied
		Variable Refrigerant Flow >= 70 kW ; EER - 3.02	Not applicable for Terminal 1.
		Computer room Air conditioning COP - 2.5	Will be complied
		Cooling Tower Fan control based on Wet bulb logic	Complied Cooling tower fan is with VFD
		Prescriptive Requirements	
		AHU Efficiency 60% , IE2	Will be Complied
		Pump Efficiency 70%	Will be Complied
		Fan Control with VFD	Complied - All the Air handling unit and Treated
		Secondary Pump with VFD	Complied
		Energy Recovery wheel for air flow higher than 1000 CFM	Complied
ECBC 6	Lighting and Controls	**Mandatory Requirement**	
		Lighting Control	Lighting Control Provided with Dimmable luminaries & Time clock dependant operation
		Control in Day light Areas	Lighting control for the areas where the

ANNEXURE-XII
ECBC 2017 COMPLIANCE REPORT OF NMIA

Terminal 1			
Section	**Category**	**Requirement- ECBC 2017**	**Compliance**
			day light is available and is compiled in line with ECBC norms.
		Exterior Lighting Control	Lighting for external applications shall be controlled by photo sensors or timers that will be capable of automatically turning off the external lighting when the daylight is available
		Prescriptive Requirements	
		Interior Lighting Power Density as per Table 6-1	Will be complied
		Exterior Power lighting as per Table 6-7	Will be complied
ECBC 7	**Electrical and Renewable Energy System**	**Mandatory Requirement**	
		Transformers - Dry type Table 7-1	Will be complied
		Energy Efficient Motors - IE2	Will be complied
		Diesel Generator - Minimum 3 Star	Will be complied
		Metering and Monitoring	Will be complied
		Power factor correction - 0.97	Will be complied
		Power distribution system:- distribution losses not to exceed 3% of the total power usage	Will be complied
		UPS - energy efficiency requirements @ 100% load, Refer Table 7.4	Will be complied
		Renewable Energy system - 1 % of the total Electrical load	Will be complied

Terminal 1 & Ancillary Building Energy & Water Conservation Measures

ANNEXURE-XII
ECBC 2017 COMPLIANCE REPORT OF NMIA

Airports consume significant levels of energy for space cooling in terminals, external and internal lighting systems and the operation of the luggage conveyance system. Terminal 1 will be targeting USGC (United States Greed Building Council) LEED Gold Certification.

The Terminal 1 airport will adopt the following energy and water conservation measures:

- Provision of skylights for Passenger Terminal Building - utilizes sunlight throughout the day without the use of artificial lighting;
- Provision of glass (double seal) façade – allows natural light into the building and restricts heat entry;
- Provision of dimming system for lighting.
- Provision of Variable Frequency Drives (VFDs) for HVAC pumps and Air handling units.
- Provision of VFDs for STP air blowers.
- Provision of a dual lighting system for main access roads.
- Provision of LED lights instead of fluorescent lamps.
- Treated fresh air unit with Variable Frequency Drive (VFD) and Enthalpy wheel for energy recovery, which in turn will reduce the chiller power consumption.
- Provision of cooling tower fan with VFD.
- Provision of an energy-efficient chilling system with non-CFC based refrigerants.
- Building demands should be managed by the provision of water-efficient fixtures, namely Sinks and Toilets.
- STP recycled water for Cooling tower, Irrigation and Flushing.
- Solar Energy to the maximum extent will be used.
- Heating, Ventilation & Cooling (HVAC) shall be controlled by well designed
- Building management system (BMS)

Energy and Water Conservation measures adopted for Ancillary buildings.

- Provision of DX Variable Refrigerant flow for Building cooling which will reduce the energy consumptions.
- Building demands should be managed by the provision of water-efficient fixtures, namely
- Sinks and Toilets
- Use of Energy Efficient Luminaries viz LED & CFL lamps.
- Efficient building envelope with low U value and SHGC for windows, low U value for walls & roof
- Provision of Solar Energy to the maximum extent.
- Recycled water for irrigation and flushing.
- Provision of an energy-efficient DX system with non-CFC based refrigerants.

Solar energy to the maximum extent will be used, and the possibility of wind energy will be explored to minimize the usage of conventional energy sources.

The proposed airport project will comply with standards included in ASHRAE & NBC for lighting levels, HVAC, comfort levels, natural ventilation and other system performance criteria. Other requirements of ECBC 2017 & ASHRAE 90.1 like building envelope, heating ventilation and air conditioning system, lighting schedule will be considered during the construction and operational phase of the NMIA project. As an airport for future, NMIA will be developed as a green airport, with a key objective of environmental sustainability through energy optimization, recycling of waste, reduction in carbon footprint, utilization of solar energy, natural day-lighting along with other sustainable measures in planning, development and operations of NMIA.

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ-1 Site Office

Sr. No.	Date of Monitoring	Week	Parameter												Reference Code
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	(ng/m^3)	($\mu g/m^3$)	(ng/m^3)	(ng/m^3)	
1	2019-01-12	I	62.8	23.9	12.9	23.9	22.5	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/01
2	2019-02-12		67.2	25.5	14.1	26.2	20.0	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/09
3	2019-09-12	II	65.5	24.9	13.0	24.0	16.1	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/33
4	2019-10-12		62.9	23.9	13.7	25.5	19.2	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/39
5	16/12/2019	III	67.6	25.7	14.1	26.1	21.7	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/61
6	17/12/2019		58.9	22.4	13.9	25.8	18.5	0.32	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/67
7	27/12/2019	IV	60.6	23.0	13.8	25.7	20.5	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/102
8	28/12/2019		67.5	25.7	13.9	25.2	18.8	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/108
9	2020-01-01	V	62.0	23.6	13.1	24.4	21.5	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/01
10	2020-02-01		68.4	26.0	13.8	25.7	18.3	0.15	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/07
11	2020-06-01	VI	56.8	21.6	13.2	24.6	15.5	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/41
12	2020-07-01		65.1	24.7	13.0	24.2	16.4	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/47
13	13/1/2020	VII	64.4	24.5	13.5	25.1	22.2	0.15	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/73
14	14/1/2020		58.3	22.2	12.3	22.9	17.6	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/79
15	20/1/2020	VIII	63.0	23.9	12.4	23.1	21.4	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/105
16	21/1/2020		67.2	25.5	13.6	25.3	14.8	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/114
17	28/1/2020	IX	62.5	23.8	13.6	24.7	19.9	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/139
18	29/1/2020		58.9	22.4	13.2	23.8	16.5	0.34	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/145
19	2020-01-02	X	60.6	23.0	12.4	23.1	18.0	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/01
20	2020-02-02		62.7	23.8	13.6	25.3	15.6	0.15	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/07
21	2020-10-02	XI	68.2	25.9	13.6	24.0	21.4	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/37
22	2020-11-02		61.9	23.5	12.6	23.4	19.0	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/43
23	17/2/2020	XII	68.2	25.9	13.2	24.6	18.2	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/64
24	18/2/2020		61.0	23.2	13.9	25.9	17.2	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/70
25	26/2/2020	XIII	59.9	22.8	13.1	24.4	18.8	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/107
26	27/2/2020		60.3	22.9	12.5	23.1	20.5	0.15	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/113
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**56.8**	**21.6**	**12.3**	**22.9**	**14.8**	**0.15**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**68.4**	**26.0**	**14.1**	**26.2**	**22.5**	**0.34**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**63.2**	**24.0**	**13.3**	**24.6**	**18.9**	**0.25**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98th Percentile			**68.3**	**26.0**	**14.1**	**26.2**	**22.4**	**0.33**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ-2 CIDCO Office Panvel

Sr. No.	Date of Monitoring	Week	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_X (µg/m³)	NH_3 (µg/m³)	CO (mg/m³)	O_3 (µg/m³)	C_6H_6 (µg/m³)	BaP (ng/m³)	Pb (µg/m³)	As (ng/m³)	Ni (ng/m³)	Sample Referance
1	2019-01-12	I	68.1	26.6	13.2	24.7	17.8	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/02
2	2019-02-12		70.8	27.5	14.4	26.9	20.6	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/10
3	2019-09-12	II	65.5	25.3	12.1	22.2	14.9	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/34
4	2019-10-12		72.8	28.3	13.4	25.1	17.6	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/40
5	16/12/2019	III	67.6	26.4	14.2	26.3	16.5	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/62
6	17/12/2019		63.8	24.9	12.7	23.7	20.6	0.32	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/68
7	27/12/2019	IV	60.6	23.6	14.2	26.6	18.6	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/103
8	28/12/2019		67.5	26.3	13.5	25.2	20.2	0.40	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/109
9	2020-01-01	V	71.1	27.7	13.3	24.9	18.4	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/02
10	2020-02-01		68.4	26.7	14.1	26.4	20.5	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/08
11	2020-06-01	VI	66.2	24.0	13.9	26.2	14.9	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/42
12	2020-07-01		71.0	27.7	13.7	25.6	19.5	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/48
13	13/1/2020	VII	64.4	25.1	13.0	23.7	19.5	0.43	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/74
14	14/1/2020		70.8	27.7	12.4	23.0	16.8	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/80
15	20/1/2020	VIII	63.0	23.8	12.7	23.7	14.9	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/106
16	21/1/2020		67.2	26.2	14.0	25.8	14.7	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/115
17	28/1/2020	IX	62.5	24.4	12.7	23.7	19.8	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/140
18	29/1/2020		74.4	30.1	13.0	24.3	19.0	0.34	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/146
19	2020-01-02	X	65.6	25.6	14.5	27.3	21.4	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/02
20	2020-02-02		68.7	26.8	12.8	23.5	14.9	0.32	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/08
21	2020-10-02	XI	72.8	31.2	12.1	22.4	15.5	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/38
22	2020-11-02		65.0	25.3	14.5	27.1	15.9	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/44
23	17/2/2020	XII	68.2	27.8	13.5	25.2	15.4	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/65
24	18/2/2020		61.6	22.5	11.7	22.0	14.6	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/71
25	26/2/2020	XIII	68.5	26.2	12.8	23.6	16.1	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/108
26	27/2/2020		66.2	25.8	13.6	25.4	18.8	0.37	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/114
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**60.6**	**22.5**	**11.7**	**22.0**	**14.6**	**0.21**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**74.4**	**31.2**	**14.5**	**27.3**	**21.4**	**0.43**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**67.4**	**26.3**	**13.3**	**24.8**	**17.6**	**0.31**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98^{th} Percentile			**73.6**	**30.7**	**14.5**	**27.2**	**21.0**	**0.43**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ3-Ulwe Sector 5

Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(mg/m^3)	(µg/m^3)	(µg/m^3)	(ng/m^3)	(µg/m^3)	(ng/m^3)	(ng/m^3)	
1	2019-01-12	I	66.5	25.1	14.2	26.4	19.7	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/03
2	2019-02-12		61.9	23.6	13.5	25.1	20.1	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/11
3	2019-09-12	II	70.7	26.9	12.2	22.7	17.2	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/35
4	2019-10-12		64.2	24.4	14.1	26.2	18.6	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/41
5	16/12/2019	III	59.0	24.2	12.6	21.7	17.2	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/63
6	17/12/2019		71.2	27.1	12.0	23.5	19.0	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/69
7	27/12/2019	IV	67.3	25.6	12.7	23.6	18.5	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/104
8	28/12/2019		65.2	24.8	14.5	25.8	17.4	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/110
9	2020-01-01	V	58.1	21.7	11.9	22.1	20.5	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/03
10	2020-02-01		63.5	24.0	13.5	25.0	20.1	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/09
11	2020-06-01	VI	65.3	25.2	14.0	26.3	14.7	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/43
12	2020-07-01		68.5	26.2	13.3	24.7	19.7	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/49
13	13/1/2020	VII	64.6	24.5	14.5	27.2	18.6	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/75
14	14/1/2020		70.2	27.1	14.6	25.6	19.2	0.36	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/81
15	20/1/2020	VIII	67.1	25.5	15.1	27.3	18.0	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/107
16	21/1/2020		64.5	24.2	13.4	24.6	19.1	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/116
17	28/1/2020	IX	62.8	23.8	12.6	23.4	15.5	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/141
18	29/1/2020		71.0	27.2	14.2	26.4	16.2	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/147
19	2020-01-02	X	58.6	21.7	13.3	22.5	18.6	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/03
20	2020-02-02		69.8	26.2	14.0	25.5	18.2	0.32	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/09
21	2020-10-02	XI	64.2	23.7	13.1	24.2	16.0	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/39
22	2020-11-02		67.2	25.5	12.8	23.0	17.1	0.36	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/45
23	17/2/2020	XII	63.7	24.2	13.1	24.4	15.5	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/66
24	18/2/2020		67.2	25.1	13.9	25.6	18.2	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/72
25	26/2/2020	XIII	62.6	23.8	14.5	27.1	15.3	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/109
26	27/2/2020		64.7	24.6	13.3	24.7	18.3	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/115
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**58.1**	**21.7**	**11.9**	**21.7**	**14.7**	**0.17**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**71.2**	**27.2**	**15.1**	**27.3**	**20.5**	**0.36**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**65.4**	**24.8**	**13.5**	**24.8**	**17.9**	**0.26**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98th Percentile			**71.1**	**27.2**	**14.9**	**27.3**	**20.3**	**0.36**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ-4 Gavan Phata Water Tank

Sr. No.	Date of Monitoring	Week	Parameter: PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_X ($\mu g/m^3$)	NH_3 ($\mu g/m^3$)	CO (mg/m^3)	O_3 ($\mu g/m^3$)	C_6H_6 ($\mu g/m^3$)	BaP (ng/m^3)	Pb ($\mu g/m^3$)	As (ng/m^3)	Ni (ng/m^3)	Sample Referance
1	2019-01-12	I	64.5	25.2	12.4	23.1	19.8	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/04
2	2019-02-12		67.2	26.0	12.9	24.0	14.9	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/12
3	2019-09-12	II	63.1	24.6	11.8	21.9	15.2	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/36
4	2019-10-12		66.9	26.1	13.1	24.4	14.6	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/42
5	16/12/2019	III	63.0	25.5	14.4	26.8	.15.2	0.39	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/64
6	17/12/2019		70.2	27.4	13.8	25.7	17.0	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/70
7	27/12/2019	IV	63.6	24.8	12.7	23.6	15.3	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/105
8	28/12/2019		71.2	27.2	11.6	21.6	17.7	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/111
9	2020-01-01	V	63.0	24.6	12.5	23.3	16.0	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/04
10	2020-02-01		68.2	26.3	14.2	26.4	14.2	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/10
11	2020-06-01	VI	70.6	27.5	13.5	25.1	16.5	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/44
12	2020-07-01		69.3	26.8	12.7	23.2	13.7	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/50
13	13/1/2020	VII	65.0	25.2	12.4	22.5	17.0	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/76
14	14/1/2020		68.3	26.0	13.8	25.8	16.5	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/82
15	20/1/2020	VIII	66.2	25.8	14.2	26.1	14.3	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/108
16	21/1/2020		69.1	26.9	13.5	24.7	19.6	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/117
17	28/1/2020	IX	67.1	26.1	12.7	23.6	15.8	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/142
18	29/1/2020		73.2	29.0	14.7	26.8	13.7	0.41	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/148
19	2020-01-02	X	62.8	24.2	12.2	22.7	18.2	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/04
20	2020-02-02		71.0	27.7	14.1	26.2	13.7	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/10
21	2020-10-02	XI	64.4	25.1	12.8	23.8	15.2	0.39	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/40
22	2020-11-02		69.8	27.2	13.7	25.5	19.5	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/46
23	17/2/2020	XII	69.5	26.6	13.4	24.9	22.5	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/67
24	18/2/2020		64.1	25.0	12.5	23.0	20.8	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/73
25	26/2/2020	XIII	72.4	26.8	13.8	25.0	16.1	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/110
26	27/2/2020		64.9	25.3	12.9	24.0	18.2	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/116
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**62.8**	**24.2**	**11.6**	**21.6**	**13.7**	**0.18**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**73.2**	**29.0**	**14.7**	**26.8**	**22.5**	**0.42**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**67.3**	**26.1**	**13.2**	**24.4**	**16.6**	**0.27**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98^{th} Percentile			**72.8**	**28.4**	**14.6**	**26.8**	**21.7**	**0.42**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ5-CIDCO branch Office, Sector 5, Kalamboli															
Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	(ng/m^3)	($\mu g/m^3$)	(ng/m^3)	(ng/m^3)	
1	2019-01-12	I	68.5	26.6	12.9	24.1	19.0	0.38	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/05
2	2019-02-12		71.0	27.8	13.5	25.2	21.5	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/13
3	2019-09-12	II	64.8	25.1	12.9	23.6	18.3	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/37
4	2019-10-12		72.5	28.3	13.8	25.8	20.6	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/43
5	16/12/2019	III	66.5	25.9	12.2	22.9	17.9	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/65
6	17/12/2019		68.9	26.7	13.1	24.5	21.8	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/71
7	27/12/2019	IV	62.7	24.5	14.3	26.7	18.2	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/106
8	28/12/2019		70.1	27.3	13.9	26.0	21.3	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/112
9	2020-01-01	V	65.8	25.7	12.4	23.2	14.8	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/05
10	2020-02-01		68.0	26.5	14.7	27.5	23.5	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/11
11	2020-06-01	VI	70.3	28.6	11.4	21.3	16.0	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/45
12	2020-07-01		67.9	27.5	13.2	24.7	17.2	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/51
13	13/1/2020	VII	72.2	26.8	14.8	27.4	20.3	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/77
14	14/1/2020		70.5	29.9	13.2	24.8	18.3	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/83
15	20/1/2020	VIII	72.8	31.2	12.9	24.1	19.0	0.39	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/109
16	21/1/2020		69.2	27.0	14.4	26.6	21.4	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/118
17	28/1/2020	IX	72.2	28.2	13.5	25.2	19.5	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/143
18	29/1/2020		68.7	26.8	12.7	23.7	21.8	0.36	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/149
19	2020-01-02	X	71.8	28.0	13.2	24.7	17.1	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/05
20	2020-02-02		73.3	28.6	14.0	26.2	18.5	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/11
21	2020-10-02	XI	68.9	26.9	13.7	25.5	19.2	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/41
22	2020-11-02		67.0	26.1	13.3	24.9	17.0	0.41	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/47
23	17/2/2020	XII	72.1	32.5	13.9	26.0	16.3	0.38	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/68
24	18/2/2020		63.0	24.6	14.2	26.6	17.5	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/74
25	26/2/2020	XIII	67.3	26.1	13.5	25.2	14.2	0.43	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/111
26	27/2/2020		67.3	26.0	14.2	26.1	17.8	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/117
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**62.7**	**24.5**	**11.4**	**21.3**	**14.2**	**0.18**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**73.3**	**32.5**	**14.8**	**27.5**	**23.5**	**0.43**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**69.0**	**27.3**	**13.5**	**25.1**	**18.8**	**0.32**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98^{th} Percentile			**73.1**	**31.9**	**14.8**	**27.5**	**22.7**	**0.43**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ6-CIDCO Bhavan, CBD, Belapur, Sector 10																
Sr. No.	Date of Monitoring	Week	Parameter													Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	(ng/m^3)	($\mu g/m^3$)	(ng/m^3)	(ng/m^3)	
1	2019-01-12	I	65.5	25.3	12.2	22.7	20.1	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/06
2	2019-02-12		68.2	26.0	13.8	25.4	17.6	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/14
3	2019-09-12	II	65.5	25.8	12.7	23.6	22.2	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/38
4	2019-10-12		71.5	27.9	13.1	24.1	20.5	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/44
5	16/12/2019	III	67.1	26.2	13.5	25.0	21.7	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/66
6	17/12/2019		70.8	27.6	11.9	22.3	15.8	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/72
7	27/12/2019	IV	63.0	24.6	14.0	26.0	21.5	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/107
8	28/12/2019		68.2	26.0	13.0	24.2	19.4	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/113
9	2020-01-01	V	67.7	25.8	12.4	21.8	20.4	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/06
10	2020-02-01		71.7	28.0	12.9	24.0	16.4	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/12
11	2020-06-01	VI	66.5	25.6	12.0	22.1	16.6	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/46
12	2020-07-01		69.4	27.1	12.6	23.4	21.8	0.37	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/52
13	13/1/2020	VII	70.8	26.7	13.5	25.1	19.8	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/78
14	14/1/2020		64.4	25.1	13.1	24.4	20.1	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/84
15	20/1/2020	VIII	58.3	22.7	13.8	25.7	22.7	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/110
16	21/1/2020		72.2	28.2	12.1	21.8	21.5	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/119
17	28/1/2020	IX	58.0	22.6	12.7	23.6	15.7	0.32	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/144
18	29/1/2020		63.3	24.7	13.4	24.4	19.2	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/150
19	2020-01-02	X	70.5	27.3	13.1	25.2	20.4	0.38	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/06
20	2020-02-02		64.2	25.0	13.3	24.5	23.0	0.43	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/12
21	2020-10-02	XI	67.8	26.4	13.8	25.6	17.5	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/42
22	2020-11-02		67.0	26.1	12.2	22.7	20.2	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/48
23	17/2/2020	XII	63.6	24.8	12.8	23.8	19.0	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/69
24	18/2/2020		61.9	24.1	12.0	22.1	22.8	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/75
25	26/2/2020	XIII	59.5	22.9	11.7	21.8	17.6	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/112
26	27/2/2020		61.2	23.7	13.1	24.1	19.3	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/118
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**58.0**	**22.6**	**11.7**	**21.8**	**15.7**	**0.17**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**72.2**	**28.2**	**14.0**	**26.0**	**23.0**	**0.43**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**66.1**	**25.6**	**12.9**	**23.8**	**19.7**	**0.28**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98^{th} Percentile			**72.0**	**28.1**	**13.9**	**25.9**	**22.9**	**0.43**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ7-Pargaon High school

Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(mg/m^3)	(µg/m^3)	(µg/m^3)	(ng/m^3)	(µg/m^3)	(ng/m^3)	(ng/m^3)	
1	2019-03-12	I	63.9	24.8	12.5	23.4	21.7	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/16
2	2019-04-12		67.2	26.2	11.6	21.7	17.9	0.15	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/22
3	2019-11-12	II	60.3	23.5	13.1	24.5	16.6	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/46
4	2019-12-12		61.5	24.0	10.9	20.4	18.7	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/52
5	18/12/2019	III	67.9	26.7	13.7	25.6	20.3	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/73
6	19/12/2019		58.8	22.9	11.3	21.1	18.7	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/79
7	30/12/2019	IV	65.5	25.5	13.6	25.4	15.1	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/121
8	31/12/2019		56.3	22.1	11.7	21.9	20.9	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/127
9	2020-03-01	V	61.7	24.3	12.0	22.0	14.5	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/13
10	2020-04-01		63.0	24.6	12.5	23.4	21.5	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/19
11	2020-08-01	VI	58.5	21.9	11.3	21.1	15.0	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/53
12	2020-09-01		64.2	25.0	13.5	25.2	18.1	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/59
13	15/1/2020	VII	62.1	24.2	12.8	23.4	15.4	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/89
14	16/1/2020		57.3	22.3	11.7	21.9	19.9	0.16	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/95
15	22/1/2020	VIII	64.2	25.2	11.2	20.5	21.5	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/120
16	23/1/2020		67.8	26.4	13.3	24.4	17.1	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/126
17	30/1/2020	IX	60.7	23.7	11.9	23.5	15.6	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/156
18	31/1/2020		65.0	25.4	13.1	24.2	17.5	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/162
19	2020-03-02	X	59.6	23.2	11.2	21.0	15.2	0.15	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/13
20	2020-04-02		58.1	22.7	13.7	25.6	16.3	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/19
21	2020-12-02	XI	63.3	24.4	11.4	21.3	20.8	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/49
22	13/2/2020		65.0	25.0	13.6	25.4	17.4	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/58
23	19/2/2020		59.2	23.1	10.9	20.4	21.7	0.16	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/81
24	20/2/2020		62.7	24.6	12.2	22.8	17.2	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/89
25	28/2/2020	XII	57.4	21.9	11.5	21.5	21.1	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/121
26	29/2/2020		62.3	23.7	12.9	24.1	14.6	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/127
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**56.3**	**21.9**	**10.9**	**20.4**	**14.5**	**0.15**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**67.9**	**26.7**	**13.7**	**25.6**	**21.7**	**0.31**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**62.1**	**24.1**	**12.3**	**22.9**	**18.1**	**0.22**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98th Percentile			**67.8**	**26.6**	**13.7**	**25.6**	**21.7**	**0.31**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ8-CIDCO Office, Kharghar, Sector 4

Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(mg/m^3)	(µg/m^3)	(µg/m^3)	(ng/m^3)	(µg/m^3)	(ng/m^3)	(ng/m^3)	
1	2019-03-12	I	63.4	24.1	11.4	21.5	18.6	0.16	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/17
2	2019-04-12		69.3	26.3	11.9	22.1	15.7	0.39	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/23
3	2019-11-12	II	72.8	27.1	13.3	24.2	20.7	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/47
4	2019-12-12		67.1	25.5	12.7	23.6	19.1	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/53
5	18/12/2019	III	65.3	24.8	13.4	24.9	20.8	0.34	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/74
6	19/12/2019		56.7	21.5	13.0	24.2	15.6	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/80
7	30/12/2019	IV	63.7	24.2	11.3	21.0	19.4	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/122
8	31/12/2019		66.2	25.0	12.0	22.3	15.8	0.16	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/128
9	2020-03-01	V	70.3	26.7	11.8	21.9	20.6	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/14
10	2020-04-01		69.3	26.3	12.5	23.3	17.6	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/20
11	2020-08-01	VI	60.4	22.7	13.6	25.3	16.4	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/54
12	2020-09-01		58.9	21.8	12.7	23.6	19.7	0.40	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/60
13	15/1/2020	VII	70.1	26.6	14.0	26.0	16.8	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/90
14	16/1/2020		60.7	22.2	12.4	23.1	17.7	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/96
15	22/1/2020	VIII	63.5	24.1	13.5	25.1	18.2	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/121
16	23/1/2020		68.7	26.3	13.1	24.4	17.0	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/127
17	30/1/2020	IX	60.8	23.0	11.9	22.1	18.9	0.38	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/157
18	31/1/2020		65.0	24.7	12.8	23.7	16.9	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/163
19	2020-03-02	X	70.0	25.7	13.6	25.3	17.0	0.32	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/14
20	2020-04-02		65.7	24.6	12.2	22.7	19.1	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/20
21	2020-12-02	XI	69.3	26.3	11.4	21.2	17.5	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/50
22	13/2/2020		71.9	25.5	14.2	26.1	14.7	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/59
23	19/2/2020		63.0	24.0	14.2	26.4	22.5	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/82
24	20/2/2020		60.1	22.3	12.4	23.1	16.2	0.36	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/90
25	28/2/2020	XII	71.8	27.7	13.5	26.8	13.1	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/122
26	29/2/2020		68.0	26.6	13.3	24.7	18.9	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/128
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**56.7**	**21.5**	**11.3**	**21.0**	**13.1**	**0.16**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**72.8**	**27.7**	**14.2**	**26.8**	**22.5**	**0.42**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**65.8**	**24.8**	**12.8**	**23.8**	**17.9**	**0.29**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98th Percentile			**72.4**	**27.4**	**14.2**	**26.6**	**21.7**	**0.42**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ9-CIDCO Guesthouse

Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(mg/m^3)	(µg/m^3)	(µg/m^3)	(ng/m^3)	(µg/m^3)	(ng/m^3)	(ng/m^3)	
1	2019-03-12	I	67.5	25.5	14.2	26.3	20.6	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/18
2	2019-04-12		71.7	27.2	13.1	24.0	21.3	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/24
3	2019-11-12	II	65.9	24.6	12.5	23.4	16.7	0.36	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/48
4	2019-12-12		71.6	27.2	14.4	26.9	19.9	0.28	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/54
5	18/12/2019	III	64.8	24.6	13.8	25.8	19.3	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/75
6	19/12/2019		68.6	26.1	13.1	24.1	22.7	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/81
7	30/12/2019	IV	63.7	24.2	13.7	25.6	20.5	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/123
8	31/12/2019		70.2	26.7	13.3	24.4	21.5	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/129
9	2020-03-01	V	68.2	25.9	12.9	24.1	15.7	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/15
10	2020-04-01		64.9	24.7	12.7	23.7	22.0	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/21
11	2020-08-01	VI	72.3	27.5	12.4	22.5	19.4	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/55
12	2020-09-01		70.5	26.8	14.2	26.6	21.5	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/61
13	15/1/2020	VII	64.7	24.6	13.7	25.6	18.9	0.37	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/91
14	16/1/2020		73.0	27.7	12.6	23.3	20.0	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/97
15	22/1/2020	VIII	71.6	26.8	13.9	26.0	18.1	0.42	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/122
16	23/1/2020		64.0	24.3	13.3	24.7	16.3	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/128
17	30/1/2020	IX	69.6	26.2	14.1	26.4	20.3	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/158
18	31/1/2020		65.9	25.0	13.5	25.2	22.7	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/164
19	2020-03-02	X	62.5	23.4	12.4	23.2	20.3	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/15
20	2020-04-02		66.1	25.0	13.7	25.6	16.5	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/21
21	2020-12-02	XI	72.0	27.4	12.3	23.0	18.4	0.36	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/51
22	13/2/2020		68.8	26.1	13.5	25.2	19.2	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/60
23	19/2/2020		64.1	24.2	14.2	26.4	18.3	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/83
24	20/2/2020		65.8	25.0	12.8	23.9	15.6	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/91
25	28/2/2020	XII	72.0	27.3	12.1	22.6	16.3	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/123
26	29/2/2020		63.8	24.2	13.5	25.2	21.7	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/129
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**62.5**	**23.4**	**12.1**	**22.5**	**15.6**	**0.17**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**73.0**	**27.7**	**14.4**	**26.9**	**22.7**	**0.42**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**67.8**	**25.7**	**13.3**	**24.8**	**19.4**	**0.27**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98th Percentile			**72.7**	**27.6**	**14.3**	**26.8**	**22.7**	**0.40**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ10-Shirdhon

Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(mg/m^3)	(μg/m^3)	(μg/m^3)	(ng/m^3)	(μg/m^3)	(ng/m^3)	(ng/m^3)	
1	2019-03-12	I	58.5	22.0	12.8	23.6	17.5	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/19
2	2019-04-12		63.3	24.1	14.1	26.2	14.1	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/25
3	2019-11-12	II	60.6	23.0	12.5	23.1	20.3	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/49
4	2019-12-12		65.9	25.2	13.4	24.5	18.5	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/55
5	18/12/2019	III	67.0	25.6	14.0	26.0	15.6	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/76
6	19/12/2019		58.2	22.1	13.7	25.5	18.4	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/82
7	30/12/2019	IV	62.7	23.9	12.6	23.0	21.4	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/124
8	31/12/2019		65.1	24.7	13.3	24.7	17.4	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/130
9	2020-03-01	V	59.8	22.5	12.9	23.6	16.2	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/16
10	2020-04-01		62.3	23.7	14.1	26.2	20.3	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/22
11	2020-08-01	VI	67.3	25.2	12.9	24.0	17.2	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/56
12	2020-09-01		68.2	26.0	12.5	23.1	17.8	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/62
13	15/1/2020	VII	58.1	22.1	13.8	25.0	18.5	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/92
14	16/1/2020		60.8	23.0	11.5	21.4	19.7	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/98
15	22/1/2020	VIII	66.2	25.2	12.7	23.3	18.2	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/123
16	23/1/2020		64.8	24.6	13.9	25.8	19.0	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/129
17	30/1/2020	IX	68.1	25.9	12.8	23.4	15.4	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/159
18	31/1/2020		65.5	24.4	13.0	24.2	15.7	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/165
19	2020-03-02	X	62.1	23.5	13.7	25.1	20.4	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/16
20	2020-04-02		57.3	21.8	14.1	26.2	21.0	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/22
21	2020-12-02	XI	67.7	25.7	12.4	23.1	18.1	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/52
22	13/2/2020		63.6	24.2	13.5	24.8	16.7	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/61
23	19/2/2020		66.9	25.4	14.0	26.2	15.2	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/84
24	20/2/2020		62.1	23.6	12.7	23.6	17.8	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/92
25	28/2/2020	XII	58.2	22.1	12.2	22.7	16.3	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/124
26	29/2/2020		61.0	23.0	13.1	24.4	21.3	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/130
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**57.3**	**21.8**	**11.5**	**21.4**	**14.1**	**0.17**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**68.2**	**26.0**	**14.1**	**26.2**	**21.4**	**0.35**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**63.1**	**23.9**	**13.2**	**24.3**	**18.0**	**0.25**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98th Percentile			**68.2**	**26.0**	**14.1**	**26.2**	**21.4**	**0.35**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ11-Hardilia IT Park in TTC Industrial Area

Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(mg/m^3)	(µg/m^3)	(µg/m^3)	(ng/m^3)	(µg/m^3)	(ng/m^3)	(ng/m^3)	
1	2019-03-12	I	63.8	24.2	12.8	23.6	15.8	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/20
2	2019-04-12		61.2	23.0	12.0	22.3	16.6	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/26
3	2019-11-12	II	66.5	25.3	13.3	24.7	17.5	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/50
4	2019-12-12		58.6	22.0	12.9	24.0	20.7	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/56
5	18/12/2019	III	64.2	24.4	13.5	25.1	22.4	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/77
6	19/12/2019		71.0	27.4	13.2	24.3	22.0	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/83
7	30/12/2019	IV	61.2	23.3	14.1	26.2	18.2	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/125
8	31/12/2019		64.9	24.7	12.8	23.7	17.7	0.40	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/131
9	2020-03-01	V	70.7	26.6	13.2	25.0	22.5	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/17
10	2020-04-01		63.3	24.1	12.6	23.4	16.1	0.18	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/23
11	2020-08-01	VI	65.6	24.9	12.2	22.7	19.2	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/57
12	2020-09-01		61.5	23.4	13.3	24.5	15.1	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/63
13	15/1/2020	VII	66.1	24.5	12.8	23.8	18.9	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/93
14	16/1/2020		65.8	25.0	14.2	26.4	22.4	0.37	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/99
15	22/1/2020	VIII	67.1	25.5	12.3	22.9	15.5	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/124
16	23/1/2020		59.9	22.8	12.8	23.8	18.6	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/130
17	30/1/2020	IX	62.7	23.6	14.0	26.0	21.4	0.15	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/160
18	31/1/2020		68.5	26.0	12.7	23.6	22.5	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/166
19	2020-03-02	X	62.4	23.7	13.0	24.2	20.8	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/17
20	2020-04-02		68.8	26.1	13.4	24.9	20.2	0.37	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/23
21	2020-12-02	XI	65.5	24.9	14.2	26.4	20.8	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/53
22	13/2/2020		67.2	25.3	13.5	25.1	21.3	0.20	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/62
23	19/2/2020		70.5	26.8	12.8	23.8	17.0	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/85
24	20/2/2020		61.8	23.3	14.0	26.0	15.2	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/93
25	28/2/2020	XII	66.4	25.2	13.3	24.7	18.8	0.38	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/125
26	29/2/2020		64.0	24.3	12.7	23.5	21.7	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/131
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**58.6**	**22.0**	**12.0**	**22.3**	**15.1**	**0.15**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**71.0**	**27.4**	**14.2**	**26.4**	**22.5**	**0.40**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**65.0**	**24.6**	**13.1**	**24.4**	**19.2**	**0.24**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98th Percentile			**70.9**	**27.1**	**14.2**	**26.4**	**22.5**	**0.39**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIII
AMBIENT AIR QUALITY MONITORING RESULTS

Location : AAQ12-Panvel Market Yard

Sr. No.	Date of Monitoring	Week	Parameter												Sample Referance
			PM_{10}	$PM_{2.5}$	SO_2	NO_X	NH_3	CO	O_3	C_6H_6	BaP	Pb	As	Ni	
			($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	(ng/m^3)	($\mu g/m^3$)	(ng/m^3)	(ng/m^3)	
1	2019-03-12	I	57.2	21.7	12.1	22.1	22.7	0.17	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/21
2	2019-04-12		65.2	24.8	13.0	24.3	16.8	0.22	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/27
3	2019-11-12	II	59.0	22.4	13.8	25.6	15.3	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/51
4	2019-12-12		57.4	21.6	12.5	23.4	18.3	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/57
5	18/12/2019	III	66.2	25.2	13.6	25.4	20.0	0.34	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/78
6	19/12/2019		58.5	22.0	13.0	23.7	18.7	0.23	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/84
7	30/12/2019	IV	65.9	25.0	13.2	24.5	19.2	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/126
8	31/12/2019		59.6	22.6	11.9	22.3	15.6	0.35	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-19/12/132
9	2020-03-01	V	69.5	26.4	12.3	23.0	20.8	0.19	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/18
10	2020-04-01		64.2	24.1	12.5	23.4	19.5	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/24
11	2020-08-01	VI	71.0	27.0	14.3	26.7	15.4	0.26	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/58
12	2020-09-01		67.3	25.6	12.0	21.8	16.3	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/64
13	15/1/2020	VII	62.8	23.9	12.8	23.9	19.9	0.16	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/94
14	16/1/2020		67.2	25.5	13.1	24.5	15.3	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/100
15	22/1/2020	VIII	57.1	21.7	12.9	24.1	23.5	0.21	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/125
16	23/1/2020		69.5	26.4	13.5	25.0	13.8	0.37	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/131
17	30/1/2020	IX	64.5	24.5	13.8	25.8	21.6	0.24	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/161
18	31/1/2020		70.3	26.8	11.9	22.3	20.2	0.29	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/01/167
19	2020-03-02	X	63.5	24.1	13.3	24.9	18.2	0.34	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/18
20	2020-04-02		61.6	23.4	12.6	23.6	16.5	0.30	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/24
21	2020-12-02	XI	65.9	25.0	14.3	26.7	15.3	0.27	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/54
22	13/2/2020		72.8	28.2	14.0	27.6	22.5	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/63
23	19/2/2020	XII	60.8	23.1	11.4	21.3	17.5	0.25	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/86
24	20/2/2020		63.4	24.0	13.8	25.8	18.7	0.33	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/94
25	28/2/2020	XIII	59.7	22.7	13.0	24.3	19.6	0.37	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/126
26	29/2/2020		64.0	24.3	14.2	26.6	21.7	0.31	<2.0	<1.0	<0.1	<0.1	<1.0	<1.0	ACD.A-20/02/132
CPCB Limits			**100**	**60**	**80**	**80**	**400**	**2**	**180**	**5**	**1**	**1**	**6**	**20**	
Minimum			**57.1**	**21.6**	**11.4**	**21.3**	**13.8**	**0.16**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Maximum			**72.8**	**28.2**	**14.3**	**27.6**	**23.5**	**0.37**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
Average			**64.0**	**24.3**	**13.0**	**24.3**	**18.6**	**0.28**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	
98^{th} Percentile			**71.9**	**27.6**	**14.3**	**27.2**	**23.1**	**0.37**	**<2.0**	**<1.0**	**<0.1**	**<0.1**	**<1.0**	**<1.0**	

ANNEXURE-XIV
BNHS REPORT

BASELINE DOCUMENTATION OF FLORA AND FAUNA OF KARNALA BIRD SANCTUARY (KBS) AND NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT AREA FOR PREPARATION OF CONSERVATION AND PRESERVATION PLAN

ANNEXURE-XIV (A)
PART I: FLORAL AND FAUNAL STUDY

BASELINE DOCUMENTATION OF FLORA AND FAUNA OF KARNALA BIRD SANCTUARY (KBS) AND NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT AREA FOR PREPARATION OF CONSERVATION AND PRESERVATION PLAN






BASELINE DOCUMENTATION OF FLORA AND FAUNA OF KARNALA BIRD SANCTUARY (KBS) AND NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT AREA FOR PREPARATION OF CONSERVATION AND PRESERVATION PLAN - PART I

BASELINE DOCUMENTATION OF FLORA AND FAUNA OF KARNALA BIRD SANCTUARY (KBS) AND NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT AREA FOR PREPARATION OF CONSERVATION AND PRESERVATION PLAN

PART - I

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1. INTRODUCTION

Biodiversity provides fundamental building blocks such as clean air, fresh water and nutrition for our survival. It is an essential component of many invaluable ecosystem services necessary for human welfare and livelihoods. Hence, understanding the impacts of rapid urbanisation around the globe on biological diversity has become crucial for its conservation (Mckinney 2002).

Urban development not only results in the fragmentation of habitats but also abets the extinction of native species and influences the invasion of non-native species (Mckinney 2008, Czech et al. 2000). It has been seen that even though cities do support regional biodiversity and native species, this has been profoundly affected by the process of urbanisation, leading to a substantial decrease in species densities across cities worldwide. Though there is an awareness about the threats of urbanisation, a thorough understanding at the levels at which it has altered biodiversity at the global scale is lacking (Aronson et al. 2014).

The most direct impact of urbanisation on biodiversity is the change in land cover associated with urban growth. Urban growth is clearly a significant global driver of land-use conversion and deforestation. Urban areas occupy approximately 3% of the Earth's land surface (McGranahan et al. 2006), although the actual number varies significantly depending on the definition of urban and the spatial grain of analysis (Schneider et al. 2009, Seto et al. 2010). A land-cover change associated with urbanisation causes considerable impacts on temperature and precipitation in and around urban areas (Seto and Shepherd 2009). They also affect many factors that impact water quality, including erosion, nutrient loading, and biogeochemical cycling. In many cases, natural habitats have lower rates of erosion and a greater capacity to absorb excess nutrients and pollutants than anthropogenic habitats. Thus, urbanisation affects land cover, which in turn affects the quantity and quality of water available.

Habitat conversion driven by urbanisation will be particularly critical in tropical areas in the future, especially in coastal and island systems, as well as biomes that are disproportionately urbanized. Cities are known to be concentrated along coastlines and major river systems, areas that also represent high species richness and endemism (Luck 2007). The world's 20 fastest-growing urban regions have been identified to be in Asia and Africa. It is hypothesized that urban growth in the coming decades will takes place primarily in Asia (China and India in particular) and in Africa (especially Nigeria) and into farmland, forests, savannas and other ecosystems (Seto et al. 2012). Approximately 400 million people are known to live within 20 m of sea level and within 20 km of a coastline globally (Small and Nicholls 2003). Many Asian countries that are largely rural are undergoing massive shifts in population trends along with economic growth, resulting in a growing percentage living in urban areas. For example, the combined populations of Kolkata and Dhaka in the Ganges–Brahmaputra Delta increased from 4.9 million in 1950 to more than 30 million in 2010 (Seto et al. 2012b). With these growing population shifts, urbanisation has become an unavoidable part of economic development. This situation has also prompted the need to identify, prioritise, conserve and manage global key biodiversity areas.

Global key biodiversity areas with high species endemism and facing exceptional habitat loss are identified as 'biodiversity hotspots' and they have been tremendously helped in concentrating conservation efforts in these areas. Predominantly, most of these 'hotspots' are situated in the tropics, which means they are located in developing countries where threats to biodiversity is greatest and there is scarcity of conservation resources (Myers et al. 2000). Urban land expansion is occurring rapidly in areas adjacent to biodiversity hotspots and even more rapidly in low-elevation, biodiversity-rich coastal zones than in other areas. Cities are increasing geographically at a fast pace, particularly in key biodiversity hotspots, which bring along an array of anthropogenic pressures to local biodiversity (Seto et al. 2012, Aronson et al. 2014). Almost 90 % of known protected areas are likely to be impacted by future urbanisation in rapidly developing low- and moderate-income countries (McDonald et al. 2008). The growth rate of human population in hotspots is substantially higher than that of the world as a whole. This suggests that massive human-induced environmental changes are likely to continue in the hotspots and population growth and expansion of human settlements will increase challenges for the conservation of species-rich regions in the future. (Cincotta et al. 2000, Luck

2007). Five biodiversity hotspots are forecasted to have the largest percentage increase in adjacent population and highest probability of becoming urbanised by 2030: the Guinean Forests of West Africa, the Caribbean Islands, Japan, the Philippines, the Western Ghats of India and Sri Lanka (Seto et al. 2012b). The Western Ghats is one of the most densely populated biodiversity hotspot in the world.

The Western Ghat ranges run parallel to west coast from Dangs in Gujarat to the Kanyakumari in Tamil Nadu, for over 1600 km (Joshi and Karanth 2013). This highly heterogeneous mountain range is extremely rich in terms of biodiversity, especially in its endemic flora and fauna. This region is home to over 7,000 species of flowering plants, out of which 38% are endemic to the range. It also harbours around 330 species of butterflies (11% endemic), 156 species of reptiles (62% endemic), 190 species of amphibians (75% endemic), 289 species of fishes (41% endemic), 508 species of birds (4% endemic), and 139 species of mammals (12% endemic) (Myers et al. 2000, Dahanukar et al. 2004, Nayar et al. 2014). Even though the forests of this region have been fairly explored in the past, recent discoveries across taxa show that there may still be a lot of unknown species yet to be discovered (Biju et al. 2014, Robin et al. 2017). Despite this, there has been a significant amount of forest loss and degradation in the past across different parts of the Western Ghats due to changes in land use pattern and deforestation (Jha et al. 2000, Reddy et al. 2013). A majority of the pristine habitats in the Western Ghats have been identified as protected areas primarily to conserve critical and threatened species. In addition to this, recently the Ministry of Environment, Forest and Climate Change (MoEFCC) issued a notice demarcating 37% of the Ghats which is roughly around 57,000 sq. km as Ecological Sensitive Areas (ESAs) based on the report submitted by High-Level Working Group (Kasturirangan 2013).

Western Ghats have been further divided into four zones based on plant species composition - northern Western Ghats, central Western Ghats, Nilgiri Mountains and southern Western Ghats (Subramanyam and Nayar 1974). The northern Western Ghats extends across the three states, namely Gujarat, Maharashtra and Goa. This region is much lower in altitude than most of the other zones of Western Ghats. It is covered by fragmented patches of forests as well as intensively used land-use patterns. The western region of Maharashtra is composed of the northern Western Ghats, with thin strip of mountains sandwiched between the Konkan plains (on west) and Deccan plateau (on east) with their characteristic flat tops. This unique topography is due to intense physical and chemical weathering of parent rock basalt which in many areas has exposed duricrusts with scarce soil cover (BVIEER 2010, Watve 2013). Key drivers of this weathering are rainfall and wind. In the four months (June–September) of south west monsoon, the northern Western Ghats receives heavy rainfall. Though this region receives the highest rainfall, it experiences dry weather over more than half the year due to unequal distribution of monsoon. The variability in rainfall and topographic diversity has generated a wide variety of vegetation types – semi-evergreen forests on the western side and at high altitudes to dry deciduous forests and scrub vegetation on the eastern slopes and lowlands (BVIEER 2010) to highly seasonal and endemic herbaceous plant communities of lateritic plateaus, which only exist for 2–3 months in monsoon (Watve 2013). This variable climate and available habitats also influence species diversity and distribution across the landscape. As already discussed the northern Western Ghats is the most fragmented zone in the Western Ghats; looking at the rapid urbanisation of the existing cities, especially coastal cities and mega-cities such as Mumbai, Panjim and Pune situated in the core of the northern Western Ghats, the future scenario indeed appears alarming.

There is a visible global trend in the expansion of coastal cities and Mumbai is no exception to this. The city, which is located in the Konkan plains of the northern Western Ghats, has always been a centre of development since europian colonisation owing to its key geographic position and abundance of the natural resources. It is the financial capital of the nation and ninth populous city in the world [current population of 26.6 million (UN 2012)]. Mumbai Metropolitan Region Development Authority (MMRDA), the planning authority for Mumbai Metropolitan Region (MMR), has predicted in its 40-year concept plan that the city would have 44 million inhabitants by 2052, spread over 1050 sq. km which is almost double the present area of 603 sq. km (Kamdar 2014). This means there will be tremendous pressure on the already shrunken natural habitats, especially mangroves and remnant patches of the natural forests, and that will eventually impact the biodiversity (Nagendra et al. 2013). Considering the coastal nature of the city, disappearance of the natural vegetation (biodiversity in general) may not only leave the city vulnerable to local environmental issues such as floods, run off of pollutants, reduction in the ground water but also global disasters such as cyclone, tsunamis and sea level rise due to global climate change (Kleppel et al. 2006). It is indeed very crucial now to understand how changing land use patterns would influence the local biodiversity in MMR in order to take up its conservation and management, thus enabling it to keep this unique costal ecosystem healthy and sustainable in the future.

In general, this research is designed to predict the impact of anthropogenic activities on biodiversity of this landscape and suggest conservation measures, especially related with airport construction in this case but not restricted to it. The specific objectives of the study are listed below:

1.1 Objectives

1. Documenting the biodiversity and selected representative taxa of the region

2. Identifying keystone, threatened or schedule, and habitat specialist species to establish their scientifically robust long-term monitoring protocols

3. Developing species richness maps

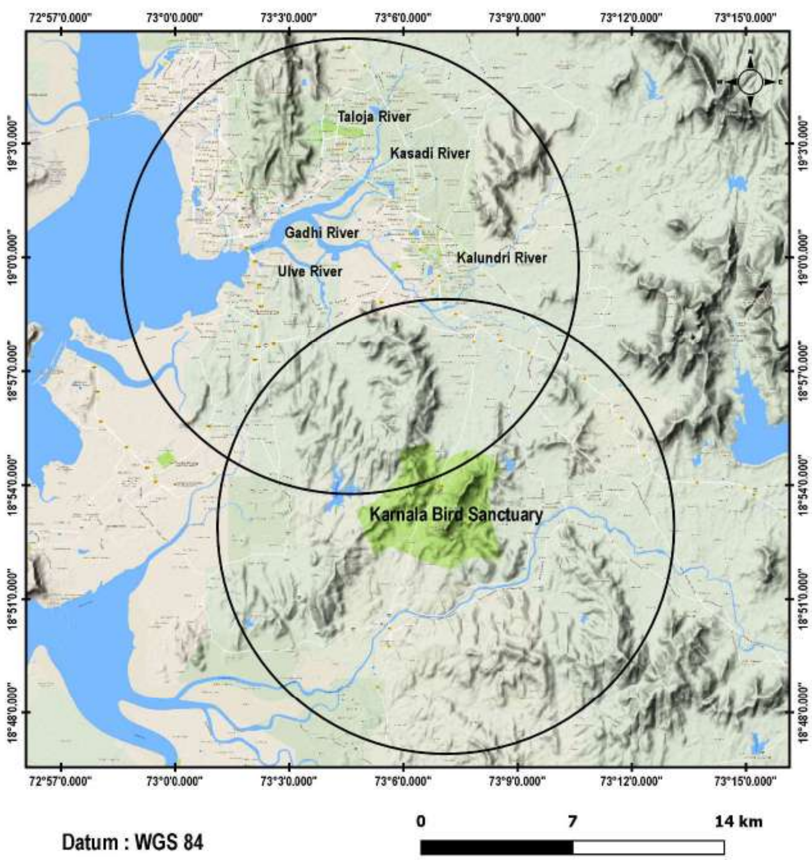
4. Identifying vulnerable key biodiversity areas

5. Developing a biodiversity conservation plan

2. MATERIALS AND METHODS

2.1 Study area

The study area was broadly divided into two scales – study site (actual airport site and 10 km radius circle around the site) and landscape (area around the study site) to maintain the balance between government norms and regulations for biodiversity assessment and scale essential for understanding the biodiversity and ecology of the species in order to develop ecologically sound conservation management plan.



Map. 1 Physical map of Navi Mumbai International Airport Site (NMIA) and Karnala Bird Sanctuary (KBS) with 10 km radius circle

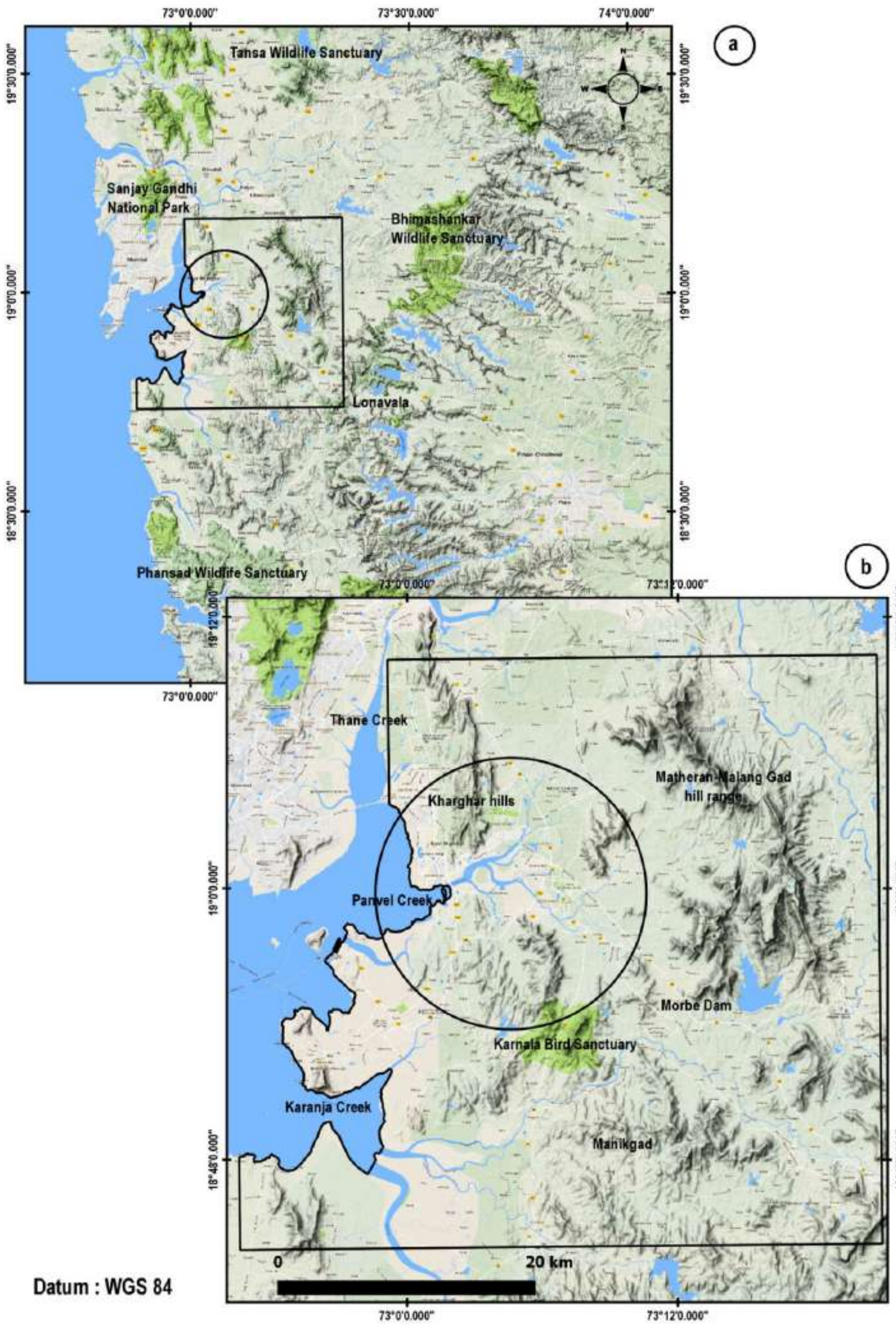
2.1.1 Study site

The proposed Navi Mumbai International Airport (NMIA) is situated (18°59'33"N, 73°04'18"E) in Panvel Taluka, Raigad District, Maharashtra. The entire area of the airport falls in two tehsils named Panvel and Uran covering 10 villages. The actual airport site, area of 1160 hectares, is bound by the Kalundre River on the north and east and JNPT road on the south. Overall, the terrain is flat except low elevated hills of Karnala Bird Sanctuary (KBS) on the south and Kharghar Hills on the north (Map 1). Geologically the area is made of basalt, well known as "Deccan Trap" – characterised by flat-topped summits and step-like appearance of rock layers, clearly seen at places like Matheran. The climate is tropical maritime with high humidity throughout the year, mostly remaining between 44% to 76%. Average annual temperature is 27.2 °C and annual rainfall is 2167 mm (Anthony 2007). The entire area is drained by five main rivers - Taloja and Kasadi in the north, Kalundre and Gadhi in the east and Ulwe in the south. More than half of the study site is covered with settlement (31%) and agriculture (33%) followed by scrub forest (19%), moist deciduous forest (5%), grassland (5%), mangrove (5%) and water (4%). For detailed information of the study site, refer EIA report of NMIA prepared by IIT, Mumbai.

2.1.2 Landscape

The landscape covers an area of approximately 1976 sq. km. It is demarcated taking into consideration ecologically important features of the region such as mangroves of Thane, Panvel and Karanja creek (on the west), moist deciduous forest of Karnala Wildlife Sanctuary (KBS) and Manikgad (on the south) and semi-evergreen to moist deciduous forest of Prabalgad-Matheran-Malanggad Hill Range (PMHR, on the east and north-east) (Map. 2 a, b). These are remnant patches of the natural vegetation. They are still interconnected and may function as corridors for connecting the other such isolated patches like Sanjay Gandhi National Park on the north-west, or link up with the main mountain range of northern Western Ghats through Manikgad–Khopoli on the south-east. Such corridors are very crucial for comparatively large bodied and mobile species like birds and mammals. Therefore, it seems ecologically rational to assess the potential of these areas for long term conservation and management of biodiversity of MMR while looking at the pace of development in this region.

Note - Environmental impact assessment (EIA) report of this airport project was submitted by IIT, Bombay to the MoEF for Environment and CRZ Clearance in June 2010; BNHS, on its part, is assisting Maharashtra Forest Department to develop conservation and management plan for the biodiversity of Karnala Bird Sanctuary and Ecological Sensitive Area (ESA) within the 10- km radius from the actual airport site

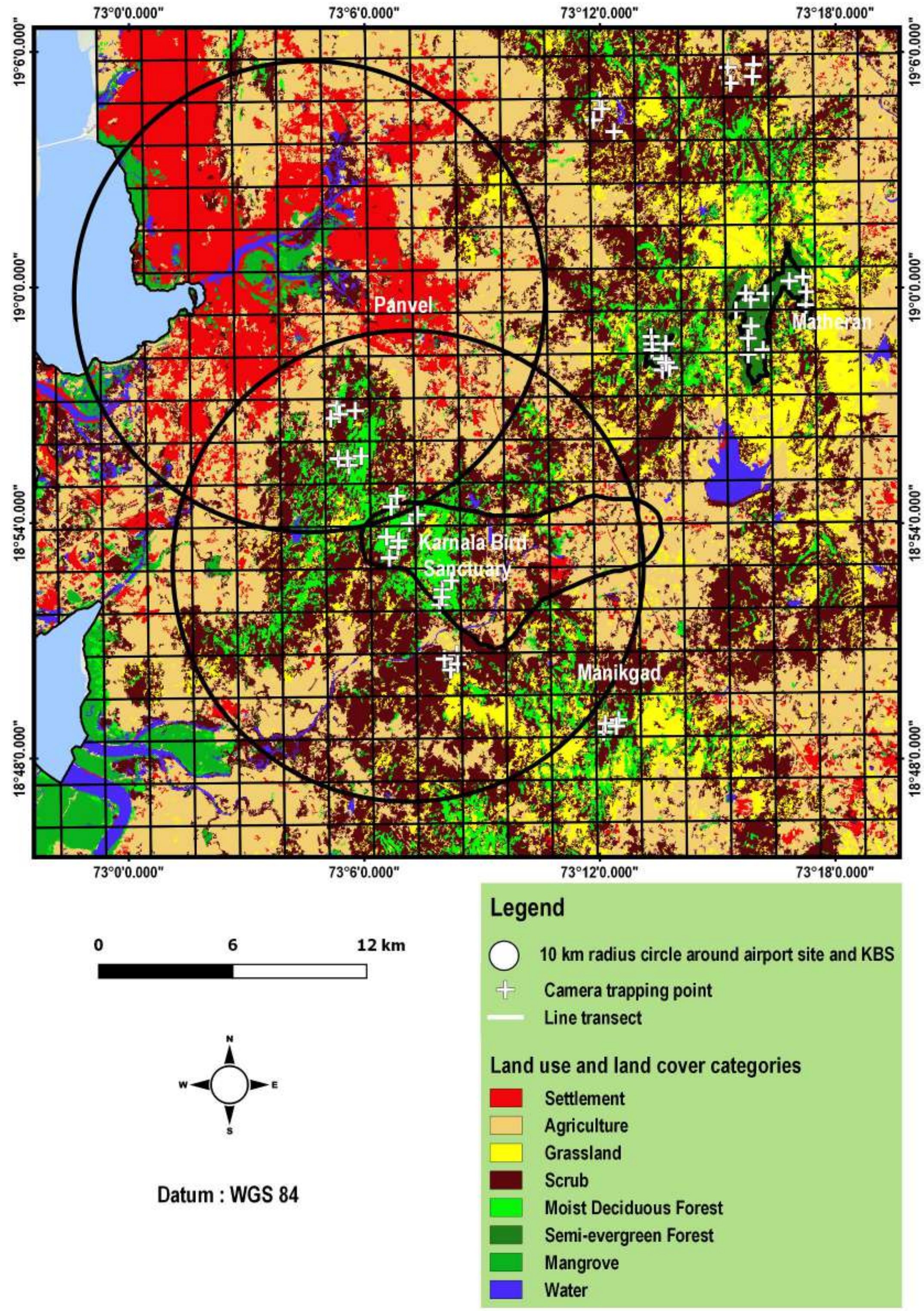


Map. 2 Map of NMIA site and landscape. a) Map showing position of the landscape in the context of the Western Ghats mountain range and protected areas. b) Map illustrating ecologically important features of the landscape

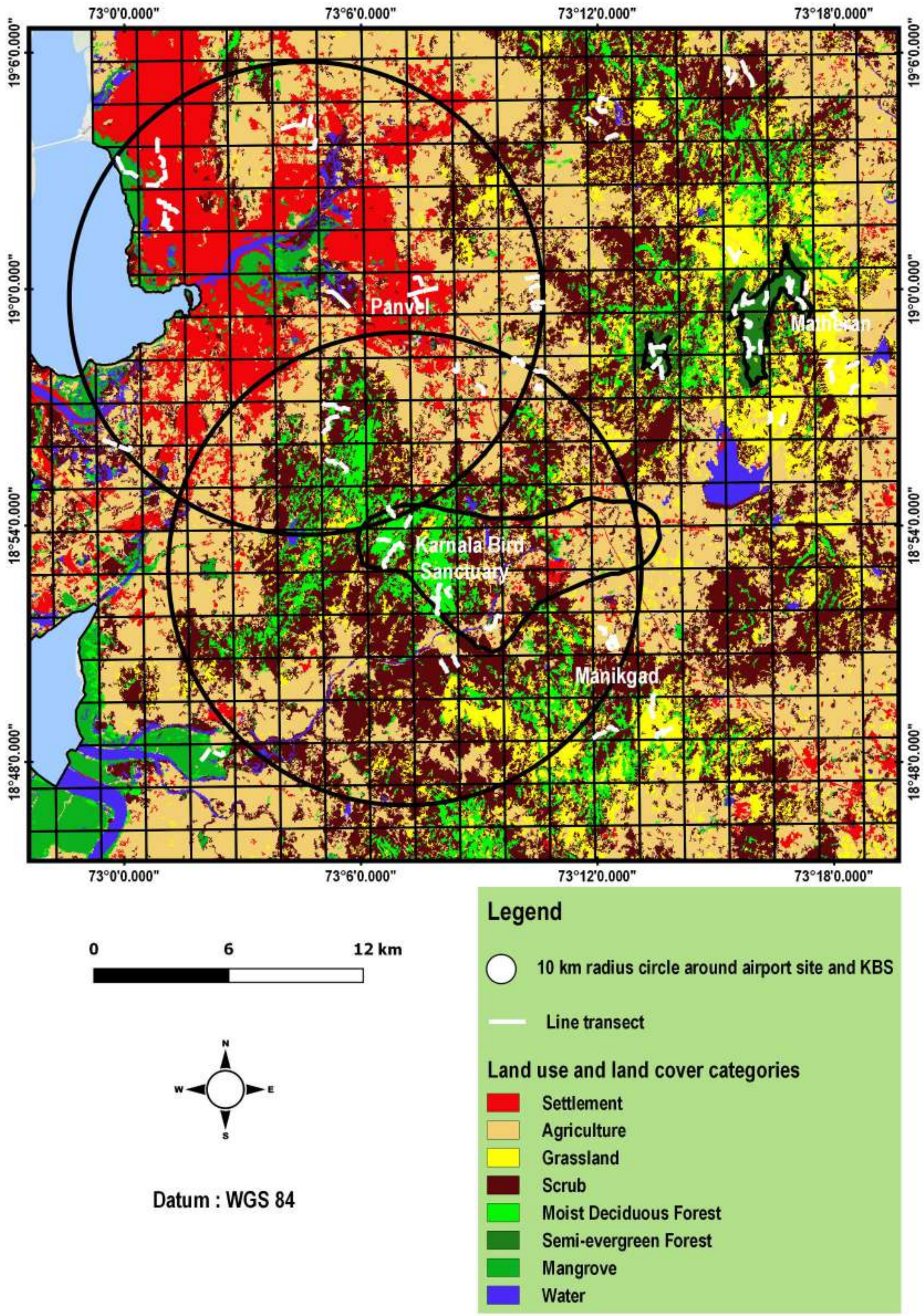
Apart from the biodiversity, the hydrological role of these key ecological areas is also vital. In addition to the rivers mentioned in the study sites, the landscape has two main rivers – Ulhas and Patalganga. Both rivers originate near Khandala, situated in the main mountain range of the northern Western Ghats. The Ulhas River runs through eastern boundary of the landscape, almost parallel to PMHR, and receives eastward flowing streams/tributaries originating from this hill range. On the other hand, the Patalganga River runs through the southern side of the landscape and during this course, receives streams/tributaries from PMHR, Karnala and Manikgad hills and finally merges into the Karanja Creek. In addition to rivers, two large water reservoirs are located at Morbe and Ransai. Ransai reservoir is located on the north-west of KBS while Morbe Dam is situated on the south of PMHR, which harvests its water from these hills and it is the main water source for Navi Mumbai.

Though this landscape is one of the highly populated and developing regions in the world, it is still largely covered with agricultural habitat (34%) followed by scrub (29%) and settlement (11%); so almost 2/3 of the landscape is occupied by degraded habitats. However, less disturbed (primary or secondary) natural habitats such as moist deciduous forest (7%), semi-evergreen forest (1%) and mangrove (3%) cover only 11% of the landscape. These land use and land cover types show clear pattern of distribution along the elevation gradient. The lowest elevation (7–11 m asl) was occupied with mangrove forest; these were mostly coastal and estuarine areas such as Thane, Panvel and Karanja Creeks. Slightly higher elevation (16–48 m asl) was occupied with agricultural fields. As one ascended further (33–200 m), the landscape was covered with scrub forest; these were easily accessible areas mostly located near villages or at the base of the hills, while moist deciduous forest and grasslands were spread (47–365 m asl) between agricultural fields and semi-evergreen forest. These were found at KBS, Manikgad and mid to lower elevation of PMHR. Moist deciduous forest was replaced with semi-evergreen forest at higher elevations (> 533m) such as Matheran and Prabalgad.

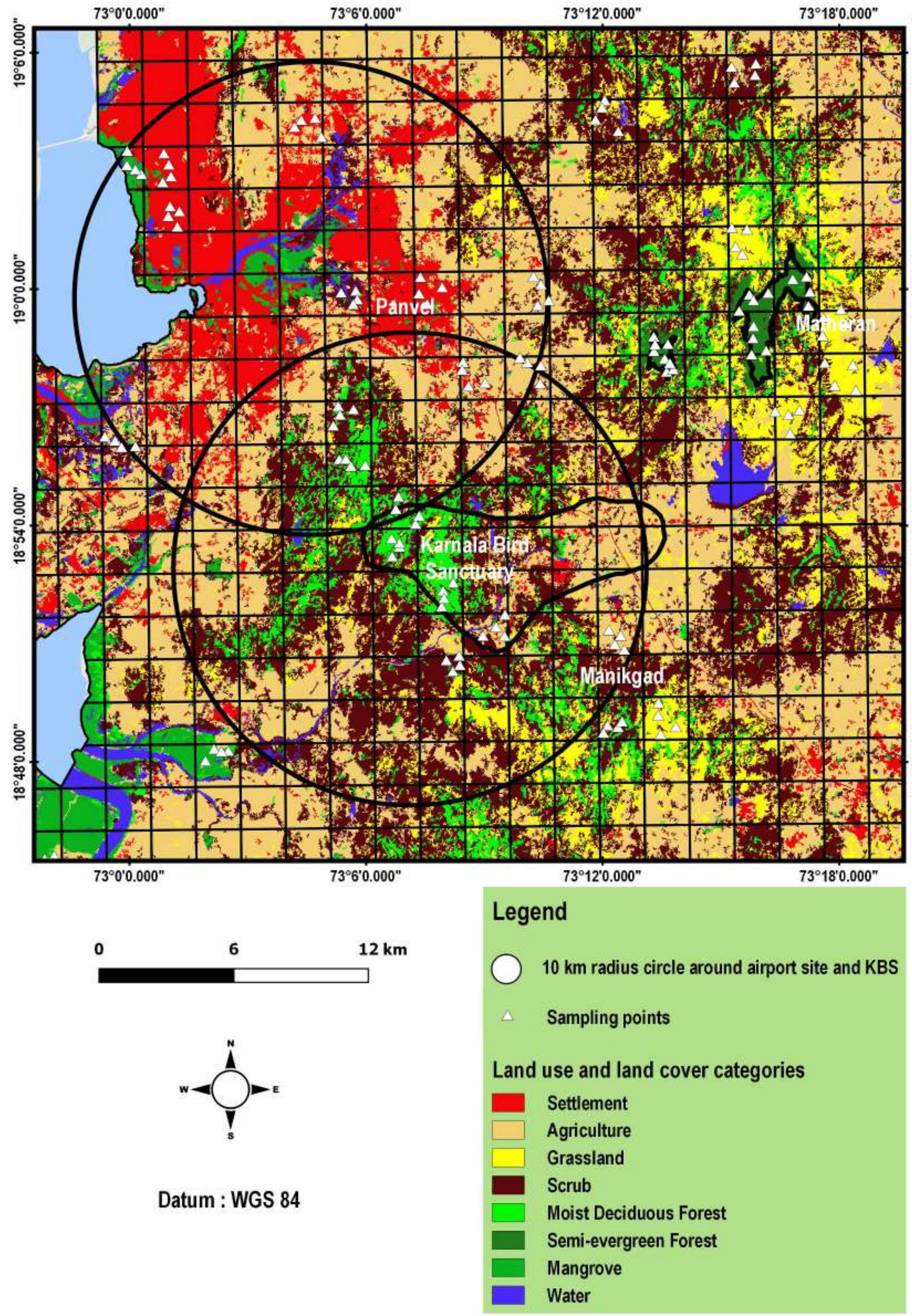
We divided the landscape into 2 sq. km grids for the assessment of the biodiversity (mammals, amphibians, reptiles, insects and plants) (Map 3). Five grids in each of these seven habitats – semi- evergreen forest, moist-deciduous forest, scrub, mangrove, grassland, agriculture and settlement (n=35) – were selected for sampling. In each grid, four random points were generated with > 200m apart, these sampling points were treated as replicates for estimating occupancy of the target taxa using multispecies occupancy model (Map 3).



Map 3 a. Map showing the sampling design for occupancy estimation of mammals in the landscape.



Map 3b. Map showing the sampling design for occupancy estimation of insects in the landscape.



Map 3c. Map showing the sampling design for occupancy estimation of amphibians, reptiles, birds and plants in the landscape

3. MULTISPECIES OCCUPANCY MODEL

Ecologists, conservation biologists and resources managers are always interested in the abundance and occurrence of species. However, when dealing with populations or communities, one realises that census (i.e.a complete enumeration) of individuals can rarely be achieved for an area of study. Eventually, we have to rely on inferences drawn from the samples. In addition to this, some individuals may not be detected during the sampling periods, which make the estimations more complicated. The failure to detect the individuals (i.e. imperfect detection, $p < 1$) may be due to a number of reasons (e.g. behavioural differences, colour, size of the individuals, differences in observers' ability etc). When a study fails to incorporate the detection probability, these imperfect detections result in the underestimation of the total number of individuals and species richness, as has been reported in a number of investigations (MacKenzie et al. 2002, Dorazio 2006, Kery and Schaub 2011).

To resolve this issue, we need a statistical framework which accounts for the detection probability while estimating the occupancy of species. Hierarchical models (also known as hierarchical state and space model) explicitly provide this framework. All ecological observations constitute two processes – one, an ecological process in which we are interested and two, an observational/measurement process which is conditional on the ecological process (Royle and Dorazio 2008). These are special class of regression models in which one or more submodel(s) (observational or measurement process model e.g. presence –absence of species in this case) conditionally depend on other submodel (ecological process model e.g. occupancy of species in this case), they shows hierarchical nature of processes hence called as hierarchical models. In most of the ecological studies, ecological processes are unobserved or partially observed (e.g. occupancy or abundance); we have to estimate them using observation through observational model containing probabilistic description of mechanism that has produced the observational data. This hierarchical framework appears more natural for studying ecological systems in which we found hierarchies of organisation e.g. population, metapopulations, communities and metacommunities.

These hierarchical community models have been recently formulated and they are growing rapidly to extract information at metacommunity level (e.g. multiple site), community level (single site) and individual species level, based on the occurrence (be precise detection and non-detection) data of the multiple species at different sites. This cohesive approach is based on i) non-detection (false absence), which can be distinguished from true absence through repetitive sampling and ii) species specific estimates can be improved using collective data of all species observed during sampling. The latter idea is useful for communities including rare species which have too few observations to estimate the occupancy (Zipkin and Royle 2010). Hierarchical community models produce estimates for rare species and while doing so, account for the detection probability (measurement error), therefore providing an unbiased and robust approach for parameter estimates at multiple levels of organisation (e.g. species to metacommunity) which is crucial for the conservation or management practices.

Hierarchical state and space model can be used to formulate site occupancy model, as discussed previously. To reiterate, it is the linking of two regression models – ecological process model for occupancy of each species and observational model for detection of the species conditioned on occupancy (Kery and Schaub 2011, Royle and Dorazio 2008).

We assume that occurrence (i.e. true presence/absence) of species i = 1, 2 ...N at a site j = 1, 2 ... J is a binary state denoted by $z(i, j)$, where $z(i, j) = 1$ when species is present and zero otherwise. But, due to imperfect detection ($p<1$), true occurrence is latent (unknown), thus it is modelled as Bernoulli distribution i.e. $z\ (i,j) \sim \text{Bern}(\Psi_{i,j})$, where $\Psi_{i,j}$ is the probability of species i occurring at site j. Instead, what we observed is data $x(i,j,k)$ for species i at site j during replicate k=1,2...K. The observational model also follows the Bernoulli distribution $x(i,j,k) \sim Bern(p_{i,j,k}.z(i,j))$ where $p_{i,j,k}$ is detection probability of species i at site j during replicate k, only when $z(i,j) = 1$, if $z(i,j)=0$ then $x(i,j,k) = 0$.

We assumed that the occurrence ($\Psi_{i,j}$) and detection ($p_{i,j,k}$) probabilities varied by species and were influenced by the habitat and survey specific factors respectively (also known as occupancy covariate and detection covariate). These effects were incorporated in the model using logit link function (Kery and Royle 2015; Kery and Schaub 2011). Simplest model specifications are logit ($\Psi_{i,j}$) = u_i + α_j (occupancy model) and logit ($\theta_{i,j}$) = v_i+ β_j (detection model), where u_i and v_i are species-level effect and αj and β_j are site effect. We followed this approach and incorporated elevation and proportion of land use and land cover (LULC) as predictors of occupancy of species. Here, to avoid complexity of model and to tackle the small sample size, we pooled seven LULC types into three ecologically meaningful categories – semi-evergreen forest, moist-deciduous forest and mangrove as a forest; scrub forest and grassland as a degraded forest; and human settlement and agriculture habitat as an anthropogenic habitat. The mean elevation and LULC proportions were extracted from 200 m buffer around the sampling point for amphibians, reptiles and birds and 100 m and 200 m buffer along transects for insects and mammals respectively. Among these covariates, we discarded those with correlation (r > 0.50) and variance inflation factor (VIF) > 10 (Neter et al. 1990, Chatterjee and Price 1991). Thus, our occurrence model for species i at site j can be formulated as

logit ($\Psi_{i,j}$) = $u_i + \alpha 1_i$ elevation $_j$+ $\alpha 2_i$ forest $_j$ + $\alpha 3_i$ anthropogenic habitat cover $_j$

Occupancy covariates were standardised so that the mean of elevation, forest and anthropogenic habitat cover were zero. Therefore, inverse-logit of u_i was occupancy of species at mean values of the occupancy covariates. The coefficients α1, α2, α3 were effect of elevation, forest and anthropogenic habitat cover on occupancy of species i respectively. Similarly, we assumed that detection probability of the species i was influenced by survey covariates. We included survey date, time, efforts, humidity, temperature, height of understorey and tree density as species specific survey/ detection covariates. While considering multitaxa analysis (some covariate were not ecologically meaningful for particular taxa), correlation among survey covariates, and sample size of the study (to avoid over parameterization of the model), we did not include all covariate in any model. We assumed that the community was closed during the survey period of one year and any fluctuations in detection between seasons were accounted by date effect. In spite of statistical issues with pooling data of different seasons, we did it because of small sample size and to keep the model simple to understand and predictions related to biodiversity conservation and management practices which are the main objectives of the project. Our detection model for species *i* at site *j* during replicate $_k$ can be formulated as

logit ($\theta_{i,j,k}$) = v_i + $\beta 1_i$ date $_{j,k}$+ $\beta 2_i$ time $_{j,k}$ + $\beta 3_i$ humidity $_{j,k}$ + $\beta 4_i$ temperature $_{j,k}$ + $\beta 5_i$ understorey height $_{j,k}$ + $\beta 6_i$ tree density $_{j,k}$

Similar to occupancy, we standardised detection covariates; hence inverse-logit of v_i was detection probability of species at mean values of the detection covariates. The coefficients β1- β6 were effect of date, time, humidity, temperature, understorey height and tree density on detection probability of species *i* respectively.

One of the advantages of using this model was that it dealt with rare species, because rare or uncommon species are found in most of communities and they have very low detections to estimate the parameters species-by-species. However, if treat species as fixed effect then we have to estimate parameters separately for each species which is statistically complicated and erroneous. Therefore, we assumed that species level parameters were random effect, governed by community level hyper-parameter. For example, we assumed that $\alpha 1_i \sim N(\mu_{\alpha 1}, \sigma_{\alpha 1})$ where $\mu_{\alpha 1}$ is community response (mean across species) to elevation and $\sigma_{\alpha 1}$ standard deviation (among species); thus hyper-parameters were simply mean and variance for each parameter measured across the species (Kery and Royle 2015).

We adopted Bayesian approach for estimation of model parameters because hierarchical models are naturally analysed with this approach (Gelman and Hill 2007). We used vague priors for hyper parameters (e.g. uniform distribution from 0 to 1 for community level occupancy and detection covariates; normal distribution with mean 0 and variance 100 for community level occupancy (site) and detection (survey) covariates). The model was run in JAGS (Plummer 2003) using the runjags (Denwood 2016) package in the program R (R Development Core Team, 2015). We ran three parallel chains with 10,000 Markov Chain Monte Carlo (MCMC) iterations after burn in ranged from 40,000 for mammals to 1, 40,000 for butterflies (burin in for other taxa were between this range) and with thinning rate of 10. Hence the inferences were based on final 3000 samples drawn after burn in and thinning. We diagnosed the convergence of the MCMC chains through visual inspection of chain mixing plots and using the Gelman-Rubin statistic R-hat ("psrf" in runjags, with value close to 1 indicates convergence, Gelman and Rubin 1992). Model fit was assessed using Pearson's residuals χ^2 by comparing the observed residuals to residuals from data simulated under the model. We calculated the Bayesian P-value as Pr (χ^2 obs > χ^2sim) with values larger than 0.95 or smaller than 0.05 indicating a lack of fit (Gelman et al. 2004).

CHAPTER 1
MAMMALS

1.1 Sampling design

We used camera trapping and line transect methods for sampling mammals in the study area. Four camera-trapping points with minimum 200 m apart and within 50 m radius around random sampling sites were selected (Map 3a). Infrared digital camera traps (Cuddeback Digital E2) were attached on suitable tree trunks at approximately 40 cm from the ground using cable lock and a metal protective case. We placed camera traps near animal trails, paths, water bodies, fruiting trees and other signs such as scat, pugmarks, hoof marks, feeding signs to maximize trapping success. The cameras were run for seven consecutive nights at each sampling site, once in summer and winter. Due to high rate of stealing and damaging of camera traps near human settlement, agriculture fields and grasslands, camera trapping was conducted in only three habitats viz. semi-evergreen forest, moist-deciduous forest and scrub forests.

We selected two 1 km transects in each grid. In forest and degraded forest, mostly the pre-existing paths were chosen, but we strictly avoided main roads and paths heavily used by people and cattle. We walked each transect with constant speed early morning (7.00–10.30) and late evening (19.30–23.00), recording diurnal and nocturnal mammals. The mammals seen or heard while walking through the transect and the indirect evidence of their presence like scat, pellets, pugmarks, hoof marks, scratch marks, wallows, carcass or other body remains were recorded. All sampling was conducted from January 2016 to January 2017.

Occupancy covariates such as canopy cover, understorey height, tree density and signs of human disturbance like logging, lopping, burning were recorded near the camera traps and along line transects. Understorey height (described in section 4.1) and tree density (described in section 7.1) were used directly, as they were measured while considering their usage for multiple taxa. Canopy cover was measured at 100 m interval along the line transects and at four cardinal directions in 100 m radius circle around the camera trapping points using spherical densiometer. In addition to this, detection covariates like time and date were recorded during each sampling occasion. In the case of camera trapping, the mid-date of trapping session and the time when the species were frequently detected were used as detection covariates.

1.2 Data analysis

Canopy cover was positively correlated with forest cover (%); hence we removed it from the model. Though understorey height and tree density were occupancy covariates, they could also be used as detection covariates, because increasing understorey and tree density reduce the detection probability by obstructing the vision. Hence, final multispecies occupancy model for mammals was included elevation, forest cover and anthropogenic habitat cover as occupancy covariates and date, time, understory height and tree density as detection covariate (please refer section 3 for more details).

1.3 Results

We sampled 14 sites using camera trapping with a total of 112 replicates, 8 replicates per site. Total camera trapping efforts were 784 days. On the other hand, 25 sampling sites were surveyed using line transect method with a total of 200 replicates, 8 replicates per site. In all, we walked 200 km in 19,305 minutes. As a result of all these efforts, we detected 26 mammal species in this landscape (Annexure I). Among them, the Indian hare, mice and Indian palm squirrel were detected at a large proportion of sampling sites (a "naïve occupancy"- measure of occupancy without accounting detectability); in contrast, the rusty spotted cat, Indian giant squirrel, leopard, rhesus macaque, fulvous fruit bat, porcupine and jackal were detected at fewer sites.

Community level covariate effect

Mean response of the community to anthropogenic habitat cover was strong negative and to elevation, moderate negative, while towards forest cover, the mean response was strong positive (Table 1.1). This implies that, in general, mean probability of occurrence across the species in this community was significantly decreased with increasing anthropogenic habitat cover and declining forest cover. Strength of the covariate effect was based on the credible intervals (strong effect = CI without 0, moderate effect = CI contained zero but not centred on zero, weak effect = CI centred on zero).

Similarly, model prediction of the species richness across a landscape with varied forest cover and elevation revealed that areas with high forest cover and elevation were more species rich than low lying degraded forest and anthropogenic habitat covered areas (Fig.1a). However, species richness at the sites would be biased (underestimation) if we only relied on the observed numbers of species or estimations without incorporating detection probability (Fig.1b). Higher estimates of richness at species-poor sites were not surprising when species

Table 1.1. Community level summaries of hyper-parameters for occupancy and detection covariates

Community-level hyper-parameter	Mean	95% credible intervals
α1 (Elevation effect)	-0.404	-1.557, 0.665 **
α2 (Forest cover effect)	2.404	1.257, 3.629 ***
α3 (Anthropogenic habitat cover	-1.812	-2.866, -0.969 ***
β1 (Date effect)	0.009	-0.097, 0.112 *
β2 (Time effect)	-0.018	-0.094, 0.063 *
β5 (Understorey effect)	-0.071	-0.222, 0.094 *
β6 (Tree density effect)	0.080	-0.078, 0.217 *

*- Weak effect; ** - Moderate effect; *** - Strong effect

detected at few sites (rare species), estimates become much more imprecise (Kery and Royle 2015). For the same reason, species accumulation curve was also corrected for detection probability, but we did not account for covariate effect and the results applied at covariate effect 0 i.e. at mean value of elevation, forest cover and anthropogenic habitat cover (Fig. 1c). Though asymptote was not achieved, the effect would have been more pronounced in case of communities having more rare species (Dorazio et al. 2006), rate of addition of species was greatly reduced after 40–50 numbers of sampling sites. Thus 25 sites sampled in this study seem close to an ideal number of sites needed to draw reliable estimates of the mammalian species richness in this landscape.

In contrast to occupancy, all detection covariates showed weak effect on detection probability across the species in this community. We were dealing with a diverse community of mammals, with each species responding very differently with detection covariate (Fig. 1d); hence we anticipated diffuse nature of the credible intervals.

Species level covariate effect

Mean occupancy varied greatly among species, ranging from 1% to 99%. Detection probability was low for many species and also varied widely (3% to 45%). The specieswith low detections (>5) such as golden jackal, leopard, Indian porcupine and barking deer yielded the widest credible interval for their occupancy estimates, hence it became hard to draw reliable inferences. Posterior summaries of occupancy and detection probability for each species, as well as species specific response to occupancy covariates, are given in Appendix I.

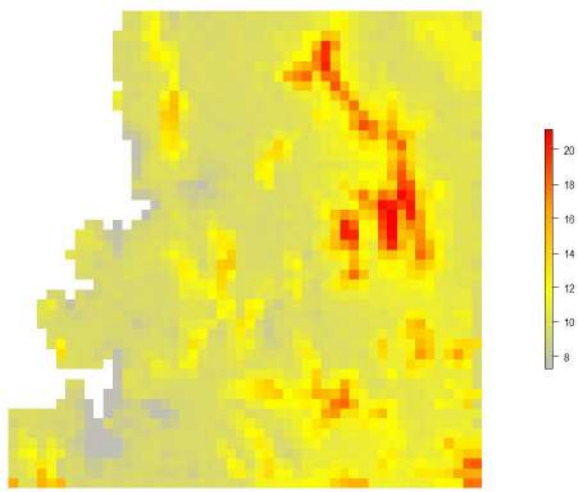


Fig. 1a. Mammal species richness at 1 sq. km. scale in the landscape based on forest cover and elevation.

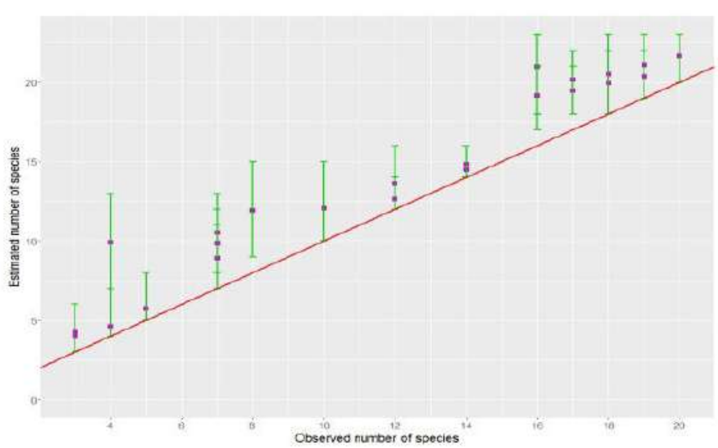


Fig. 1b. Relationship between estimated number of species and observed number of species.

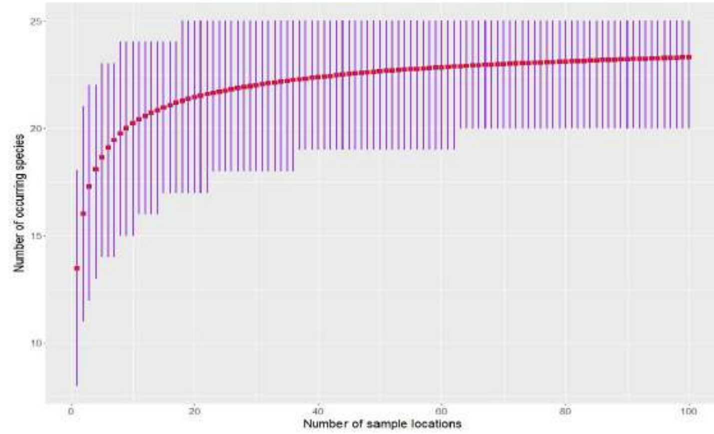


Fig. 1c. . Species accumulation curve for mammal species in the landscape.

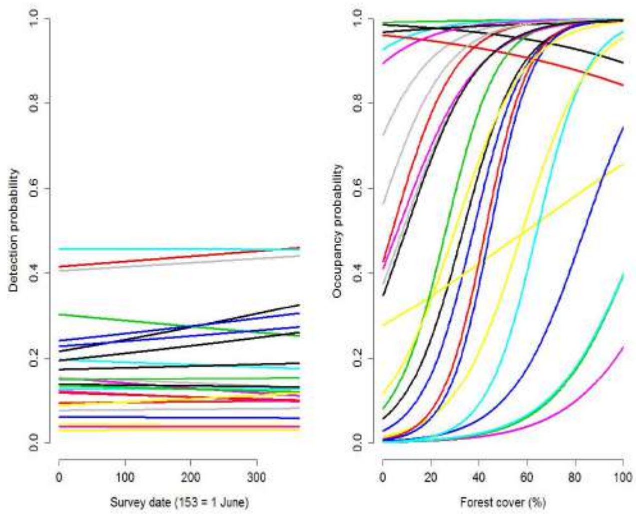


Fig. 1d. Species-specific predictions of detection and occupancy probability as function of survey date and forest respectively in 1 sq. km. grid in the landscape.

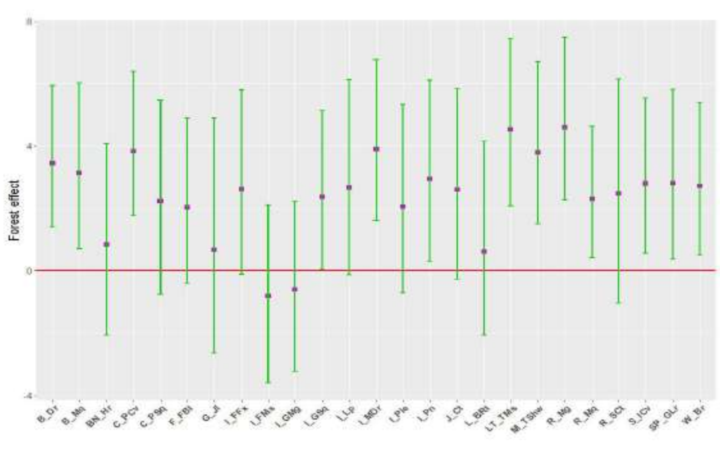


Fig. 1e. Forest cover effect in logit scale (α2, 95% CI) on occupancy of mammal species in the landscape.

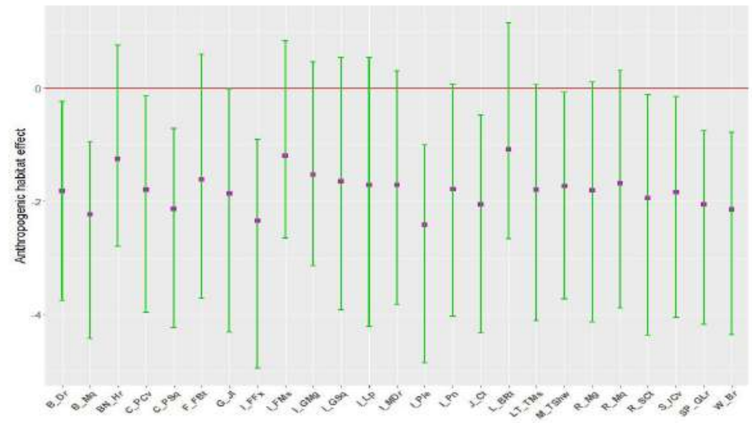


Fig. 1f. Anthopogenic habitat cover effect in logit scale (α3, 95% CI) on occupancy of mammal species in the landscape.

Forest cover had large positive effect on the occupancy of species compared to elevation (Fig. 1e). In all, 52 % of the species (13 of 25 species) showed significant positive association, and 36 % of the species (9 of 25 species) had moderate to weak positive correlation with the forest cover. In contrast, all species showed the negative impact of the anthropogenic habitat cover – 52 % of the species (13 of 25 species) showed strong negative and 44 % species (11 of 25 species) showed moderate negative impact (Fig. 1f). Besides overall response, various groups of mammals like ungulates, carnivores, primates and small mammals exhibited distinct patterns of responses to occupancy covariates.

Ungulates species recorded in this study showed comparatively higher occupancies (> 40%), except mouse deer (4%). They had significant positive association with forest cover, and significant negative correlation with anthropogenic habitat, except mouse deer, which had moderate negative impact. The mouse deer had weak positive association with elevation. In contrast, the barking deer and wild boar showed weak negative correlation with elevation.

Unlike ungulates, carnivores had low occupancies, though eight species of carnivores observed in this study showed varied occupancies e.g. lowest for leopard (3%) to highest for Indian grey mongoose (94%). Except Indian grey mongoose (which showed significant negative response), carnivores such as Asian palm civet, small Indian civet and ruddy mongoose showed significantly positive correlation with the forest cover, while the golden jackal, jungle cat and rusty-spotted cat showed weak negative association with forest cover. Elevation had a weak negative effect on all the carnivores, except Indian grey mongoose (which showed strong negative correlation).

Similar to ungulates, all species of primates indicated significant positive association with forest cover and significant negative correlation with anthropogenic habitat cover, except rhesus macaque, which had moderate negative response. Rhesus macaque appeared to be uncommon, mean occupancy at 1.4% (CI – 1 – 12%), compared to bonnet macaque and southern plain grey langur, which had occupancy > 80%. Effect of elevation was weak on all primate species.

Among all, small mammals showed highest as well as a wide range of occupancies – from low abundant fulvous fruit bat and Indian giant squirrel (1 – 1.2 %) to highly abundant Indian hare and Indian palm squirrel (98-99%). Indian giant squirrel, Indian porcupine, long-tailed tree mouse and Madras tree shrew had significant positive association with forest cover. Of these, the Madras tree shrew showed strong negative impact of the anthropogenic habitat cover while remaining three species had moderate negative impact. Indian hare indicated weak positive association with forest cover and moderate negative correlation with anthropogenic habitat cover. On the other hand, Indian palm squirrel showed moderate positive effect of the forest cover and significant negative impact of anthropogenic habitat. Indian giant squirrel showed moderate positive association with elevation; in contrast, bandicoot and mice had moderate negative and strong negative correlation with elevation respectively.

1.4 Discussion

Our results provided strong evidence of the adverse impact of anthropogenic habitats on the mammalian community of this landscape. In general, findings of this study indicated that probabilities of occurrence of most the species would increase with increasing forest cover and decreasing anthropogenic habitat. A moderate decline in occupancy of overall mammalian community with elevation was not totally unexpected and it might be due to correlation between elevation and land use land cover types. Most of the high elevated areas in this landscape were occupied with semi-evergreen forest. As elevation dropped, they were replaced with moist deciduous forest followed by scrubs. Comparatively a small number of mammal species are adapted to semi-evergreen forest (Prater 1971, Johnsingh and Manjrekar 2015), and intermediate disturbance hypothesis (Connell 1978) suggest that diversity increases at moderately disturbed areas, which may explain high diversity and occurrence probability of the mammals in moist deciduous forest (comparatively more disturbed than semi-evergreen forest due to easy accessibility) in this study.

Unlike the effect of occupancy covariates, the weak effect of the detection covariates – date, time, tree density and understorey height on mammalian community was anticipated. As mentioned earlier, since the community consists of diverse species of mammals, they show remarkable variations in their daily and seasonal activity patterns and habitat preference, therefore weak response of the overall community to the detection covariates seems logical. However, incorporation of the detection probability greatly improved the estimation of the species specific occupancies. E.g. the mean occupancies of wild boar, southern plain grey langur, bonnet macaque and Indian palm squirrel could have been underestimated (compared to naïve occupancy) by -21%, -24%, -21% and -23% (Appendix I) respectively had we not incorporated their detection probabilities. The underestimation of the probability of occurrence of the species due to imperfect detection (not accounting for the detection probability) has been discussed in detail in large number of case studies (Kery and Royle 2015, Kery and Schaub 2011). In contrast to the above mentioned common species, rust-spotted cat, Madras tree shrew, Indian giant squirrel, Indian mouse deer, Indian porcupine, leopard and golden jackal were either rare or not common in this landscape. Inferences about any population always depend on the sample size as stated by central limit theorem; in our study, rare species due to their small sample size (those with fewer detection) yielded comparatively imprecise estimates of the parameters. However, the most important feature of multispecies occupancy modelling is the estimation of the occupancy of rare species; it produced some useful estimates of the rare species. E.g. Indian giant squirrel with only 13 detection at 5 sites resulted in mean occupancy 1% (CI–1–20%). It appeared to be realistic, but with single species occupancy model, it would not be possible to estimate occupancy or it becomes erroneous. In addition to this, multispecies occupancy approach had provided flexible framework for unravelling the overall pattern of response of the mammals in this landscape.

We identified the general pattern of response among the mammalian groups to forest cover and anthropogenic habitat. The primates and ungulates were most strongly associated with forest followed by carnivores and small mammals. Herbivores (primates and ungulates) in this investigation faced significant adverse impact of anthropogenic habitat, except Indian mouse deer and rhesus macaque which had moderate negative association. The response of these two species seemed like effect of the small sample size (few detections) and further increase in detections could change these results. Barking deer, wild boar and Indian mouse deer heavily depend on the forest for their food such as fruits, flowers, buds, leaves, seeds and roots (Dinerstein 1989, Roberts 1997, Krishnan 1972). Though there is a lack of detailed studies on the Indian mouse deer, investigation on related species of mouse deer in Southeast Asia has shown that the species is association with primary forest and is sensitive to depletion of food resources, mainly fruits (Heydon 1994, Heydon and Bulloh 1997).

In contrast, bonnet macaque, rhesus macaque and southern plain grey langur are comparatively more adapted to human habitation than ungulates but some populations prefer forested areas while others retreat to forest for food and protection (Roonwal and Mohnot 1977, Krishnan 1972, Oppenheimer 1977). These primates, despite having commensal relationships with humans, have shown a decline in their population in the recent years, which is associated with anthropogenic activities such as forest fragmentation, intensification of agriculture, illegal logging, poaching, overexploitation of forest for firewood and increasing intolerance towards these species in urban localities (Sugiyama and Parthasarathy 1978, Kumara et al 2010, Khan 1984, Singh and Rao 2004).

Unlike the herbivores, carnivores like golden jackal, jungle cat and rusty-spotted cat had moderate to weak association with forest cover and strong negative correlation to anthropogenic habitat cover. This could suggest that these species prefer intermediate habitat such as degraded forest (scrubs and grassland). This finding is consistent with previous studies (Aiyadurai and Jhala 2006, Prater 1971, Dayan et al. 1990). In contrast, Asian palm civet, small Indian civet and ruddy mongoose significantly associated with the forest, though the former two species were frequently found near human settlement in search of food – rodents, fruiting trees and dumped food, they depend on the forest cover for protection (Prater 1971, per. obs.). The negative response of the Indian grey mongoose with forest cover as well as anthropogenic habitat cover indicated that the species favours habitats at periphery of the human settlement (especially outskirts of suburban and rural areas). Kalle et al. (2013) and Rajashekara and Venkatesha (2015) also found that Indian grey mongoose prefers open scrubs and avoids dense canopy areas.

In contrast to Indian grey mongoose, the significant increase in the probability of occurrence of Indian giant squirrel and Madras tree shrew with forest cover was expected. Indian giant squirrel throughout its range is restricted to mature forests, with continuous canopy cover and high tree diversity (Borges 2015). This was further supported by its moderate positive correlation with elevation because such kind of mature forests in this landscape are now confined to high elevated areas. Similarly, the tree shrew is restricted to forest floor generally away from human habitation (Roonwal and Mohnot 1977). Though, long-tailed tree mouse, an arboreal mouse, was associated with forested habitats, it was also observed in forest fragments on the outskirts of rural areas (per. obs.) and that might be the reason for moderate negative effect of anthropogenic habitat cover on this species. Similarly Indian hare, one of the most abundant species (mean occupancy 99%, CI 93–100%) found in the study area, showed moderate negative association with anthropogenic habitat cover and weak positive correlation with forest cover. It could suggest affinity of the species to open habitat, especially away from human settlement and also amidst forested areas. Sabnis (1981) and Manakadan and Rahmani (1999) also found that Indian hares flourish in areas with sparse vegetation. In contrast to Indian hare, very few detections of the Indian porcupine was disturbing, which could be an indication of local hunting pressure. The species is hunted heavily throughout the Western Ghats (Madhusudan and Karanth 2002).

Multispecies occupancy modelling approach revealed interesting pattern of response of mammalian community as well as species to various land use and land cover changes. Some species showed low abundance and contrasting responses to land use and land cover changes (compared to their general habit and habitat). While considering the wide distribution of most of the mammals found in this study area, one can expect intra-specific variability (Lott 1991), i.e. geographical or local variations in ecology and behaviour of the species. Despite these variations, this study clearly indicated that forest cover was an essential factor for the occurrence of most of the mammal species. In contrast, increasing anthropogenic habitats would adversely affect large number of species and in extreme cases such as urbanisation of this landscape can lead to the extinction of most of the forest-dependent species.

CHAPTER 2

BIRDS

2.1 Sampling design

We used fixed radius point count method for sampling birds in this landscape (Bibby et al. 1992). Fixed radius of 50 m approach was adopted by knowing potential bias induced by varying detection probability in open habitats (Raman 2003). Point count survey of 10 minutes duration was carried out on sunny day during first 3 hours after sunrise. All the birds heard or seen, sometimes flying under the canopy within a fixed distance of 50 m radius were recorded. In each grid, four point counts (treated as spatial replicates for estimating detection probability) were carried out. We sampled seven habitats and each habitat with five grids. So in total 140 point counts in a season (Map 3c). A minimum distance of 200 m was maintained between two points. All sampling was carried out by observer(s) familiar with birds in this region. These surveys were conducted in winter (December 2015–February 2016) and summer (March–May 2016), considering migrants as well as residential birds. We identified birds using field guides (Grimmett et al. 2001, Ali 2002). In addition to this, ad hoc surveys were conducted for free listing of the birds encountered outside sampling points.

At each sampling point (in 100 m radius) we measured occupancy covariates such as canopy cover, understorey height, tree density and signs of human disturbance like logging, lopping, and burning. Understorey height (described in section 4.1) and tree density (described in section 7.1) were used directly, as they were measured while considering their usage for multiple taxa. Canopy cover was measured at four cardinal directions in 100 m radius circle around the sampling point using spherical densiometer. In addition to this, detection covariates like time and date were recorded during each sampling occasion.

2.2 Data analysis

Canopy cover was positively correlated with forest cover (%); hence we removed it from the model. Though understorey height and tree density were occupancy covariates, they could also be used as detection covariates because increasing understorey and tree density reduce the detection probability by obstructing the vision. Hence, a final multispecies occupancy model for birds was included, with elevation, forest cover and anthropogenic habitat cover as occupancy covariates and date, time, understorey height and tree density as detection covariate (please refer section 3 for more details).

2.3 Results

We sampled 35 sites with total 280 replicates. In all, 280 species of birds were observed in this study, of which 135 species with 1605 detections were recorded in quantitative sampling (Annexure II). Among them red-whiskered bulbul, house crow, plain prinia and black drongo were found at most of the sites with large number of detections; in contrast, large number of bird species (~53%) were observed at a few localities with small number of detections (< 5). This indicated overall rarity of large number of birds in this landscape.

Community level covariate effect

At community level, mean response of the community to anthropogenic habitat cover and elevation was strong negative while it was weak positive for forest cover (Table 2.1).

Table 2.1. Community level summaries of hyper-parameters for occupancy and detection covariates

Community-level hyper-parameter	Mean	95% credible intervals
α1 (Elevation effect)	-0.572	-1.081, -0.072***
α2 (Forest cover effect)	0.172	-0.115, 0.477*
α3 (Anthropogenic habitat cover	-0.693	-1.073, -0.349***
β1 (Date effect)	0.027	-0.060, 0.124*
β2 (Time effect)	0.043	-0.022, 0.105*
β5 (Understorey effect)	-0.251	-0.461, -0.054***
β6 (Tree density effect)	0.038	-0.091, 0.160*

*- Weak effect; ** - Moderate effect; *** - Strong effect

Similarly, species richness across the landscape predicted by the model showed that areas with high forest cover and elevation were more species rich than low lying areas with degraded forest and anthropogenic habitat cover (Fig.2a). Though birds showed strong negative correlation with elevation, they had positive association with forest cover and in this landscape, undisturbed forests were mostly confined to high elevations, which seems to be reflected in species richness map. Species richness estimated at most of the sites appeared to be much higher than observed species richness, while looking at number of rare birds in the community we anticipated imprecision in the estimates (Fig. 2b) (Kery and Royle 2016). This rarity of large number of birds in the community could be the reason for species accumulation curve not reaching the asymptote (Dorazio et al. 2006). However, the rate of addition of species was greatly reduced after 40–50 numbers of sampling sites (Fig. 2c). Thus, 35 sites sampled in this study appear close to ideal number of sites needed to draw reliable estimates of bird species richness in this landscape.

In contrast to occupancy, all detection covariate except understorey height showed weak effect on detection probability across the species in this community. We were dealing with diverse community of birds, each species have distinct ecological, behavioural and evolutionary traits. Hence it was more likely that they respond to detection covariate very differently (Fig. 2d); this was reflected in the diffuse nature of the credible intervals for detection covariates.

Species level covariate effect

Mean occupancy among birds varied greatly, ranging from 4% to 98%. In general, detection probability was low and also varied (1% to 34%). The species with low detections (> 5) such as Loten's sunbird, verditer flycatcher and small minivet, yielded the widest credible interval for their occupancy estimates; hence in their case, it became difficult to draw reliable inferences. Subsequent summaries of occupancy and detection probability for each species, as well as species specific response to occupancy covariates, are given in the Appendix II.

Anthropogenic habitat cover had overall negative impact on the occupancy of birds (Fig. 2e). In all, 85 % of species (115 of 135 species) showed negative impact of anthropogenic habitat cover; among them 7 % of species had strong negative association, 41% of species showed moderate negative relation. However, only house sparrow showed strong positive association with anthropogenic habitat cover. Similarly, 70% of species (94 of 135 species) showed negative correlation with elevation and remaining 30% depicted positive association. Most notable were Malabar whistling thrush, Nilgiri wood pigeon, orange-headed ground thrush, white-cheeked barbet and white-rumped shama, which showed strong positive association with elevation. In contrast, 88 % of species (118 of 135 species) exhibited moderate to weak positive response towards forest cover (Fig. 2f). In addition to overall response of birds towards occupancy covariates, different guilds of birds showed various patterns of occupancies – some guilds had low occupancies while other had high occupancies.

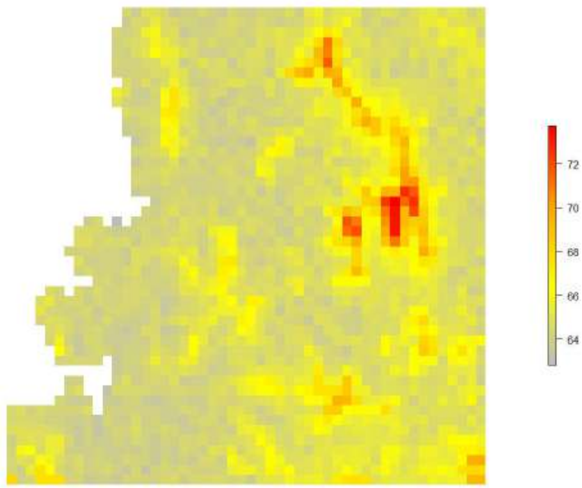


Fig. 2a. Bird species richness at 1 sq. km. scale in the landscape based on forest cover and elevation.

Fig. 2b. Relationship between estimated number of species and observed number of species.

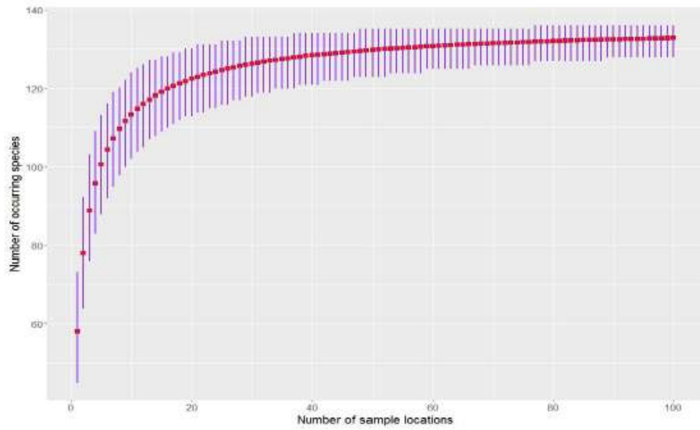


Fig. 2c. Species accumulation curve for bird species in the landscape.

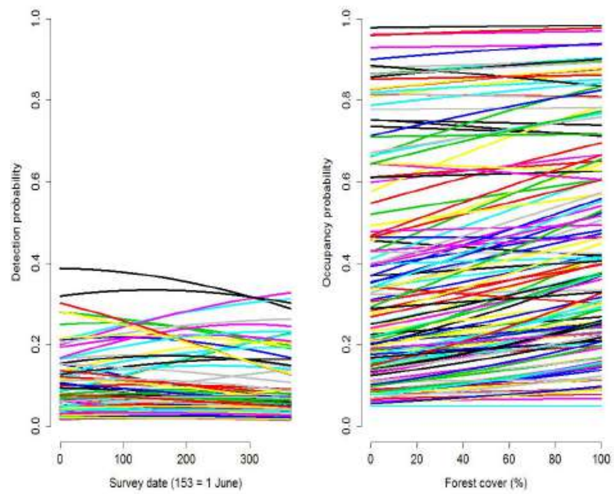


Fig. 2d. Species-specific predictions of detection and occupancy probability as function of survey date and forest cover respectively in 1 sq. km. grid in the landscape.

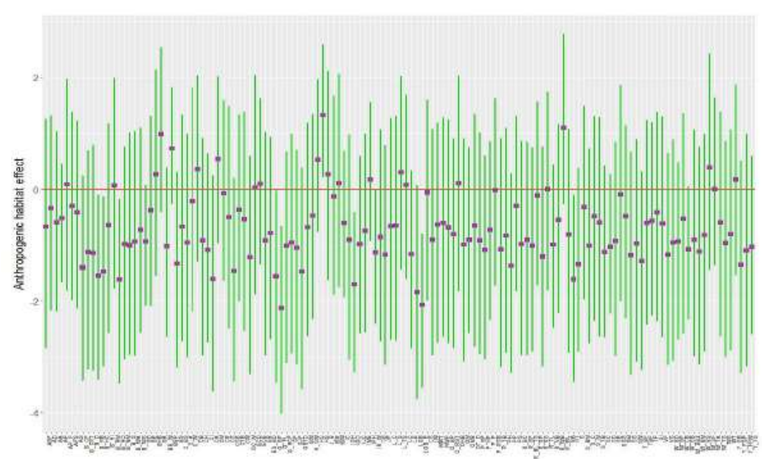


Fig. 2e. Anthropogenic habitat cover effect in logit scale (α3, 95% CI) on occupancy of bird species in this landscape.

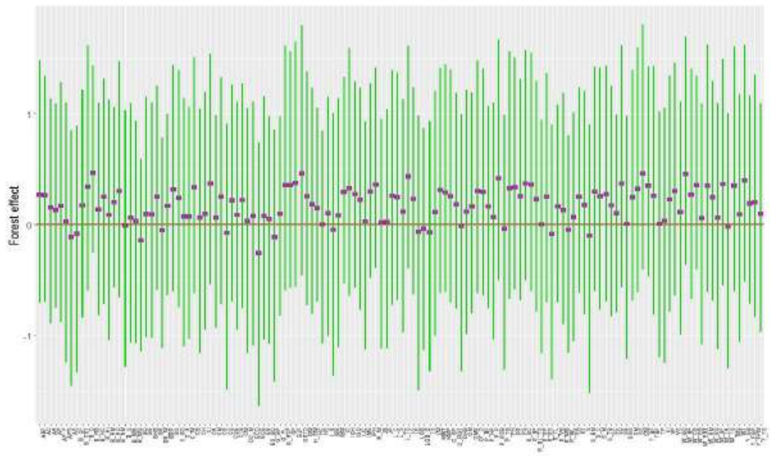


Fig. 2f. Forest cover effect in logit scale (α2, 95% CI) on occupancy of bird species in the landscape.

Highest occupancies (median – 64.17 %) were shown by a guild of omnivorous birds; occupancies ranged between 9 % for white-eared bulbul to 94% for red-whiskered bulbul. About 70 % (12 of 17 species) of species showed moderate positive association with forest cover; whereas black drongo and rufous-tailed lark showed moderate and weak negative correlation respectively. On the contrary, 59% (10 of 17 species) of the species depicted strong to moderate negative impact of anthropogenic habitat cover; while, house crow, black kite and common myna showed moderate positive association. Similarly, 47% (8 of 17 species) of the species exhibited strong to moderate negative correlation with elevation, e.g. black kite and white-eared bulbul had strong negative correlation, while among four species showed positive association with elevation orange-headed ground thrush depicted strong positive association. Unlike omnivores, insectivore birds were most specious and diverse; adding up to 64 species. They also showed high occupancies (median – 36.72 %), ranged from the lowest for Blyth's reed-warbler (4%) to the highest for plain prinia (96%). In insectivores, 60 % (38 of 64 species) of the species exhibited moderate positive and 24% (15 of 64 species) of the species had weak positive association with forest cover; whereas, alpine swift, brown-cheeked fluvetta and grey-breasted prinia showed moderate negative association with forest cover. In contrast, 53 % (34 of 64 species) of the species depicted strong to moderate negative impact of anthropogenic habitat cover. Most notable were black-headed cuckooshrike, grey-breasted prinia, Indian reed warbler and little green bee-eater, all showing strong negative correlation. While 10 % of the species showed moderate to weak positive association with anthropogenic habitat cover, red-wattled lapwing depicted moderate positive association. Similarly, 56 % (36 of 64 species) of the species, except Indian reed-warbler with strong negative correlation, showed moderate to weak negative correlation with elevation; and 39 % (25 of 64 species) of the species exhibited moderate to weak positive association with elevation, while Malabar whistling thrush and white-rumped shama had strong positive correlation.

Like omnivores, nectarivore birds showed high occupancies (median – 37.05 %) which ranged between 2 % (loten's sunbird) to 80% (purple sunbird). This guild included 9 species; all of them depicted moderate positive association with forest cover, except golden-fronted leafbird, which had weak positive correlation. Except crimson-backed sunbird, which had moderate positive association with elevation, the rest of the species showed weak positive or negative effect. In contrast, they showed moderate to weak negative impact of the anthropogenic habitat cover, except golden-fronted leafbird, which exhibited significant negative impact.

Unlike nectarivore and insectivores, frugivores showed low occupancies (median – 21.60 %) which ranged between 7% (white-cheeked barbet) to 85% (rose-ringed parakeet). All 10 species in this guild revealed moderate positive association with forest cover, except rose-ringed parakeet, which had weak positive association. In contrast, except coppersmith barbet with weak positive association, most of the species exhibited moderate to weak negative impact of anthropogenic habitat cover; brown-headed barbet and black-hooded oriole showed significant negative impact. Similarly, except significant correlation of Nilgiri wood pigeon and white-cheeked barbet with respect to elevation, and moderate positive correlation of brown-headed barbet, rest of the species showed moderate or weak negative effect of elevation.

Similar to frugivores, granivores also showed low occupancies (median – 22.41%) which ranged between 6 % (house sparrow) to 63% (scaly-breasted munia). All 12 species of granivores showed weak to moderate positive association with forest cover, except scaly-breasted munia, which depicted weak negative association. On the contrary, except Oriental turtle dove with moderate positive correlation with elevation, rest of the species showed weak to moderate negative correlation with elevation; spotted dove and blue rock pigeon had significant negative correlation. About half of the granivores showed positive association with anthropogenic habitat cover, most notable were house sparrow with strong positive and blue rock pigeon with moderate positive association; and remaining species depicted moderate to weak negative impact of anthropogenic habitat cover. Like frugivores and granivores, carnivores also had low occupancies (median – 23.69 %) which ranged between 7% (Intermediate egret) to 86% (Eastern cattle egret). Among 22 carnivore birds, 86% (19 of 22 species) of the species showed moderate to weak positive association with forest cover; in contrast, 81% (18 of 22 species) of the species depicted moderate to weak negative impact of the anthropogenic habitat cover. Similarly, except crested serpent eagle, all species showed negative correlation with elevation.

2.4 Discussion

This study clearly showed that, in general, the anthropogenic habitat cover in the landscape had significant negative impact on occupancies of the birds across communities. Though overall response of the birds to forest cover across community was weak positive, most of the birds at species level response showed moderate to significant positive association with forest cover. Other studies also found similar pattern (Emlen 1974, Naithani and Bhatt 2012, Raman and Sukumar 2002, Raman 2006). This suggested the significance of the forest cover in sustaining bird diversity in this landscape. Like anthropogenic habitat cover, elevation also had strong negative effects on occupancy of birds across communities which might be due to correlation between elevation and land use land cover types. Most of the high elevated areas in this landscape were occupied with semi-evergreen forest; as elevation dropped they were replaced by moist deciduous forest followed by scrubs. While looking at highly specialised habitats such as semi-evergreen forest at high elevation, it becomes more likely that this type of habitat is colonised by specialised and, to a large extent, limited number of species (Raman and Sukumar 2002, Raman 2006). In addition to this, intermediate disturbance hypothesis (Grime 1973, Horn 1975, Connell 1978) states that diversity increases at low to moderately disturbed areas. Therefore, higher diversity and occurrence probability of the birds in moist deciduous forest (comparatively more disturbed than semi-evergreen forest due to easy accessibility) in this study was not unlikely.

Unlike the effect of occupancy covariates, the weak effect of the detection covariates – date, time, and tree density on bird community was anticipated. As mentioned earlier, the community comprises diverse species of birds. They show remarkable variations in their daily and seasonal activity patterns and habitat preferences; therefore weak response of the overall community to the detection covariates seems logical. On the contrary, understorey height showed strong negative effect on detection probability of community, which is well documented observation because increasing understorey obstructs the visibility and ultimately reduces the detection probability; besides, species that prefer understorey are shy (Praveen and Nameer 2008).

In contrast to understorey height, tree density had weak positive impact on community detection probability of birds. This pattern looks similar to community occupancy response towards forest cover; it may be because in this landscape forested areas had higher tree density and richness, hence they could provide more microhabitat to sustain abundant and diverse assemblages of birds, which eventually increased the community level detection probability of birds (Joshi et al. 2013, Raman and Sukumar 2002, Raman 2006). Similarly, community detection probability had weak positive association with date, which implied that the detection probability of birds across community increased with advancing dates. These increasing dates indicated post-monsoon and winter season, during which food resources are very abundant and evenly distributed in this landscape; besides, it is also an ideal season for monsoon and winter migrant birds (Beelher et al. 1986, Ali 2002). Therefore, increase in detection probability of birds across communities was more likely.

We found interesting patterns in occupancy of bird guilds and habitat cover types. Generally, ominivore and insectivore birds showed high occupancies; they had comparatively small number of species positively associated with forest, hence obviously less number of species negatively impacted by anthropogenic habitat cover. In contrast, though nectarivores, frugivores and granivores had low occupancies, almost all species depicted positive association with forest cover. Hence eventually large numbers of them were negatively impacted by anthropogenic habitat cover. Similar pattern has been reported in other studies – generally frugivores and nectarivores have restricted food preference (fruits and flowers), which they obtain from undisturbed natural forests; whereas, omnivores and insectivores have very wide food preference, which they can easily find in anthropogenically disturbed habitats (May 1982, Daniels et al. 1990, Daniels et al. 1992, Beehler, 1986, Raman and Sukumar 2002).

In general, anthropogenically disturbed habitats appear to provide suitable habitat for omnivores like house crow, black kite and common myna. These species were positively associated with anthropogenic habitat cover. These birds along with red-vented bulbul, red-whiskered bulbul, Indian jungle crow, black drongo and Southern coucal formed one of the most frequently detected and high occupancy group of birds in this landscape. Most of the species in this group had also shown moderate positive association with forest cover, which suggested disturbed nature of original forest in this landscape, because these are open forest dwelling and generalist species (Daniels et al. 1990, Daniels et al. 1992, Sidhu et al. 2010). This landscape has long history of disturbances. Some of the areas where remnant of natural forests were found were forts, which were used til the 16th and 17th centuries (Veach et al. 2003); hence it is more likely that the natural vegetation was destroyed during that time period. Similarly, from the 17th to 18th century, first the Portuguese and then the British colonised this region. During this colonial period, the forests in this landscape were heavily exploited to supply timber to the shipping industry (Pereira 1935). Hence, the natural remnant forested areas seen in this landscape could be regenerated and secondary in nature.

Unlike generalist and abundant omnivores, grey Junglefowl, orange-headed ground thrush, Indian golden oriole and rufous treepie were less abundant and negatively associated with anthropogenic habitat cover. Among these, the orange-headed ground thrush and grey junglefowl are strictly evergreen and moist deciduous forest dwelling species (Raman 2006). This observation was supported by strong positive correlation of the orange-headed ground thrush with elevation, because semi-evergreen forests are restricted to high elevation in this landscape.

Like omnivores, insectivores were also abundant and showed variations in their occupancies in response to different habitat cover. For example, insectivores such as plain prinia, ashy prinia, little green bee-eater, common iora, common tailorbird, Indian reed-warbler and Oriental magpie robin showed high occupancies and detections. This may be related to their preference for degraded forest habitats such as scrubs, grasslands and open forest, which was suggested by their negative association with anthropogenic habitat and elevation and positive association with forest cover. They feed on insects, i.e. highly protein rich food, and their small body size gives additional advantage to survive in disturbed habitat with limited food resources; other studies have also discussed this general pattern of inverse relationship between body size and abundance (Terborgh & Winter 1980; Kattan et al. 1994, Joshi and Bhatt 2011).

In contrast to these abundant and open habitat insectivores, ashy drongo, Asian paradise-flycatcher, black-naped blue flycatcher, bronze drongo, brown-cheeked fulvetta, greater flameback, greater racket-tailed drongo, greenish warbler, grey-headed canary flycatcher, heart-spotted woodpecker, Malabar whistling thrush, orange minivet, puff-throated babbler, Tickell's blue flycatcher, verditer flycatcher and white-rumped shama showed low occupancies and detections. Most of them are canopy insectivores, generally found in natural and undisturbed habitats like evergreen, semi-evergreen and riparian forests (Raman 2006, Sidhu et al. 2010, Raman and Sukumar 2002, Ali 2002); those are highly restricted in this landscape. Habitat specialist nature of this insectivorous group of birds was revealed by their negative association with anthropogenic habitat, moderate positive association with forest cover and in some, moderate to strong positive correlation with elevation.

Unlike insectivores, granivores were less abundant. While species like blue rock pigeon, house sparrow and spotted dove were frequently detected, except spotted dove, all had positive association with anthropogenic habitat cover and forest cover whereas negative correlation with elevation. This indicates their affinity for degraded habitats (Chamberlain et al. 2007); these granivores occupied large proportion of this landscape. In contrast, black-headed bunting, Eurasian collared dove, Indian baya weaver, red avadavat, scaly-breasted munia, white-rumped munia, black-headed munia and common rosefinch had very few detections. This may be sampling artefact because most of these species live in flocks that are very unevenly distributed (Ali 2000); hence point count may not be a better method for estimating abundance of these species. In addition to this, change in agricultural practices such as traditional rainfed and organic farming replaced by advanced irrigated farming with intensive use of fertilizers and pesticides could have affected these birds. Because they primarily feed on grains produced by crops and seeds of the grasses, those were comparatively abundant and non – toxic in traditional agricultural fields (Ali 2000, Dhindsa and Saini 1994).

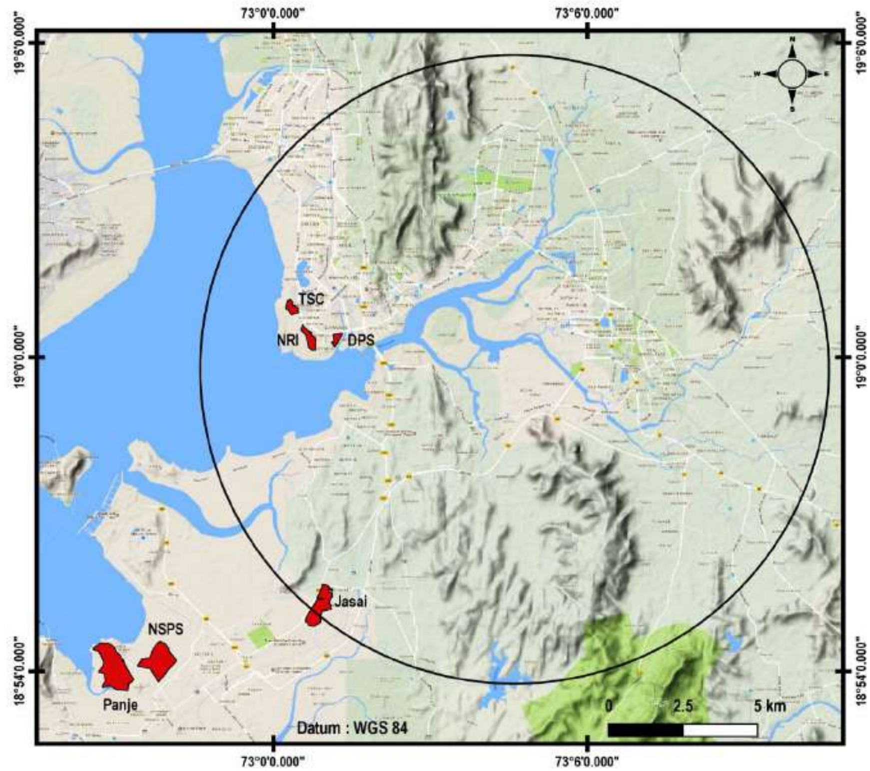
Though frugivores and nectarivores were less abundant in the landscape, those present showed variations in abundance patterns. Birds like Asian koel, brown-headed barbet, rose-ringed parakeet and purple sunbird were detected frequently and showed high occupancies. Their negative correlation with elevation and moderate positive association with forest revealed their affinity for degraded forests (scrubs and open patches in the forests). Forest trees like *Bombax ceiba*, *Butea monosperma*, *Ficus racemosa*, *Syzygium cumini*, *Cassia fistula*, *Madhuca longifolia*, *Mangifera indica, Ziziphus mauritiana* and *Erythrina stricta* on which these birds feed were fairly common and occupied large area of the landscape. Which may explain the high abundance and positive association of these frugivores and nectarivores with degraded forest.

On the other hand, golden-fronted leafbird, small sunbird, Nilgiri wood pigeon and white-cheeked barbet showed low occupancy in the landscape and yielded few detections. Former two species had strong and moderate negative association with anthropogenic habitat, while the latter two species showed significant positive association with elevation; except golden-fronted leafbird, all had moderate positive association with forest. It clearly suggested their strong affinity of these birds for undisturbed forests, which is highlighted in previous studies in the Western Ghats (Raman 2006, Sidhu et al. 2010, Raman and Sukumar 2002, Ali 2002). These frugivores and nectarivores-insectivores are all canopy birds and they directly depend on floristic composition. Especially, plants belonging to families Moraceae, Lauraceae, Myristicaceae and Loranthaceae, generally found in mature forests, are vital for these frugivores and nectarivores – insectivores (Raman and Sukumar 2002, Ali and Ripley 1983).

Overall, multispecies occupancy modelling approach revealed interesting patterns of responses of bird communities as well as species to various land use and land cover changes. While omnivores and insectivores showed high occupancies with less impact of anthropogenic habitat cover, frugivores and nectarivores – insectivores had low occupancies and were highly affected by human disturbances. This study clearly indicated that forest cover was essential for the occurrence of most of the bird species, especially for those adapted to mature and undisturbed forests. We suspect that increasing anthropogenic habitat cover would adversely affect large number of birds. In extreme cases such as urbanization of this landscape, it can lead to the extinction of most of the forest dwelling species

CHAPTER 3
WATERBIRDS

3.1 Study area



Map 4. Water bird monitoring sites with 10km radius circle around NMIA site.

Six temporary saltwater pools, where large aggregations of waterbirds were observed during our earlier studies, were identified for exploring patterns of the bird composition, fluctuations in their population size and drivers of these fluctuations. In addition to this, these sites were close to Navi Mumbai International Airport site. Of the six sites, Delhi Public School (DPS), Non-resident Indian Complex (NRI), Training Ship Chanakya and Jasai are within 10 km and Nhava Sheva Police Station (NSPS) and Panje are within 20 km radius from the airport site, hence it was more likely that they are affected or may affect the aircraft.

Three saltwater pools DPS (9 ha), NRI (19 ha) and TSC (13 ha) are located in the northwest of the airport site. They are close to Seawood Railway Station. They were formed by the destruction of the original mangrove forest and were isolated from direct influence of tides by building bunds. Therefore, these habitats became more open and less saline, which may explain the occurrence of non-saline species of grasses, shrubs and trees. These sites, along with remnant mangroves on the edges of the pools, have created ideal bird roosting habitats. Water level in these pools was maintained mainly by the tide level and local fishermen. During high tide, the wetland receives water and is retained by small check dams created by the local people. These pools are mostly surrounded with mangroves, except NRI buildings between NRI and DPS and highly urbanised and populated northern side demarcated by Palm Beach Road.

On the other hand, Jasai (63 ha), Panje (124 ha) and NSPS (87 ha) are situated in the southwest of the airport site. All these three sites are connected with the sea through water channels and their water level is maintained by the local fishermen. Panje has fencing from all the sides and is covered with grasses and highly degraded mangroves, while Jasai has scanty vegetation and is situated between JNPT and Uran-Panvel Road and is also flanked with villages. NSPS is located between these two sites but close to Panje. These sites are situated in an area which has almost lost its mangrove cover.

3.2 Sampling Design

Waterbirds were counted by two people from a good vantage point at each site, using binocular or spotting scope (Bibby et al. 2000). We also walked through the vegetation on the edges or on the bunds for recording hidden and cryptic birds. One of the objectives of the study was to examine the effect of low and high tide, and time on water bird numbers. Therefore, we counted birds during four-hour time period, which was divided into 15-minute blocks. So total 8 blocks were sampled, i.e. 4 blocks before and 4 blocks after tide (during low as well as high tide). In each time block, birds were counted once and care was taken to avoid the double counts when birds flew from place to place. Similarly, all six sites were sampled simultaneously on the same day to minimize the double counts because these sites were close to each other and we suspected that birds moved between sites.

We identified birds to species level but, for some birds identification was difficult or doubtful, hence they were assigned to a broad group, especially waders. Birds were counted from 13 October 2016 to 14 February 2017. We extracted tide height for each sampling occasion from standard tide table.

3.3 Data analysis

We broadly categorised the waterbirds into tidal birds (whose movement largely depend on tide) and non-tidal birds (whose movement do not chiefly depend on tide) (Annexure III). Then, we used survey date, time and tide height as predictor covariate for a number of waterbirds and conducted exploratory data analysis as suggested by Zurr et al. 2010. It showed non-linear relationship between waterbirds and survey dates and tide height. In addition to this, there were considerable true outliers and heterogeneity in the response of birds to predictor covariates among sites.

Therefore, we adopted generalise mixed effect models (GAMM) approach, while considering their robustness and flexibility for non-linear data (Zurr et al. 2009). Date, tide height and time were standardised (mean=0; variance=1) before analysis for technical (easy convergence of model) and interpretation (easy interpretation) reasons. We included random effect of site to account for site level variations. After preliminary analysis, we dropped smoother for time because response of bird numbers to time was linear and almost steady across sites. Thus, in final model only date and tide height had smoother (cubic splines).

We used Tweedie distribution which is Poisson-gamma distributions that are continuous and non-negative with a spike at zero (Swallow et al. 2016). Our data had large numbers of zeros and values close to zero; therefore Tweedie distribution was ideal for this data. Model fit was assessed by c-hat value (residual deviance/residual degrees of freedom), close to 1 indicated good fit of model. All statistical analysis was carried out in mgcv (Wood 2011) and ggplot2 (Wickham 2009) packages in the program R (R Development Core Team 2015).

3.4 Result

In total, 40 water bird counting sessions were carried out – 28 during high tide and 12 during low tide. We recorded 77 species (waders were included as species though it was a group) of waterbirds; among them 47 were tidal birds and 30 were non-tidal birds. In a single day, maximum and minimum numbers of waterbirds recorded (pooled across sites) were 10,861 and 947 respectively.

Table 3.1 Table showing effective degrees of freedom (edf) and p values for smoothers; and R^2 and c-hat for GAMM for tidal and non tidal birds.

	Tidal birds		**Non-tidal birds**	
	edf	*p-value*	*edf*	*p-value*
S(date):DPS	8.582	2×10^{-16}	8.326	2×10^{-16}
S(date):Jasai	7.945	2×10^{-16}	8.882	2×10^{-16}
S(date):NRI	8.547	2×10^{-16}	8.965	2×10^{-16}
S(date):NSPS	8.491	2×10^{-16}	1.000	9.35×10^{-15}
S(date):Panje	8.759	2×10^{-16}	8.009	2×10^{-16}
S(date):TSC	8.819	2×10^{-16}	8.780	2×10^{-16}
S(tide height):DPS	7.697	3.78×10^{-13}	7.940	3.13×10^{-12}
S(tide height):Jasai	6.837	2×10^{-16}	8.864	2×10^{-16}
S(tide height):NRI	7.339	1.36×10^{-9}	8.866	2×10^{-16}
S(tide height):NSPS	8.783	2×10^{-16}	5.467	2.19×10^{-13}
S(tide height):Panje	8.898	2×10^{-16}	8.839	2×10^{-16}
S(tide height):TSC	7.757	1.33×10^{-11}	8.528	2.45×10^{-5}
R^2(adjusted)	0.761		0.838	
c-hat	1.03		1.01	

Tidal as well non-tidal models showed good fit to the observed data and explained considerable variations, respectively 76.1 % and 83.8 % (Table 3.1). All smoothers showed highly significant relationship between the numbers of waterbirds with date and with tide height at all sites.

Though, in general, DPS, NRI and TSC sites showed an increasing trend in the number of birds during the five-month study period, they exhibited variations in the number as well as composition (tidal and non-tidal) of birds (Fig. 3.1 a-c; Fig. 3.4). For example, tidal birds at TSC showed high fluctuation in numbers (at least three peaks were observed) in October, December and January (median range – 7 to 243.5), while at DPS the increase was gradual with prominent peak during December and January (median range – 35 to 190). Unlike DPS, at NRI, the numbers dropped down to the lowest in November–December and thereafter ascended until it attained its peak in January (median range – 14 to 434).

In contrast to tidal birds, non-tidal bird numbers were less fluctuating and their peak numbers at all three sites were recorded in December–January (Fig. 3.1 g-i; Fig.3.4). Though comparatively stable, they showed site-specific trends. For example, at DPS, the total number increased gradually till January (median range – 5 to 17); on the contrary, at TSC the number dropped down in earlier months and increased suddenly in January (median range – 6 to 180).

Apart from these two sites, NRI showed two small peaks in the total numbers in October and December and a large peak in January (median range – 31 to 513). Similarly, these sites showed variations in the proportion of non-tidal birds – NRI had a large proportion of non-tidal birds (40% – 77%); whereas TSC (7% to 43%) and DPS (9% – 20%) were comparable.

In addition to temporal response, the birds exhibited various patterns of response to tide height (Fig. 3.2 a-c & g-I, Fig. 3.5). At NRI and TSC, tidal as well as non-tidal bird numbers declined with increasing tide height at low tide, whereas at TSC, high tide non-tidal birds continue to decline and tidal birds increased, and at NRI, both non-tidal and tidal birds increased with tide height. On the contrary, at DPS, both bird categories increased with tide height at low as well as at high tide, but increase in the number was substantial for tidal birds.

In contrast to DPS, NRI and TSC, the total number of birds at Jasai, NSPS and Panje showed a declining trend (Fig. 3.1 d-f & j-l; Fig. 3.4). At Jasai, tidal and non-tidal birds exhibited gradually decreasing peaks in October, November and December (median range of tidal birds – 87 to 619; non-tidal birds – 143 to 417); similar trend was seen at NSPS (median range of tidal birds – 5.5 to 35.5; non-tidal birds – 1 to 10), except for the fact that non-tidal birds almost diminished from November and tidal birds once again increased in February. Like Jasai and NSPS, Panje also showed gradually decreasing peaks of tidal bird numbers in October, November and

December (median range – 44 to 1052), while non-tidal birds depicted unimodal pattern with peak count in November and December (median range – 102 to 5318).

Among all sites, Panje had a large number of waterbirds; a substantial part of them comprised non-tidal birds (19% – 84%) in comparison to Jasai (31% – 58%) and NSPS (1% - 28%). At Jasai and Panje, tidal birds were almost stable during increasing tide height at low tide; at Jasai, during high tide they first increased and then decreased but at Panje, they continuously increased with increasing tide height (Fig. 3.2 d-f & j-l, Fig.3.5). On the contrary, non-tidal birds increased slowly at Jasai and rapidly at Panje during low tide with increasing tide height, whereas at high tide, they decreased steadily at Jasai and steeply at Panje with increasing tide height. At NSPS, tidal as well as non-tidal birds were steady at low tide but they increased considerably at high tide with increasing tide height.

Tidal Birds

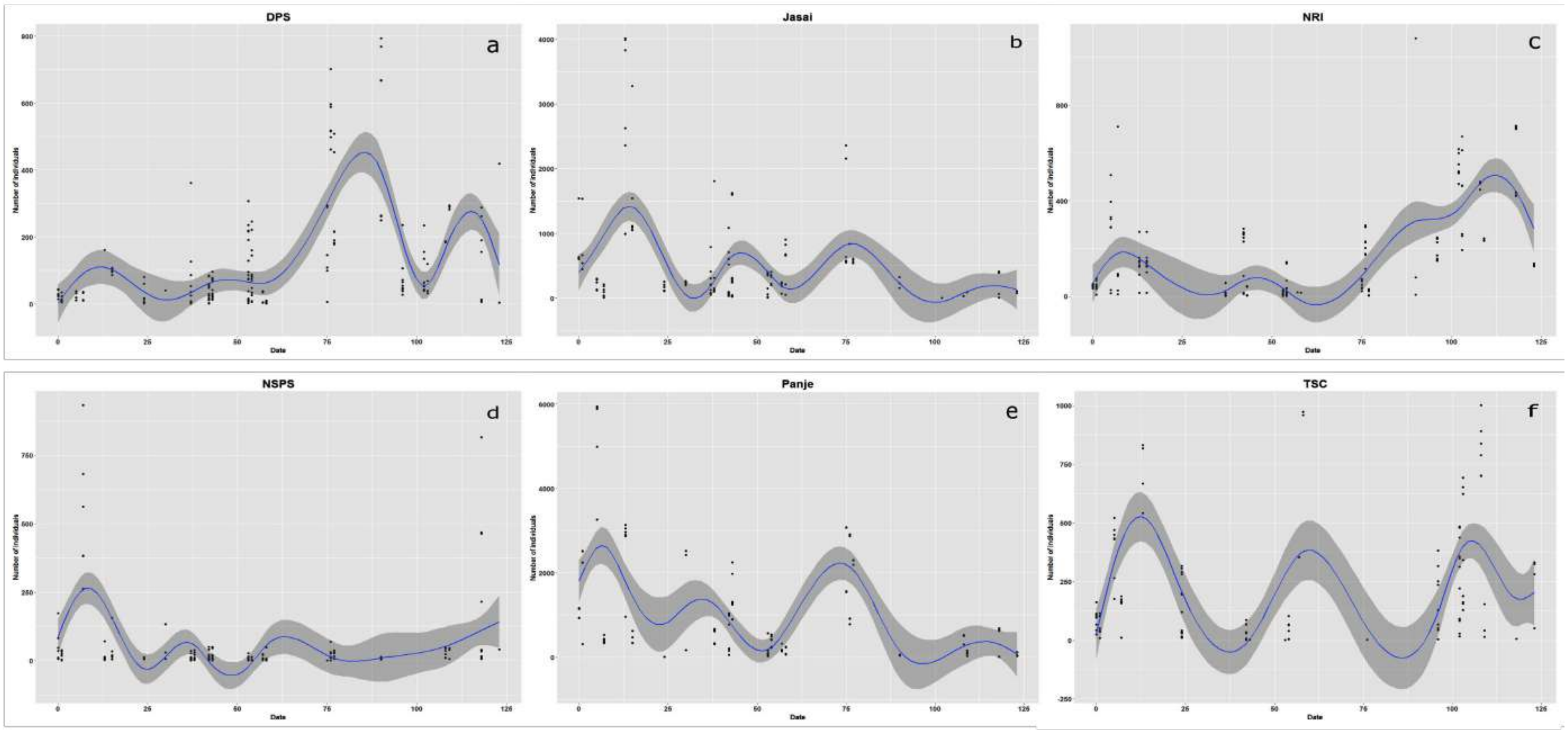


Fig. 3.1. Plots of number of individuals of tidal birds counted against date at six sites. Blue line is smoother and grey ribbon is 95% confidence interval (a-f).

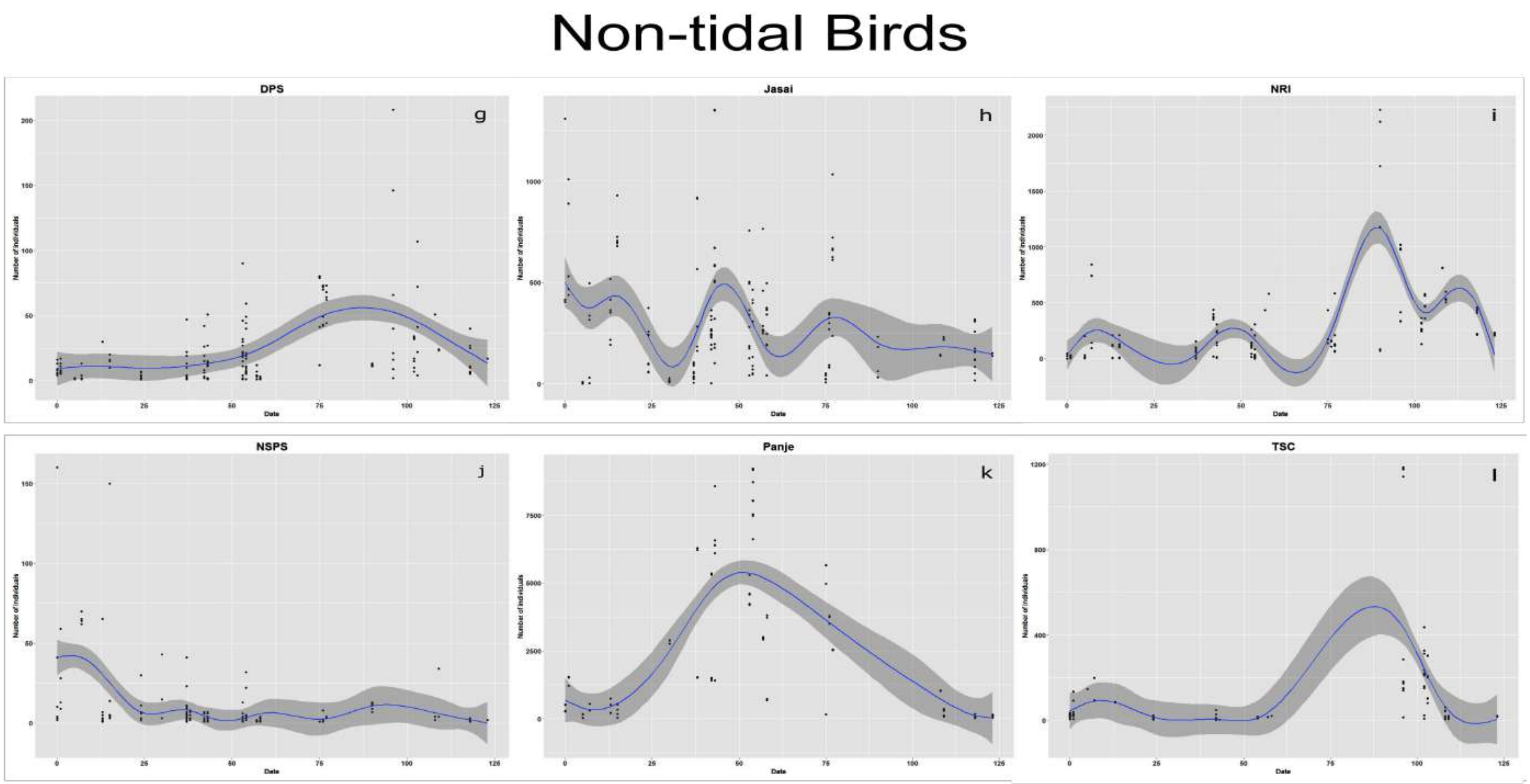


Fig. 3.1. Plots of number of individuals of non-tidal birds counted against date at six sites. Blue line is smoother and grey ribbon is 95% confidence interval (g-l).

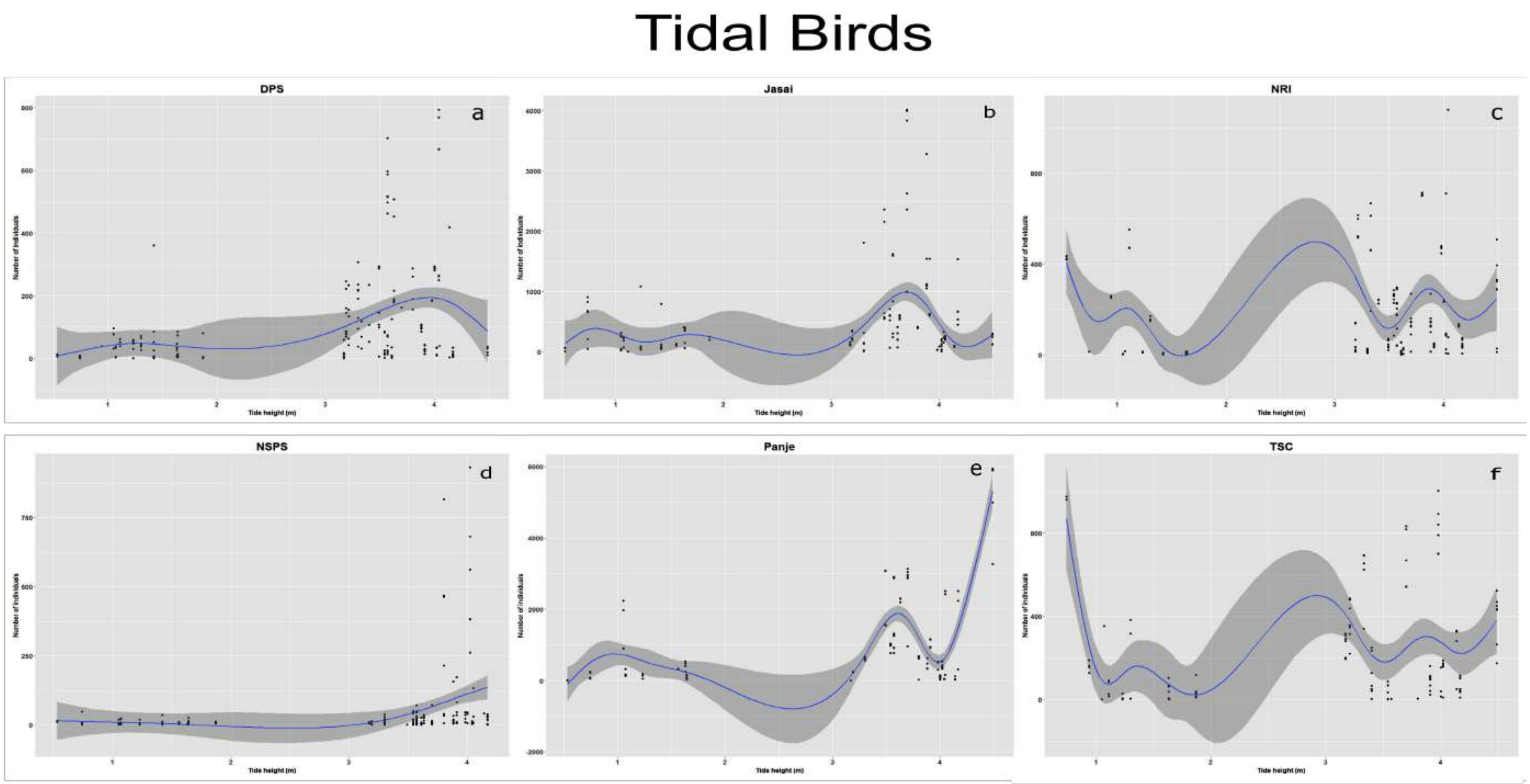


Fig. 3.2. Plots of number of individuals of tidal birds counted against tide height at six sites. Blue line is smoother and gray ribbon is 95% confidence interval (a-f).

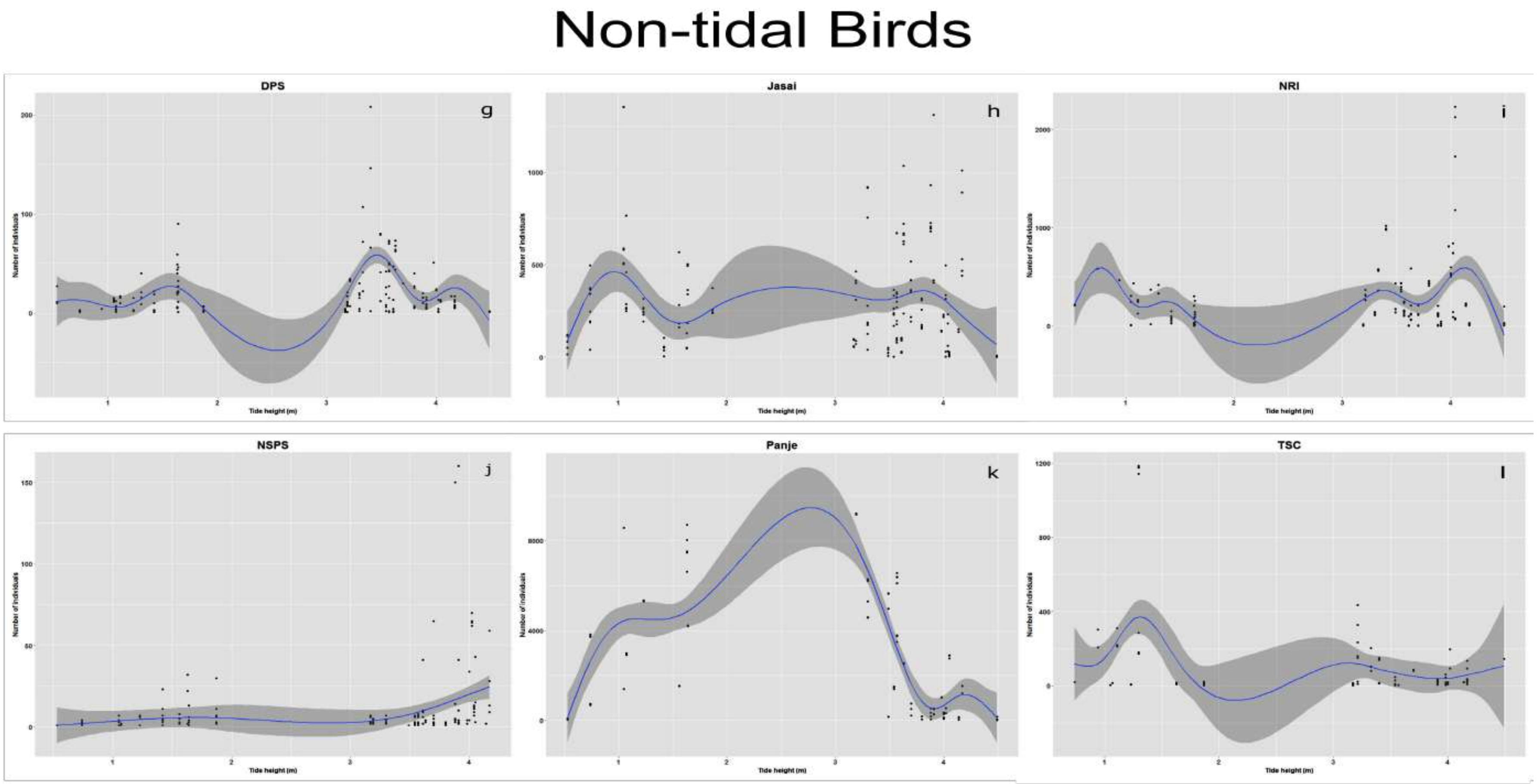


Fig. 3.2. Plots of number of individuals of non-tidal birds counted against tide height at six sites. Blue line is smoother and gray ribbon is 95% confidence interval (g-l).

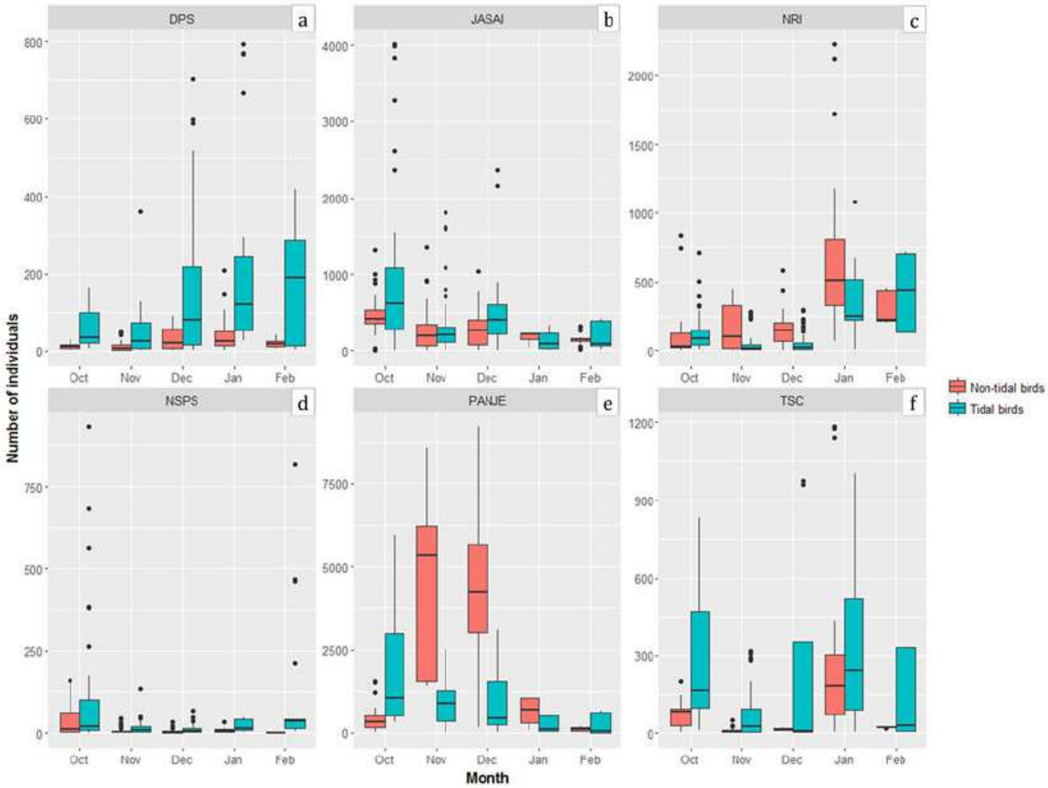


Fig. 3.4. Boxplots of number of individuals of birds counted against months at six sites.

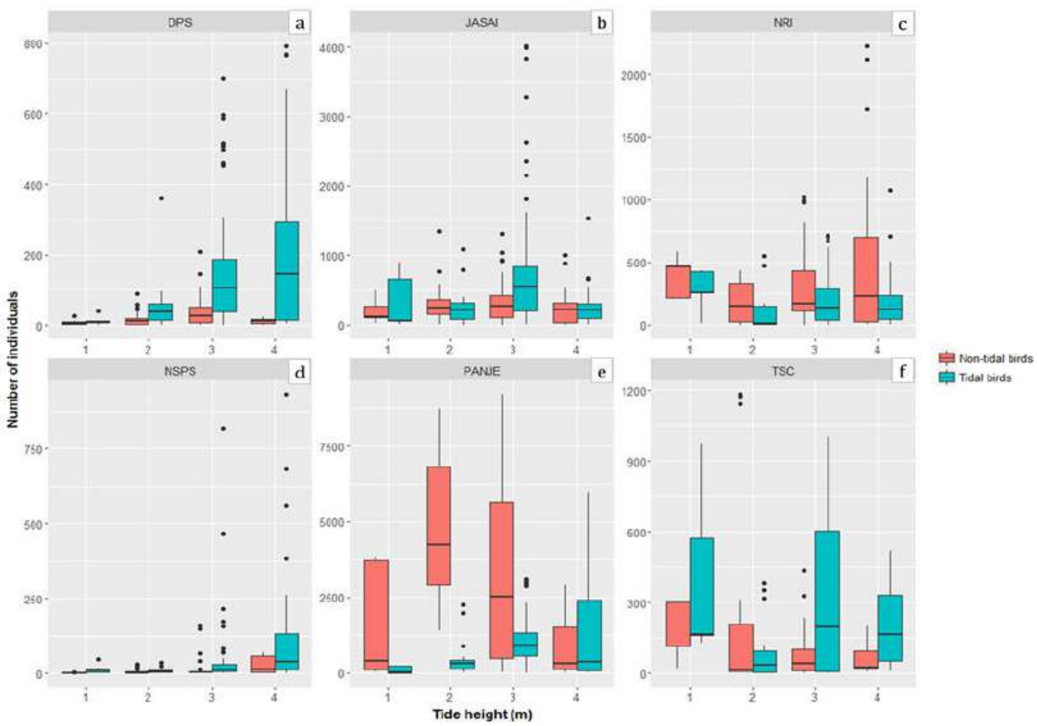


Fig. 3.5. Boxplots of number of individuals of birds counted against tide height at six sites.

3.5 Discussion

In general, the fluctuations in water bird numbers were significantly related with tide height but not time of the day. In particular, tidal birds usually increased dramatically with increasing tide height at high tide, in contrast non-tidal birds showed increasing as well as decreasing trajectories. In addition to these daily fluctuations, waterbirds also revealed significant oscillations in numbers during different months. Similarly, looking at the trend of increase in the number of birds at some sites, and at the same time, a decrease in other sites, it may be attributed to the movement of the birds between sites.

One such movement pattern may be explained by rapid increase in the number of tidal as well as non-tidal birds at DPS, NRI and TSC from December to February. At the same time steep decline in water bird numbers was seen at Jasai, Panje and NSPS. Therefore it became more likely that the rapid increase in the number of birds could be because of their movement among these sites. This movement of waterbirds, we suspect, was driven by the persistence of temporary salt water pools created by local fisherman at DPS, NRI and TSC. They were generally shallow and hence ideal sites for feeding and resting for the birds, especially for waders, gulls and terns during high tide. In contrast, disturbances such as land filling at Jasai carried out by JNPT in November, and maintenance of high level of water in temporary ponds by local fishermen at Panje and NSPS for fishing and harvesting salt may have distracted the waterbirds from utilising these sites.

In addition to this local movement of non-tidal birds, winter migrants may also have contributed to the increase in non-tidal bird numbers. The latter seems more likely while looking at the dramatic increase in the number of non-tidal birds at Panje during November and December; at the same time, the decline in the number of non-tidal birds at NSPS and TSC may also have had a small share in elevating the non-tidal bird population at Panje.

Apart from temporal patterns, birds also showed various responses towards tide height at low and high tide at different sites, especially the tidal birds. Tidal birds feed on mudflats during low tide, but at high tide these mudflats were under water, and hence became unsuitable for feeding or resting, which forced tidal birds to nearby areas with shallow water ideal for feeding and/or resting. Therefore, as we anticipated, individuals of non-tidal birds declined (except NSPS and NRI) and tidal birds increase at high tide with increasing tide height at all sites. In general, it could indicate the predominance of tidal birds over non-tidal birds, which in turn may be related to the scarcity of resources such as food and resting places provided by most of these sites, both of which are crucial for tidal birds during high tide period. In contrast, the abundance of resources at NSPS and NRI could have sustained increasing numbers of non-tidal birds along with tidal birds.

Though there was a decrease or relatively stable number of tidal birds with the increase in tide height during low tide, it could signify the importance of these areas for tidal birds during low tide in addition to high tide. In contrast, non-tidal birds showed small increase in their number during low tide which was not surprising, because tidal birds flew from these sites to nearby mudflats for feeding as they got exposed during low tide. As mentioned previously, it could be related to direct competition between tidal birds and non-tidal birds. The extreme case of this observation was seen at Panje where an increase in the number of non-tidal birds during low tide was substantial, compared to the tiny number of tidal birds. It would be interesting to investigate what attracts such huge number of non-tidal birds at this site.

Waterbirds associated with coastal areas is one of the highly stochastic and complex systems, and in human-dominated landscape, these characteristics were increased by many folds. Therefore, this short duration study is not sufficient to explain dynamics or cause-effect relation of water bird numbers at NMIA area. Even then, it has thrown light on the coarse patterns of variations of water bird numbers associated with time and tide. With reference to time during December and January, large number of waterbirds were counted, which appeared to be related to the local movement of birds between sites due to fluctuation in the water level among temporary salt water pools controlled by local fisherman; while in the case of non-tidal birds, it may have also been associated with the arrival of migrants during this period. The response of the birds to tide showed that tidal birds were largely influenced by tide height, especially during high tide. At high tide, these birds through their large numbers of aggregation, clearly suggested the importance of temporary salt water pools created by local people, as they served as key feeding and/or resting sites. Though not tide dependent, non-tidal birds (residential as well as migrants) also indicated their significant association with these sites through their fluctuating numbers survey dates.

CHAPTER 4
AMPHIBIANS

4.1 Sampling design

Quadrat method was used for sampling amphibians of this landscape. We adopted sampling design described by Campbell and Christman (1982) – four quadrats of 25 X 25 m were laid exactly opposite to each other at randomly selected points (Map 3c). The corners of each quadrat were marked with coloured ribbons and GPS locations were recorded for conducting repetitive surveys. Total area sampled at each random point was 0.25 ha. On an average, 20 min of search efforts were undertaken by two people from late morning to afternoon (9.00 a.m–15.00 p.m.) for diurnal and at night (18.00 p.m.–24.00 a.m.) for nocturnal amphibians. We overturned leaf litter, branches and stones with hand and checked rock crevices and tree holes, fissures and buttresses for amphibians. However, in a habitat like mangrove, where quadrats were not feasible to sample due to inaccessibility, we laid quadrats adjacent to each other (collectively 100 m length and 25 m width, so total area was 0.25 ha) and searched for an average of 20 min to keep sampling efforts comparable. In addition to this, we conducted ad hoc surveys for free listing of the species encounter outside the quadrat.

In these quadrats, we measured occupancy covariates those influence the occurrence of the amphibians such as understorey height, leaf litter thickness and ground cover (rock, soil, wooden log, leaf litter etc.). Thickness of leaf litter (measured with steel scale) and presence/absence of rock, soil, wooden log and leaf litter were recorded at every 5 m interval along a diagonal in each quadrat. However, the average height of the trees and shrubs (< 3 m height) was recorded in 1 m radius around the centre of the quadrat as understorey height. In addition to this, detection covariates like temperature, humidity, time and date were recorded during each sampling session. All sampling was conducted from January 2016 to January 2017.

Amphibians were captured using hands. Captured individuals were released immediately after recording their qualitative and quantitative body characters. We then identified the individuals based on the measured characters using literature (Boulenger 1890; Daniel 2002).

4.2 Data analysis

Canopy cover was positively correlated with forest cover (%); hence we removed it from the model. Though understorey height is occupancy covariate, it can also be used as detection covariate because increasing understorey reduces the detection probability by obstructing the vision. In contrast, tree density did not seem like an ecologically meaningful detection covariate while looking at the habit of the amphibians and the sampling method (the quadrates which were closely and thoroughly sampled), hence it was not included in the model. Hence, final multispecies occupancy model for amphibians included elevation, forest cover and anthropogenic habitat cover as occupancy covariates and date, time, temperature, humidity and understorey height as detection covariates (please refer section 3 for more details).

4.3 Results

We sampled 35 sites with a total of 840 replicates, about 24 replicates per site. In all, we found 16 amphibian species with 310 detections (Annexure IV). Among them *Fejervarya* sp1, *Fejervarya* sp2, *Duttaphrynus melanostictus, Polypedates maculatus, Euphlyctis cynophlyctis* and *Hoplobatrachus tigerinus* were detected at large number of sites; in contrast, *Indotyphlus battersbyi, Raorchestes ghatei, Uperodon globulosus, Indirana leithii* and *U. mormorata* were found at fewer sites.

Community level covariate effect

Overall, mean occupancy of the amphibian community showed strong positive association with forest and moderate negative correlation with elevation. However, the community exhibited significant negative impact of the anthropogenic habitat cover on the mean occupancy (Table 4.1).

This negative impact of anthropogenic habitat cover and importance of the forest cover on amphibian communities was further emphasized by species richness map of the landscape (Fig. 4a). It showed that high elevated, less disturbed and forest covered areas were species rich than the lowlands covered with human settlements, agricultural fields and degraded forests. Though species accumulation curve failed to reach asymptote, indicating rarity of many amphibians, the rate of addition of species greatly reduced. Hence, looking at the species accumulation curve and estimated against observed plot of species richness (Fig. 4b and Fig. 4c), the number of sites sampled in this study (n=35) appeared adequate to draw reliable inferences about species richness at sites and across the landscape.

Table 4.1. Community level summaries of hyper-parameters for occupancy and detection covariates.

Community-level hyper-parameter	Mean	95% credible intervals
α1 (Elevation effect)	0.484	-0.677, 1.713**
α2 (Forest cover effect)	1.311	0.353, 2.493***
α3 (Anthropogenic habitat cover	-0.773	-1.640, -0.012***
β1 (Date effect)	-0.532	-1.364, 0.238**
β2 (Time effect - squared)	0.124	-0.184, 0.402*
***B*3 (Humidity effect)**	0.023	-0.184, 0.241*
***B*5 (Understorey height effect)**	0.239	-0.012, 0.501**

*- Weak effect; ** - Moderate effect; *** - Strong effect

Unlike occupancy covariates, except date and understorey height, other detection covariates had weak effect on mean community detection probability across amphibian community. Date showed moderate negative and understorey had moderate positive effect on detection probability. In contrast, humidity and squared effect of time exhibited weak positive relation with mean community detection probability. This diverse response (i.e. detection probability) of the amphibian community unravelled through detection covariates effect was clearly seen (Fig.4d). Considering ecologically, behaviourally and evolutionarily diverse assemblages of the amphibians examined in this study, variability in detection probability appears more likely.

Species level covariate effect

Mean occupancy of the amphibian species varied greatly, 0.9% to 94%. In general, detection probability was very low and had narrow range of variation from 0. 4% to 9.4%. Species like *Nyctibatrachus humayuni, I. battersbyi and U. mormorata* had very little detection and therefore their credible intervals were too wide to draw reliable inferences. Posterior summaries of occupancy and detection probability for each species as well as species specific response to occupancy covariates are given in Appendix III.

Anthropogenic habitat cover had negative impact on species occupancy (Fig. 4e). While except one species, *Raorchestes cf. bombayensis*, showed strong evidence for negative effect, remaining 93.75% of species (15 out of 16 species) had moderately negative impact. In contrast, the forest had positive effect on species occupancy (Fig. 4f); for example 18.75% of the species (3 out of 16 species) showed significant positive association, 75 % of them (12 out of 16 species) had moderately positive correlation and one species showed moderately negative effect. Apart from overall response of amphibians towards occupancy covariates, different groups of amphibians showed various patterns of responses.

Bush frog exhibited low occupancies, *R cf. bombayensis* – 1.3 % (CI – 1–12%) and *R. ghatei* – 1.3 % (CI – 0–10.5%). *R cf. bombayensis* had significant positive correlation with elevation and negative association with anthropogenic habitat cover, while it showed moderately positive correlation with forest cover. On the other hand, *R. ghatei* had moderate positive correlation with forest cover and elevation, and moderate negative association with anthropogenic habitat cover. Unlike bush frogs, tree frog *P. maculatus* appeared to be fairly common in this landscape, with mean occupancy 50.1%. This species showed strong positive association with forest cover, moderate negative impact of anthropogenic habitat cover and weak positive correlation with elevation.

Similar to arboreal frogs, four species of forest floor dwelling amphibians showed wide range of occupancies such as uncommon *U. globulosus* with occupancy 5.4%, to most common *D. melanostictus* with occupancy 82.65%. Interestingly, *S. breviceps* and *U. mormorata* exhibited significant positive association with forest cover and weak negative effect of elevation, whereas *D. melanostictus* and *U. globulosus* had moderate positive correlation with forest cover. All species showed moderately negative impact of anthropogenic habitat cover.

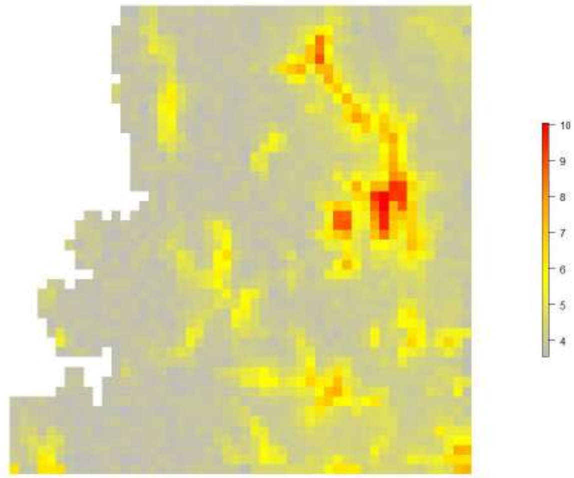


Fig. 4a. Amphibian species richness at 1 sq. km. scale in the landscape based on forest cover and elevation.

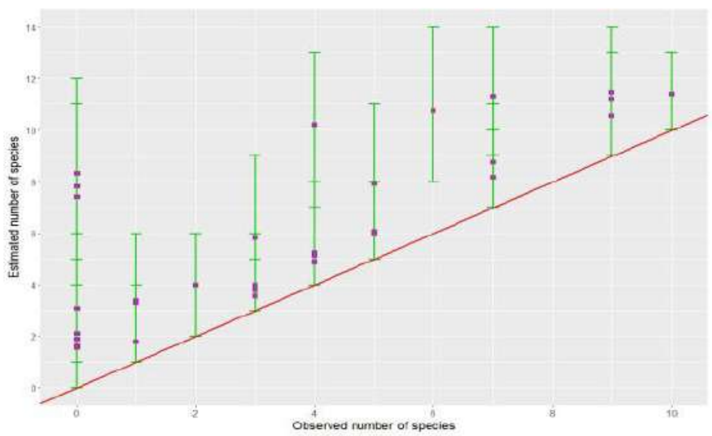


Fig. 4b. Relationship between estimated number of species and observed number of species.

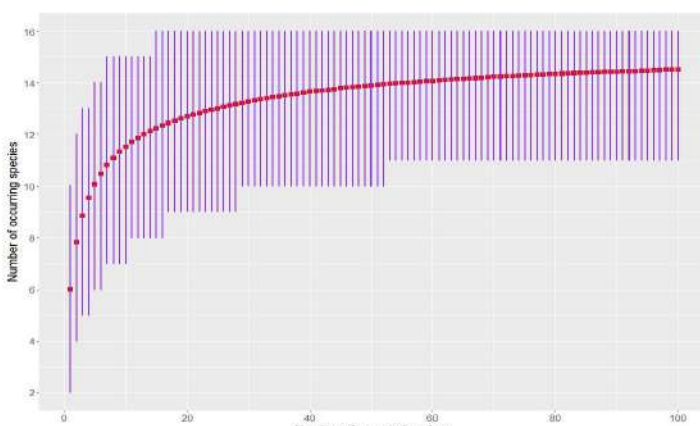


Fig. 4c. Species accumulation curve for amphibian species in the landscape.

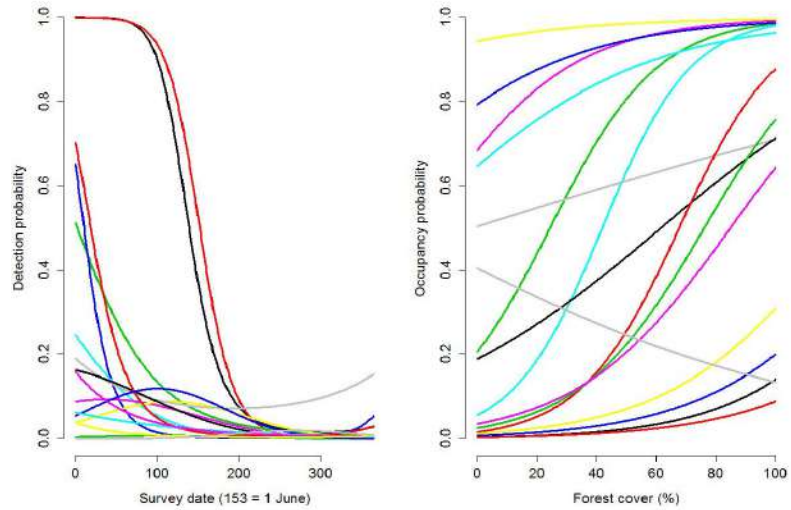


Fig. 4d. Species-specific predictions of detection and occupancy probability as function of survey date and forest cover respectively in 1 sq. km. grid in the landscape.

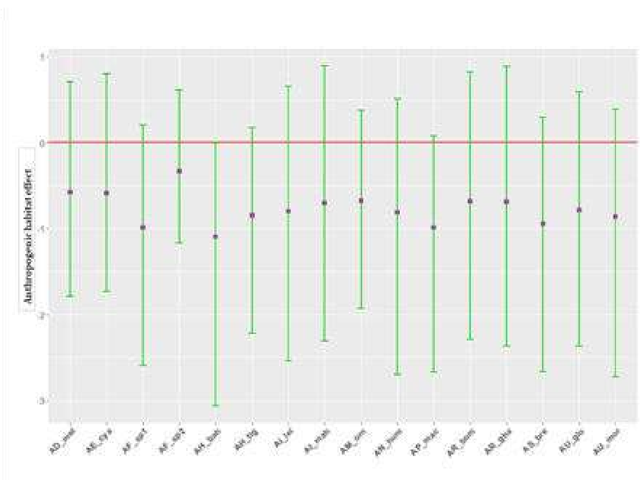


Fig. 4e. Anthropogenic habitat cover effect in logit scale (α3, 95% CI) on occupancy of amphibian species in the landscape.

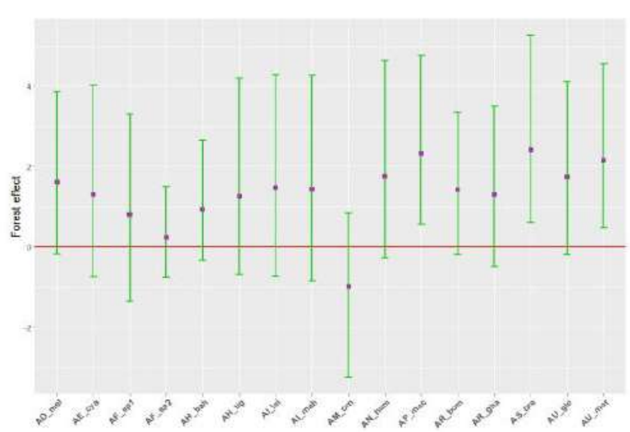


Fig. 4f. Forest cover effct in logit scale (α2, 95% CI) on occupancy of amphibian species in this landscape.

In contrast to forest dwelling amphibians, four species of water pool dwelling amphibians had comparatively high occupancies – *Fejervarya* sp.1 (94.8%), *E. cynophlyctis* (78.6%), *H. tigerinus* (70.5%) and *F. sp.*2 (53.8%) – except for *Hydrophylax bahuvistara,* which had mean occupancy of 19.1%. *H. bahuvistara* had significantly negative impact of anthropogenic habitat cover while other species showed moderate negative impact. All five species depicted moderate positive association with forest cover. On the other hand, *Microhyla ornata* showed low mean occupancy estimate of 12.3% and had moderate negative correlation with forest and anthropogenic habitat cover. This species also exhibited weak negative association with elevation.

Unlike amphibians mentioned above, two species – a frog and caecilian – had the lowest detections. *N. humayuni,* a stream dwelling frog, exhibited low occupancy 11.5% (based on 5 detections). It had moderate positive correlation with elevation and forest whereas the impact of anthropogenic habitat cover was moderate negative. Similarly, *I. battersbyi*, a caecilian, had low occupancy 6.2%; while considering single detection of the species, this occupancy estimate became highly unreliable to draw any inferences.

4.4 Discussion

In general, findings of the study indicated significant negative impact of the anthropogenic habitat cover on the amphibian community; in contrast, forest had strong positive effect. This simply implies that amphibian species richness significantly increased with increase in forest cover and decreased with increase in anthropogenic habitat cover. Similar pattern of decrease in species richness along disturbance gradient such as species rich evergreen forest to species poor anthropogenic habitats was found by Ganesh et al. 2002. In addition to this, elevation also showed moderate positive effect on the amphibian community. This may be redundant pattern because most of the less disturbed and closed canopy forests were confined to comparatively higher elevations in this landscape. This trend of direct correlation of the amphibian richness with elevation, particularly at local scale, has been observed in the Western Ghats (Naniwdekar and Vasudevan 2007).

In similar vein, understorey height also related with the elevation and forest cover – mostly high elevated and less disturbed forest had substantial understorey. Therefore, moderate positive association of understorey did not seem unlikely because it provided microhabitat for diverse amphibian species populations, which in turn reflected an increase in detection probabilities with increasing understorey (Krishnamurthy 2003). Though the squared effect of the time had weak effect on the detection of amphibians, it may be interesting because it indicated non-linear effect of time on detection, which also means peak detection probability at certain time period only. This phenomenon of peak activity of most of the frogs during a particular time period was not uncommon; hence we anticipated squared positive effect of time on detection probability. However, weak effect of the humidity on detection probability of amphibians was puzzling because as per their physiological evolution, most amphibians prefer humidity and humid habitats. This could be due to a number of possibilities such as effect of humidity masked by other covariates; recording equipment may not be sensitive enough to detect small change in humidity; frequency of recording the data; and also due to insufficient data.

Bush frogs *R cf. bombayensis*, *R. ghatei,* tree frog *P. maculatus* and balloon frog *U. mormorata* showed strong positive correlation with forest and understorey height. These species prefer semi-evergreen and moist deciduous forests, especially undergrowth below the canopy; evolutionary hence their positive association with forest was expected. However, strong to moderate association of bush frogs and weak positive to negative correlation of tree frog and balloon frog with elevation would be interesting. It could suggest niche segregation of the species along the elevation.

Unlike bush frogs and tree frog, pond dwelling frogs like *E. cynophlyctis, H. tigerinus* and *H. bahuvistara* had moderate positive association with forest and moderate negative correlation with human habitation. It appeared that these species prefer moderately disturbed habitat i.e. degraded forest cover (scrub forest and grasslands), which was logical also because none of these species were forest specialists. Open habitat in degraded forest cover along with ponds and puddles formed by anthropogenic disturbances could have created an ideal habitat for these species and it could be the reason for their occurrence in this habitat.

In contrast to pond dwelling frogs, stream dwelling frog *N. humayuni* is strictly found in high torrent streams. During this study we sampled only few such streams due to random sampling and investigation was not focused on this particular species. This could be the reason for low detections of the species; hence inferences were less reliable in this case. It had moderate positive and negative correlation with forest and anthropogenic habitat cover respectively. This indicated that species prefer forest covered torrent streams and will be affected adversely due to anthropogenic disturbances, especially clearing of the forest cover over the streams.

Considering the small scale of the investigation and that most of the amphibians recorded in this study were common and widespread, extracting any general pattern of response of species to anthropogenic disturbances became challenging. However, this new multispecies occupancy modelling approach provided useful insight into the overall response of the amphibian community as well as species specific effect of the land use and land cover changes. This study clearly indicated that forest cover was the key factor in the occurrence of most of the amphibians; in contrast, increasing anthropogenic habitats would adversely affect large number of species, and in extreme cases such as urbanisation of this landscape, it could lead to the local extinction of most of the amphibian species.

CHAPTER 5
REPTILES

5.1 Sampling design

Quadrat method was used for sampling reptiles of the landscape. We adopted sampling design described by Campbell and Christman (1982) – four quadrats of 25 X 25 m were laid exactly opposite to each other at randomly selected point (Map 3c). The corners of each quadrate were marked with coloured ribbons and GPS locations were recorded to conduct repetitive surveys. Total area sampled at each random point was 0.25 ha. On an average 20 min search efforts were taken up by two people from late morning to afternoon (9.00 a.m.–15.00 p.m.) for diurnal species and at night (18.00 p.m.–24.00 a.m.) for nocturnal amphibians and reptiles. We overturned leaf litter, branches and stones with hand and checked rock crevices and tree holes, fissures and buttresses for reptiles. However, in a habitat like mangrove where quadrats were not feasible to sample due to inaccessibility, we laid quadrats adjacent to each other (collectively 100 m length and 25 m width, so total area was 0.25 ha) and searched for average 20 min to keep sampling efforts comparable. In addition to this we conducted *Ad hoc* surveys for free listing of the species encounter outside the quadrat.

In these quadrats, we measured occupancy covariates which influence the occurrence of the reptiles such as understorey height, leaf litter thickness and ground cover (rock, soil, wooden log, leaf litter etc.). Thickness of leaf litter (measured with steel scale) and presence/absence of rock, soil, wooden log and leaf litter were recorded at every 5 m interval along a diagonal path in each quadrat. However, the average height of the trees and shrubs (< 3m height) was recorded in 1 m radius around the centre of the quadrat as understorey height. In addition to this, detection covariates like temperature, humidity, time and date were recorded during each sampling sessions. All sampling was conducted from January 2016 to January 2017.

Reptiles were captured using hands and snake stick. Captured individuals were released immediately after recording their qualitative and quantitative body characters. Then we identified the individuals based on the measured characters using literature (Boulenger 1839; Daniel 2002; Smith 1935; Whitaker and Captain 2004).

5.2 Data analysis

Canopy cover was positively correlated with forest cover (%), hence we removed it from the model. Though understorey height was occupancy covariate, it could also be used as detection covariate because increasing understorey reduced the detection probability by obstructing the vision. In contrast, tree density did not seem ecologically meaningful detection covariate while looking at the habit of reptiles and sampling method (the quadrates which were closely and thoroughly sampled), hence it was not included in the model. Therefore, final multispecies occupancy model for reptiles included elevation, forest cover and anthropogenic habitat cover as occupancy covariates and date, time, temperature and understorey height as detection covariates (please refer section 3 for more details).

5.3 Results

We sampled 35 sampling sites with a total of 840 replicates, about 24 replicates per site. In all, we found 36 species of reptiles with 880 detections (Annexure V). Among these *Hemidactylus cf brookii, Eutrophis carinata, E. macularia,* and *Calotes versicolor* were detected in most of the sites, while in contrast *H. frenatus, Chamaleon zylanicus* and most of the snakes were recorded from very few sites.

Community level covariate effect

Overall, mean occupancy of the reptile community showed moderate positive correlation with elevation and moderately negative association with forest cover. However, mean response of reptile community showed significant negative impact of anthropogenic habitat cover. (Table 5.1)

Similarly, predictions of species richness of reptiles across landscape with forest cover and elevation also emphasised negative impacts of the anthropogenic habitat cover and importance of the forest cover (may also be that of degraded forest cover) on reptile communities of this landscape (Fig. 5a)

Table 5.1 Community level summaries of hyper-parameters for occupancy and detection covariates.

Community-level hyper-parameter	Mean	95% credible intervals
α1 (Elevation effect)	0.689	-0.654, 2.493**
α2 (Forest cover effect)	-0.703	-2.289, 0.749**
α3 (Anthropogenic habitat cover	-2.375	-4.027 -1.011***
β1 (Date effect)	-0.472	-0.582, -0.371***
β2 (Time effect)	0.213	0.105, 0.310***
B4 (Temperature effect)	-0.121	-0.237, 0.001**
B5 (Understorey height effect)	0.421	0.235, 0.582***

*- Weak effect; ** - Moderate effect; *** - Strong effect

Generally, it showed that forest and degraded forest covered areas were species rich than lowlands covered with human settlements and agricultural fields. The species accumulation curve failed to reach asymptote (Fig. 5b), and thus indicated rarity of some reptile species, but the rate of addition of species was greatly reduced. Hence, looking at the species accumulation and estimated against observed plot of species richness (Fig. 5c) suggests that number of sites sampled in this study (n=35) were not too less to draw credible inferences about species richness at sites and across the landscape.

In similar vein of occupancy covariates, understorey height and time had significant effect on mean detection probability of reptiles across communities. While date showed strong negative correlation and temperature had moderate negative effect on the detection probability (Fig. 5d).

Species level covariate effect

Mean occupancy with respect to individual species varied greatly in the range of 0.8% to 99%. Overall, detection probability was low and also had considerable variations, 0.2% - 30%. Most of the snake species and lizards like *C. zylanicus* and *H. frenatus* had very few detections (< 5), thus giving rise to very vague credible intervals of occupancy estimates afftecting logical interpretation. Posterior summaries of occupancy and detection probability for each species, as well as species-specific responses to occupancy covariates are given in Appendix IV.

Anthropogenic habitat cover had negative impact on species occupancy except for *H. frenatus*, which showed a weak positive association with anthropogenic habitat (Fig. 5e). In general, 41.66% (15 of 36 species) of the species showed moderately negative association, and 27.77% (10 of 36 species) of the species showed strong negative correlation. Similarly, most of the species showed negative impact of forest cover on their occupancies (Fig. 5f). About 25% (9 out of 36 species) of the species exhibited weak positive effect of forests, while 63.88% (23 out of 36 species) of the species depicted weak negative association and 8.33% (3 of 36 species) of the species showed moderately negative impact. Only *H. cf brookii* showed significant negative impact of the forest cover.

Among geckos, *H. frenatus* showed the lowest occupancy with 21% (CI – 3 %–99%) while *H. cf brookii* had the highest occupancy of 97% (CI – 85 %–99%). It showed a moderate positive correlation with elevation and significant negative impact of forest cover as well as anthropogenic habitat cover. On the other hand, *H. maculatus* and *Cyrtodactylus deccanensis* showed a weak positive correlation with elevation and forest cover and strong negative association with anthropogenic habitat cover. Except *H. frenatus,* all other geckos showed a positive correlation with elevation.

Among the three species of agamids, *C. rouxii* showed the lowest occupancy with 53% while *C. versicolor* had the highest occupancy of 99%. All the agamids showed a weak positive correlation with elevation. *C. versicolor* showed weak negative association with both forest and anthropogenic habitat cover, while *Sitana spinaecephalus* had moderate and weak negative association with forest and anthropogenic habitat cover respectively. *C. rouxii* was the only species which exhibited weak positive association with the forest cover and strong negative correlation with anthropogenic habitat cover.

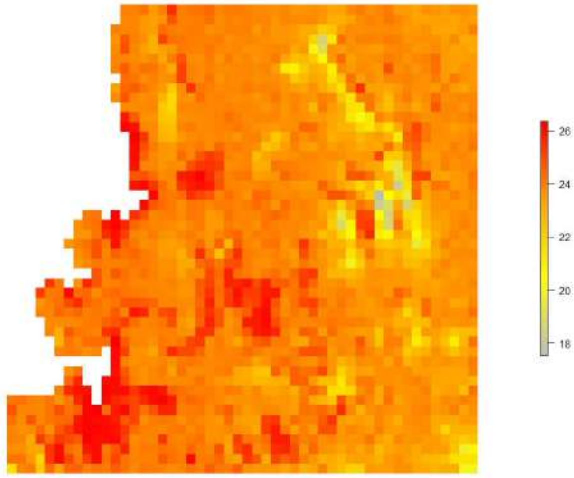


Fig. 5a. Reptile species richness at 1 sq. km. scale in the landscape based on forest cover and elevation.

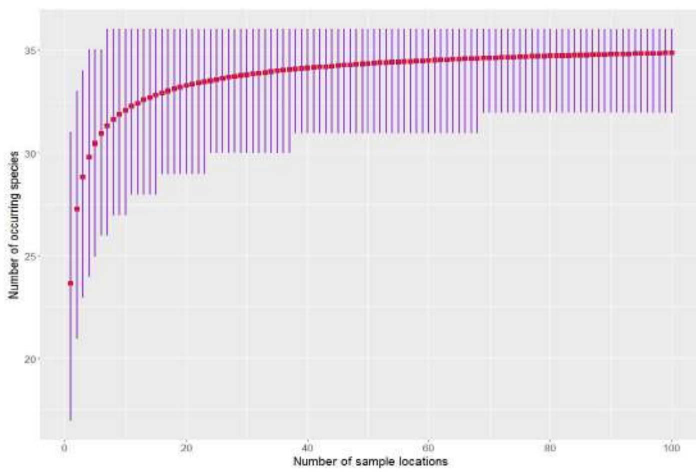


Fig. 5b. Species accumulation curve for reptile species in the landscape.

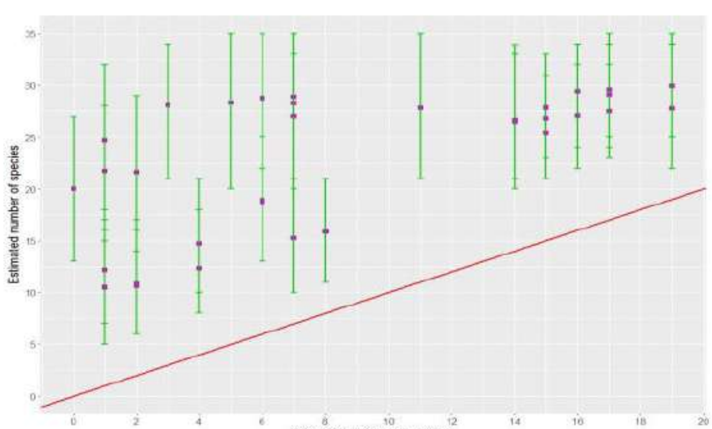


Fig. 5c. Relationship between estimated number of species and observed number of species.

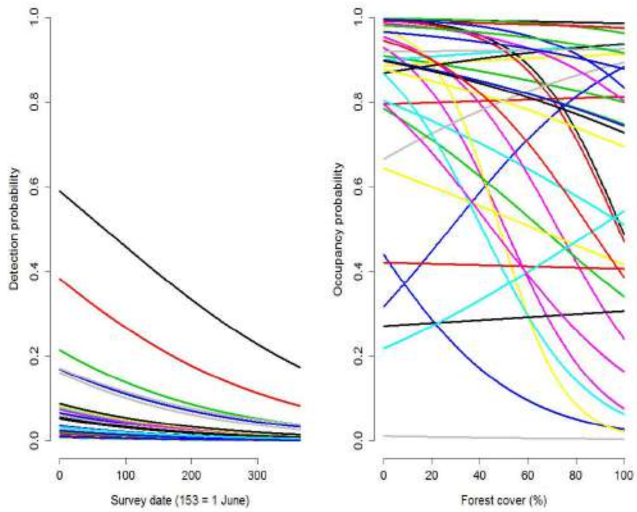


Fig. 5d. Species-specific predictions of detection and occupancy probability as function of survey date and forest cover respectively in 1 sq. km. grid in the landscape.

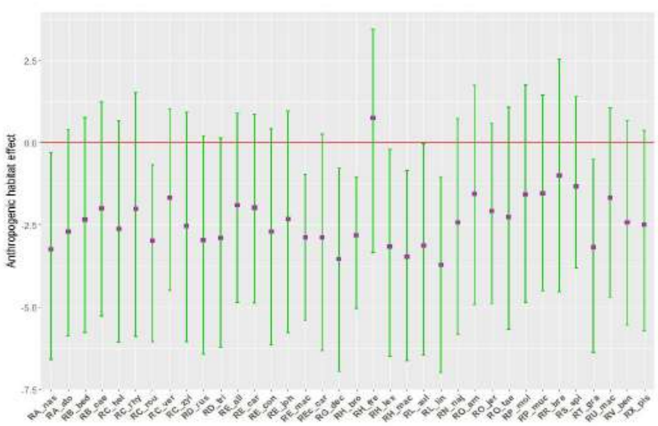


Fig. 5e. Anthropogenic habitat cover effect in logit scale (α3,95%CI) on occupancy of reptile species in this landscape.

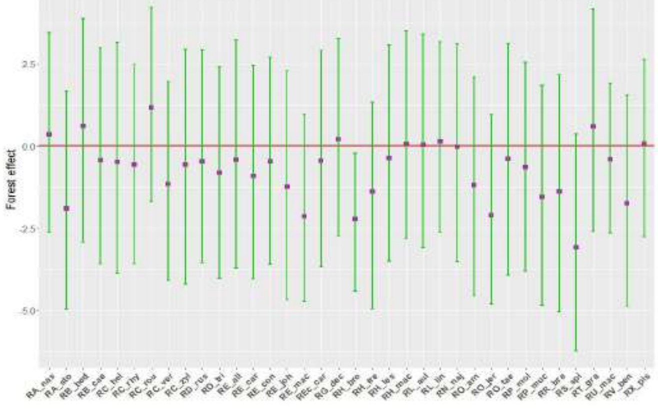


Fig. 5f. Forest cover effect in logit scale (α2, 95% CI) on occupancy of reptile species in the landscape.

Snakes showed a very wide range of occupancies; for example, burrowing snake *Uropeltis macrolepis* had occupancy of <1% while *Trimeresurus gramineus* with occupancy of 98.78%. Even though 16 of the 21 species of snakes recorded had a mean occupancy of more than 60%, 14 of these had wide credible intervals and hence it was difficult to draw reliable inferences. In contrast, arboreal species such as *T. gramineus* and *Ahetula nasuta* showed high mean occupancy of 98.78% and 98.47% respectively. Both these species had a weak positive association with elevation and forest cover but a strong negative correlation with anthropogenic habitat cover. Similarly, *Lycodon aulicus, Xenochrophis piscator* and *Boiga beddomei* also had weak positive association with forest cover and *L. aulicus* showed strong negative impact of anthropogenic habitat cover. Overall, snakes were found to be negatively associated with anthropogenic habitat cover. While, in the case of elevation, except for *Dendrelaphis tristis, Ptyas mucosus* and *Cerberus rhyncops* that had a weak negative correlation, the rest of the snakes showed a weak positive correlation.

5.4 Discussion

General findings of the study showed significant negative impact of anthropogenic habitat cover on the reptile community. Similarly, forest cover also had moderate negative impact on community but looking at species level only three species had shown moderate negative effect. The significant negative effect of anthropogenic habitat and weak negative response of 65% of reptiles towards forest habitat may indicate their preference for degraded forest cover. We did not include degraded forest cover in this analysis due to its correlation with forest cover ($r = -0.53$) and it was similar to forest habitat in its vegetation structure and composition than anthropogenic habitats. This simply implies that reptile species richness increases with increase in forest (and/or degraded forest) cover and decreases with increase in anthropogenic habitat cover. Other studies in the Western Ghats and Northeast India have also identified similar patterns in the decrease of species richness along disturbance gradient; disturbed and fragmented habitats have less species richness when compared to primary habitats (Ishwar et al. 2001, 2003).

In addition, elevation also had a moderate positive effect on the reptile community; this may be redundant pattern because most of the less disturbed and closed canopy forests were confined to comparatively higher elevations in the landscape. This trend of direct correlation of the reptile species richness with elevation, particularly at local scale, has been observed in many studies (Naniwdekar and Vasudevan 2007, Kannan and Bhupathy 2009, Chettri et al. 2011).

Similarly, understorey height was also directly related with the elevation and forest cover as most of the high elevated and less disturbed forests had substantial understorey cover. Therefore, strong positive association of understorey height is expected because understorey provides the important microhabitat necessary for diverse reptile species, especially as there are many with arboreal habits. This in turn is reflected by the increase in detection probabilities with increasing understorey height (Inger et al. 1987). Like understorey, time of the sampling had strong positive correlation with detection probability, which implied that either during warm hours of the day or late night, detection probability was high. Reptiles are poikilothermic animals and are sensitive towards changing temperatures and generally need optimum temperature for their activities (Bohm et al. 2013). Hence, it appears that during a particular time of the day or night (during optimum temperature) reptiles became more active, which led to high probability of their detections.

In contrast to understorey and time, date had strong negative effect on detection probability of reptiles, which indicated that in late winter and summer, detection probability was high. It was not surprising because, during this season, habitats in the landscape were comparatively more open and it was also dispersing time for juvenile and sub-adults of reptiles born in the monsoon. We suspect this explains high detection probability of reptiles across communities during late winter and summer. The moderate negative impact of temperature on detection probability could be related with temperature above optimum range of temperature tolerance which ultimately affect the reptiles adversely or it may also be due to more reptiles detected in nocturnal surveys when temperature was generally lower than day time temperature. Like overall reptilian community, various groups of reptiles showed different patterns of responses towards occupancy covariates.

For example, among geckos, except *H. frenatus,* all other species of reptiles were negatively affected by anthropogenic habitat cover. *H. frenatus,* is known to be a commensal species and have been often observed associated with human settlements, taking refuge in human-made structures (Daniel 2002, Smith 1935, Somaweera and Somaweera 2009). Even though *H. cf brookii* was found to have the highest occupancy, it showed negative association with both forest and anthropogenic habitat, which suggested its affinity for degraded forest habitats. These habitats are very abundant in this landscape, hence may explain high occupancy of *H. cf brookii.* It is also observed that this species is one of the most generalist and widely distributed among geckos and is known to occur commonly in drier, slightly disturbed habitats like scrub, agriculture and rocky outcrops (Daniel 2002, Smith 1935).

Like *H. cf brookii,* the agamid lizards, *C. versicolor* also showed high occupancy but negative association with both forest and anthropogenic habitat. It is also a generalist lizard with preference for open habitats. On the contrary, *C. rouxii* being a forest specific species had low occupancy and positive association with forests. Unlike the other two, *S. spinaecephalus* is a ground dwelling agamid lizard with affinity to dry and scrub habitats. So its moderate and strong negative association with forest and anthropogenic habitat can be anticipated (Ishwar et al. 2003, Kannan and Bhupathy 2009).

Unlike geckos and agamids, skinks and lacertids are ground dwelling lizards known to hide among leaf-litter and under logs and stones on the forest floor. The negative association of almost all the species in this group with forest cover could be an artifact due to missing out on hiding individuals during diurnal surveys. In forested habitat, the forest floor is often covered with litter and logs that provide easy escape routes for these small lizards. Sighting them in open habitats like grasslands and agriculture is easier due to the scarcity of litter load. Thus overall negative response of skinks and lacertids towards forest cover seems a result of flawed sampling method used for this group.

In contrast to comparatively abundant groups like geckos, agamids and skinks, snakes belonged to a group where most of the species (16 of 21 species) had low detections, hence they showed wide credible intervals. We anticipated these results because our sampling method is not ideal for the detection of all snakes. Arboreal species like the *T. gramineus* and *A. nasuta* had high occupancies and positive association with elevation and forest cover. Arboreal snakes like the pit viper and vine snakes, are likely to have association with forests, as they need understorey as a microhabitat. These species are ambush predators and so are more likely to stay within a specific habitat type when compared to other ground-dwelling snakes (Ishwar *et al* 1998, Sawant et al. 2010, Whitaker and Captain 2004, Plummer 1981, Heatwole 1982).

Using multispecies occupancy modelling approach to understand species response to various land use and land cover types not only provided useful insight into the overall response of reptile community but also highlighted species specific responses. Most of the species observed during the study belong to varied groups and differed extensively in their habitat requirement, abundance and home ranges right from small commensal geckos to large monitor lizards and pythons. In spite of these variations, this study clearly indicated that forest cover was essential for the occurrence of most of the reptile species while increasing anthropogenic habitat cover would adversely affect most of the species, in extreme cases such as urbanization of this landscape could lead to extinction of large number of species.

CHAPTER 6
INSECTS

6.1 Sampling design

We studied butterflies (Lepidoptera) and dragonflies and damselflies (Odonata) as representatives of insect diversity in this landscape. These groups were targeted because they are diverse and more conspicuous, hence easy to identify and monitor. They are sensitive to microhabitat and habitat changes; therefore they can be used as indicators of habitat changes, especially due to human disturbances (Gerlach *et al* 2013, Gullan and Cranston 2010).

We mainly adopted Pollard walk method (Pollard 1977), for counting butterflies and odonates. In a randomly selected grid (n=35), belt transect of 500 m length and 10 m width was sampled at each random point (2-4 points/grid, Map 3b). In case of inaccessibility, two transects in a grid were repeated twice in order to obtain four replicates in grid. Transects were walked between 8 am to 12 pm when activity of the target group was at its peak. We counted the number of individuals of butterflies and odonates observed in the transects. They were identified using standard literature (Dijkstra et al. 2013, Fraser 1933, 1934, 1936, Kehimkar 2008, Kunte 2000, Subramanian 2009). The sampling was carried out in three seasons: - post-monsoon (October 2016–November 2016), winter (December 2015–February 2016 and December 2016–February 2017) and summer (March 2016–May 2016)

In these transects we measured occupancy covariates which influence the occurrence of the butterflies and odonates such as understorey height, tree stem density and canopy cover. Understorey height (described in section 4.1) and tree stem density (described in plant sampling) were used directly, as they were measured while considering their usage for multiple taxa. Canopy cover was recorded at every 100 m interval on transect using spherical densiometer and at the same interval host and food plants of butterflies were recorded within 5 m radius circle. In addition to this, detection covariates like temperature, humidity, time and date were recorded during each sampling occasion.

In addition to quantitative data, we also collected qualitative data such as night-flying insects those are attracted towards light. This data was collected by setting up light traps – A 14W CFL bulb used to illuminate a white cloth (3m X 2m) with the help of a mini-inverter. Light trapping was conducted from 8 to 10 p.m. in evergreen, deciduous, scrub and agriculture habitats across three seasons. In settlements, insects seen near light sources in residential complexes and along roads were recorded; but due to inaccesibilty light trapping was not carried out in mangroves.

Relatively few groups of these night-flying insects are well studied, hence it was not possible to identify many of the species attracted to the light, especially diverse groups of small-sized insects. In such cases, taxa were assigned up to family or genus level. We did not collect any insect specimen during this sampling.

6.2 Data analysis

Canopy cover was positively correlated with forest cover (%) hence we removed it from the model. Though understorey height and tree density were occupancy covariates, they could also be used as detection covariates because increasing understorey and tree density reduce the detection probability by obstructing the vision. Hence, final multispecies occupancy model for butterflies, elevation, forest cover and anthropogenic habitat cover were included as occupancy covariates and date, time, temperature, humidity, understory height and tree density as detection covariates (please refer section 3 for more details).

In contrast to butterflies, more than 50% of odonates had very few detection (≤ 5); thus, for ecological as well as technical reasons (non-convergence of MCMC chains) we did not run multispecies occupancy model for odonates. These low detections could be because of sampling design as most of odonates were associated with aquatic habitats like streams, ponds and lakes; in our random sampling strategy, it appered that we undersampled these particular habitats in order to draw reliable inferences about odonates.

6.3 Results

We sampled 35 sites with 420 replicates, 12 replicates per site. In all, 105 species of butterflies were observed in this study, of which 99 species with 1774 detections were recorded in quantitative sampling (Annexure VI). Common crow, common grass yellow, common cerulean and gram blue were detected in large proportions of sampling sites; in contrast angled castor, black rajah, red helen, vindhyan bob, water snow flat, large salmon arab etc. were only detected once during the entire study.

Community level covariate effect

Butterfly community did not show significant effect of the forest cover as well as anthropogenic habitats. Mean response of the community to anthropogenic habitat cover was weak positive and moderate positive to forest cover, while it was moderate negative to elevation (Table 6.1). Moderate positive effect of forest cover indicated that many butterfly species were not strictly associated with the forest. Looking at moderate negative effect of elevation, it could suggest low land habitats, especially degraded forest and anthropogenic habitat cover, also supported substantial richness of butterflies.

Species richness predictions map reinforced the importance of forest cover for butterflies i.e. richness was comparatively higher in forest covered and high elevated areas than human dominated lowland habits (Fig. 6a). However, these species richness predictions appeared imperfect while looking at the species accumulation curve (Fig. 6b); it did not reach asymptote, clearly pointing towards insufficient sample size (n=35). Similar pattern was also seen in the graph estimated against observed number of species. Species poor sites had unrealistic estimates of the species richness which one can anticipate when the community had many rare species (also means that new species are slowly being added to the community) (Fig. 6c).

Unlike occupancy covariates, detection covariates such as date and temperature had significant effect on detection probability of the butterflies. Date had strong negative effect on detection probability which implies that species detection decreased significantly with increasing date of surveys. Similarly, temperature and tree density also showed significant effect on detection probability while it had positive effect. In contrast, understorey showed a weak negative effect on detection probability (Fig. 6d).

Table 6.1. Community level summaries of hyper-parameters for occupancy and detection covariates.

Community-level hyper-parameter	Mean	95% credible intervals
***α*1 (Elevation effect)**	-0.336	-1.149, 0.447**
α2 (Forest cover effect)	0.589	-0.002, 1.281**
α3 (Anthropogenic habitat cover	0.212	-0.447, 0.927*
***β*1 (Date effect)**	-0.624	-0.878, -0.350***
***Β*4 (Temperature effect)**	0.283	0.102, 0.454***
***β*5 (Understorey height effect)**	-0.143	-0.508, 0.218*
***β*6 (Tree density effect)**	0.353	0.010, 0.662***

*- Weak effect; ** - Moderate effect; *** - Strong effect

Species level covariate effect

Mean occupancy varied considerably among species, ranging from 4% to 92%. Similarly, detection probability also varied widely (1.2% - 82%). The species with low detections (< 10) such as angled castor, black rajah, chestnut-streaked sailer, common five-ring, common nawab, malayan, common banded awl, blue pansy, common jay and small cupid showed widest credible interval for their occupancy estimates. Posterior summaries of occupancy and detection probability for each species, as well as species specific response to occupancy covariates, are given in the Appendix V.

Forest cover had moderate positive effect on the occupancy of the butterflies (Fig. 6e) – among them about 30% of species showed moderate positive association; only three species – common silver line, plain tiger and striped tiger had weak negative correlation with forest cover; while remaining 66% of species depicted weak positive relation. On the other hand with anthropogenic habitat cover, 57% of the species showed weak positive association, 11% of the species had moderate positive correlation and 31% of the species exhibited weak negative correlation (Fig. 6f). Most of the species (89%) had weak negative association with elevation. Whereas, common gull, small salmon arab and tiny grass blue showed moderate negative and the rest 7% of species including Hesperiids and Nymphalids exhibited moderate positive correlation with elevation. In addition to overall response of butterflies towards occupancy covariates, different groups of butterflies showed various patterns of occupancies – some groups had low occupancies while the other/s had high occupancies.

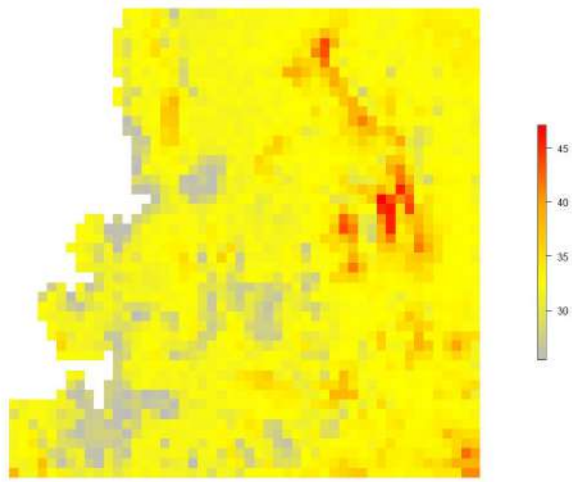


Fig. 6a. Butterfly species richness at 1 sq. km. scale in the landscape based on forest cover and elevation.

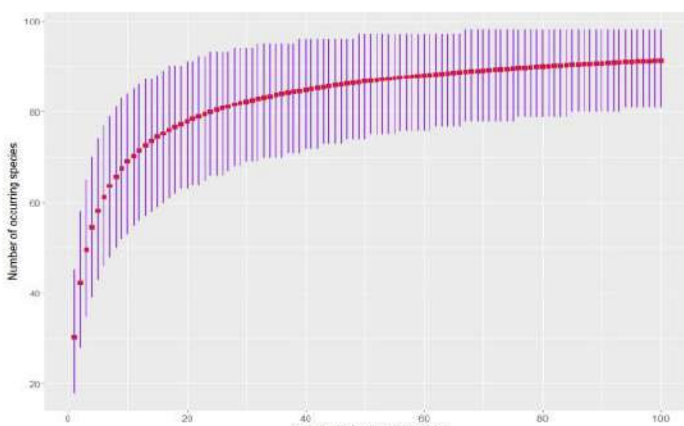


Fig. 6b. Species accumulation curve for butterfly species in the landscape.

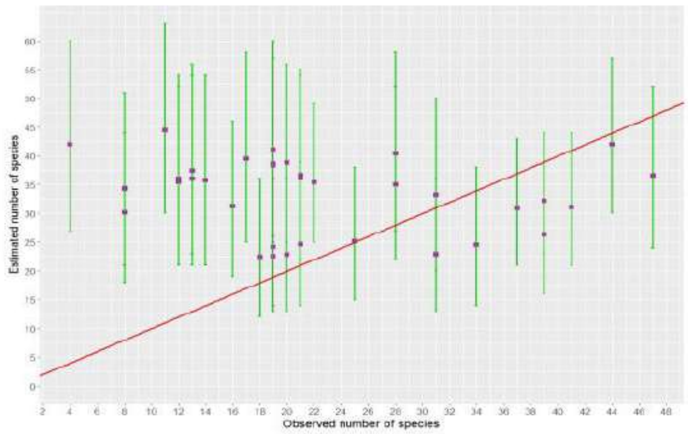


Fig. 6c. Relationship between estimated number of species and observed number of species.

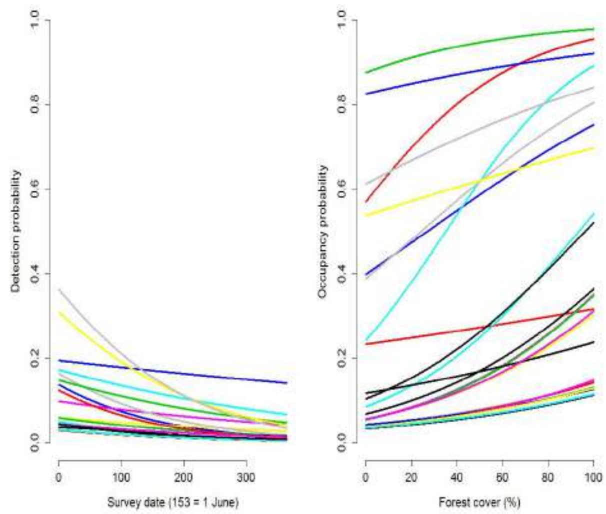


Fig. 6d. Species-specific predictions of detection and occupancy probability as function of survey date and forest cover respectively in 1 sq. km. grid in the landscape.

Fig. 6e Forest cover effect in logit scale (α3,95%CI) on occupancy of butterfly species in this landscape.

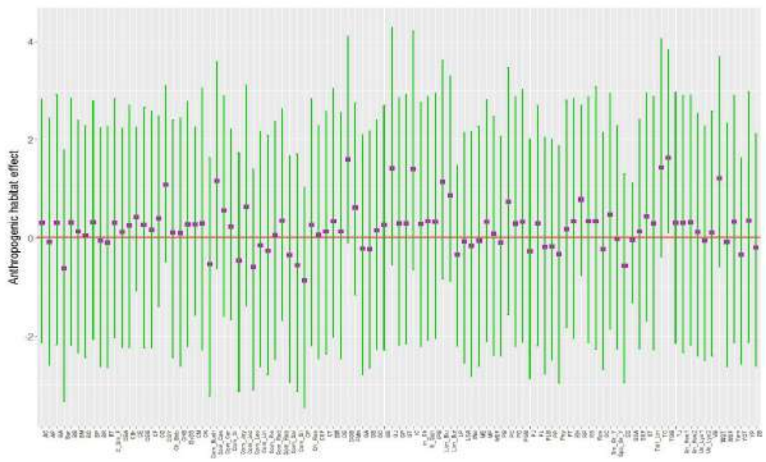


Fig. 6f. Anthropogenic habitat cover effect in logit scale (α2, 95% CI) on occupancy of butterfly species in the landscape.

A group of twenty butterfly species (belongs to Nymphalidae, Lycaenidae, Pieridae and Papilionidae) showed high occupancies (> 40%). Among them, eight species of Nymphalids had varied occupancies, highest for common crow (92%) and lowest for small grass yellow (41%). Five species of Nymphalids had moderate positive effect of forest cover, while the remaining peacock pansy and baronet showed weak positive association and plain tiger depicted weak negative correlation. These species showed weak negative impact of anthropogenic habitat cover, except common crow and plain tiger which had weak positive response. Common crow and common bushbrown showed weak positive effect of elevation while the rest of the Nymphalids had weak negative association, except chocolate pansy (moderate positive). On the other hand, all Lycaenids exhibited weak negative correlation with elevation. They showed overall weak effect of forest cover and anthropogenic habitat cover, except moderate positive association of common cerulean to forest cover and rounded pierrot to anthropogenic habitat cover.

However, the yellows (Pieridae) showed weak positive association with forest cover, except common gull which had moderate positive correlation. Similarly, anthropogenic habitat cover also had weak positive impact on all yellows, except common grass yellow (moderate positive). Common gull showed moderate negative relation with elevation while the rest of the species had weak negative association. Among Swallowtails (Papilionidae), common mormon and common rose showed weak positive impact of forest cover and anthropogenic habitat cover but had weak negative association with elevation. Whereas, common jay exhibited moderate positive correlation with forest cover but it had weak negative association with anthropogenic habitat and weak positive correlation with elevation.

Unlike species with high occupancy, 34 species showed very low occupancy (<10%). Among them, 11 species of skippers (Hesperidae) showed overall weak effect of all occupancy covariates. All skippers had weak positive association with forest cover, except spotted small flat and common banded awl, which exhibited moderate positive correlation. Similarly, anthropogenic habitat cover also depicted weak positive impact on all skippers. However, seven species of skippers showed weak negative association with elevation; but spotted small flat had moderate positive correlation and Indian palm bob and grass demon showed weak positive association with elevation. Similar to skippers, all Lycaenids, Swallowtails and Nymphalids showed weak positive impact of forest cover and anthropogenic habitats but weak negative effect of elevation. Most of the species (33 of 34) had low detections that in turn reflected in their wide credible intervals (1–95%, Appendix V). Hence, it became difficult to draw reliable inferences about the occupancy of these species. In contrast, small salmon arab showed low mean occupancy of 6% (CI – 1–22%) but yielded narrow credible interval, due to large number of detections, i.e. 50.

In addition to butterflies with high and low occupancies, about 45 species showed moderate mean occupancies, ranging from 11 to 40%. Of these, twenty species showed detections ≤ 5 and thus had wide credible interval for their occupancies (Appendix V). All six skippers in this group exhibited overall weak effect of occupancy covariates, while chestnut bob had moderate positive association with forest cover and elevation and weak positive correlation with anthropogenic habitat cover.

In contrast to skippers, eight of nineteen species of blues had ≤ 5 detections, hence showed wide credible interval (Appendix V). Remaining 11 species depicted weak positive impact of forest cover, except common silverline and common hedge blue which had weak negative and moderate positive effect respectively. In general, blues showed weak negative impact of anthropogenic habitat cover except grass blues, grass jewel and lime blue which had moderate positive effect and common hedge blue which showed weak positive association. The blues showed weak negative association with elevation, except tiny grass blue with moderate negative correlation and common hedge blue with weak positive relation.

Similarly, five Nymphalids had ≤ 5 detection and wide credible interval (Appendix V). Common sailer, blue tiger and danaid eggfly showed moderate positive effect with forest cover while striped tiger and common castor had weak negative and weak positive correlation respectively. In contrast, common sailer and blue tiger depicted weak negative impact of anthropogenic habitat cover, while striped tiger and danaid eggfly had weak positive and common castor exhibited moderate positive impact. On the other hand, striped tiger, blue tiger and common castor showed weak negative association with elevation, whereas common sailer and danaid eggfly had weak positive correlation.

Among swallowtails, lime butterfly showed weak positive effect of the forest cover while spot swordtail and blue mormon had moderate positive effect. Lime butterfly, blue mormon and spot swordtail showed moderate positive, weak positive and weak negative impact of anthropogenic habitat cover respectively; in addition, they had weak negative, moderate positive and weak positive association with elevation respectively. Like swallowtails, yellows also showed a mixed response to the covariates. Excluding the least detected species like mottled emigrant and large salmon arab, three species - psyche, common jezebel and yellow orange tip had moderate positive association with forest cover while white orange tip exhibited weak positive effect. Impact of the anthropogenic habitat cover on psyche and yellow orange tip was weak negative, while it was weak positive for common jezebel and moderate positive for white orange tip. On the contrary, all species had weak negative correlation with elevation. Plum judy, the sole member of Family Riodinidae, showed moderate positive association with forest cover, weak negative impact of anthropogenic habitat cover and weak positive correlation with elevation.

6.4 Discussion

Overall, the findings of this study indicated that butterflies had no significant association with forest or anthropogenic habitat cover either at community or at species level. Though effect of forest cover on butterfly communities was moderate positive, not statistically significant, it suggested its importance for butterfly assemblages. This relationship seemed ecologically meaningful because the forest cover (semi-evergreen forest, moist deciduous forest and mangrove forest in this case) composed of diverse plant communities ranging from small herbs to large flowering trees, harbouring a large array of host plants, nectar plants and other microhabitat essential for the survival of the butterflies (Arun and Vijayan 2004, Kunte 2000, Tiple et al. 2007).

On the other hand, weak positive effect of anthropogenic habitat cover on butterfly communities was not unusual because it included agricultural habitat. These agricultural habitats are located on the outskirts of the urban or rural areas which still have the remnants of natural plant diversity or have plantation/cultivation of plants essential for butterflies. Such habitats attract butterflies, mostly the generalists and those that prefer open habitats (Kunte 1997, Kunte 2000, Kehimkar 2008). Although overall communities showed moderate negative association with elevation, species-specific response of most of the species had weak negative or moderate positive correlation with elevation. This pattern was further emphasised by species richness prediction map which clearly illustrated that the richness increases with elevation. In this landscape elevation was positively correlated with forest cover; as one started ascending hilly areas, one encountered less disturbed and closed-canopy forests which were rich in species.

In contrast to occupancy, butterfly community showed strong negative effect of date on detection probability. Though, it appears that model predictions were in contrast to common pattern of peak richness and abundance of butterflies in post-monsoon (Kunte 1997), the observed data clearly showed the high abundance and richness of butterflies during post-monsoon season. While looking at low detections of the species in summer, it appeared that the results might be heavily influenced by post-monsoon and winter data. Hence, if we focused on pattern of richness and occupancy of butterflies in post-monsoon and winter, due to strong negative correlations as date increases i.e. winter approaches, the detection probability of the species decreases which may be related with gradual decline in abundance and richness of species after post-monsoon (Kunte 1997). This decline could be associated with the transformation of favourable conditions of the post-monsoon period, which aided the butterfly communities to flourish, into harsher situations marked by extreme weather and scarcity of food (Kunte 1997, Sengupta 2014).

In weather, temperature was the key factor for species like the butterflies which depended on the ambient temperature for their activities. The rise in temperature intensified their activities which in turn increased their detection probability. It was evident by significant positive effect of temperature on community detection probability of the butterflies (Bonebrake et al. 2010). In addition to weather, vegetation also influenced community detection probability of the butterflies, for example the tree density had strong positive impact. This pattern looks similar to the community occupancy response towards forest cover; it may be because in this landscape forested areas had higher tree density and richness which appeared to sustain abundant and diverse assemblages of butterflies, which eventually increased the communities' detection probability. On the contrary, understorey had weak negative effect on detection probability; though the effect was weak, it may elucidate a general pattern i.e. increasing understorey obstructs visibility, which ultimately reduces the detection probability.

In addition to community level effects, we also found interesting occupancy patterns at species level. Species with high occupancies (> 40%) were commonly seen in this landscape and most of these species were either polyphagous (Kunte 2000, Kehimkar 2008) or their larval and adult food plants were abundant. Among Nymphalids, peacock pansy and baronet showed weak positive association with forest cover and was mostly due to their habit of occurring in open areas and degraded forests which support the growth of their larval host plant – *Hygrophila auriculata*, a herb typically found along marshy places in open areas (Ingalhalikar 2012). In contrast, plain tiger had weak negative impact of forest cover as its larval host plants are the milkweeds like *Asclepias curassavica* and *Calotropis gigantea*, particularly found in human-dominated areas. Similarly, weak positive association of common crow and plain tiger with anthropogenic habitats was may be due to their larval food plants used as ornamental plants in settlements e.g. *Nerium indicum* and *Asclepias curassavica*. Moderate positive effect of elevation and forest cover on chocolate pansy could be explained by its occurrence from high elevated semi-evergreen forests to low-lying agriculture fields and degraded forests containing its larval host plants such as *Carvia* sp., *Hygrophila* sp. and *Justicia* sp. On the contrary, Lycaenids which showed weak negative correlation with elevation, as they are weak fliers and inhabitants of low-lying agricultural fields or deciduous forest patches which harbour their larval host plants like *Pongamia pinnata*, shrubs and herbs of Acanthaceae and Asteraceae families. Similarly, caterpillars of rounded pierrot are known to feed on *Ziziphus* sp., a thorny plant typically found in degraded forests, in agricultural areas as well as in settlements.

Similar to Lycaenids, the yellows are primarily grass and herb feeders, but their larval host plants also include legumes like *Cassia fistula*, *C. siamea, C. tora*; trees of family Fabaceae; and shrub of family Caesalpiniaceae. These plants are fairly common in deciduous forests as well as settlements, especially during post-monsoon. However, forest fires and grazing had an adverse impact on the growth of grasses and herbs which ultimately destroyed larval and adult food sources, causing a decline in local butterfly populations (Kunte 1997). In this landscape such disturbances were regularly seen, particularly during early winter when grasses in open patches, on hill slopes and under forest cover were burnt and sometimes this activity continued in agriculture fields in summer also. Hence the weak positive response of yellows to forest cover and anthropogenic habitats was rather anticipated, except a few polyphagous species such as common grass yellow. Similarly, larval host plants of swallowtails were distributed naturally (e.g. Citrus members, *Murraya koenigii* and Annonaceae members) as well as planted in settlements (e.g. *Polyalthia longifolia*). Besides this, invasive species like *Lantana camara* was one of widely used nectar sources for them owing to their hovering habit while feeding. These might be the reasons for weak or moderately positive association of Swallowtails with forest and anthropogenic habitats.

In opposite to butterflies with high occupancies, it becomes highly uncertain to draw any inferences about species with a very few detections. In most of these cases, special habits of the species appear to influence their detections and those particular habits were not considered while designing our general sampling strategy. For example, most of these species were skippers, and they were not detected frequently due to their crepuscular habit or because they were often sighted outside the transect which may be due to their fast flying ability, as they were quickly fly away from the transect before being detected. Similarly, Lycaenids, Swallowtails and Nymphalids too have peculiar examples – malayan, common hedge blue and chestnut-streaked sailer were seen puddling or feeding on dead crabs or dung in dry streambeds; some are season specific like monkey puzzle and yamfly, were only found in post-monsoon while others like red helen is uncommon in northern Western Ghats (Kehimkar 2008). Among these salmon arab was exception, which is truly locally abundant having mean occupancy of 6% (CI – 1– 22%), the narrow credible interval owed to its number of detections i.e. 50. Local abundance of this species was due to its dependence on larval host plant *Salvadora persica,* which was abundant in mangrove forest and mangroves were locally abundant in this landscape.

In addition to low and high occupancies, most of the butterflies showed moderate occupancies (11–40%). For example, among skippers, chestnut bob depicted moderate positive effect of forest cover and elevation. This species is supposed to be associated with dense forest (Kunte 2000); in this study it was mainly detected in semi-evergreen forests of Matheran and Prabalgad, especially in forest openings and in moist deciduous forest patches of KBS. Similarly, common hedge blue showed moderate positive effect of forest cover. It was seen mainly feeding on *Leea indica* flowers in semi-evergreen forests and puddling in streambeds in deciduous forest. Common hedge blue along with the weak-fliers such as tiny grass blue, dark grass blue and grass jewel exhibited weak negative impact of elevation and anthropogenic habitats. This was obvious as their larval and adult feeding sources were distributed mainly in low-lying agricultural habitats as well as deciduous forest patches.

In similar vein, Nymphalids which included mainly common species like striped tiger, blue tiger, common castor, danaid eggfly and common sailer had moderate positive association with forest cover. They are polyphagous species feeding on diverse plant families such as Tiliaceae, Mimosaceae, Fabaceae and milkweeds like Apocynaceae and Asclepiadaceae. Members of these families are common in deciduous and degraded forests, which may explain positive association of these butterflies with forest cover. On the other hand, Common Sailer, having its larval host plants mainly in forested areas, showed weak negative impact of anthropogenic habitats. In contrast, anthropogenic habitat cover had weak positive impact on common castor. The larvae of common castor feed particularly on *Ricinus* *communis,* which is an exotic plant common throughout the settlements along the railway tracks and barren lands. As the resources of tigers and castors were abundant in low-lying habitats, they were less detected at elevated areas; thus, showing weak negative correlation with elevation.

In contrast to common castor, Swallowtails such as blue mormon and spot swordtail showed moderate positive association with forest cover. These species were detected more in forests as their food plants were abundant in semi-evergreen and deciduous patches such as *Atlantia racemosa, Miliusa tomentosa*, *Murraya koenigii* and *Annona* sp. *Atlantia* and *Murraya* sp. were abundant especially at high elevation areas, which could be the reason for positive association of these butterflies with elevation. Many forest species of butterflies are supposed to be shifted to human settlements as their larval host plants are cultivated in home gardens and orchards frequently, hence such butterfly species are abundant in settlements (Kunte 2000). For example, tailed jay butterfly whose larval host plants *Polyalthia longifolia, Annona squamosa* and *Michelia champaca* were cultivated in gardens and along the roads. Similarly, detection of lime butterfly and blue Mormon could have increased in settlements due to the presence of their food plants, *Citrus lemon* and other *Citrus* sp., which explained moderate to weak positive response of these species to anthropogenic habitat cover.

Similar to some of the Swallowtails, Yellows like psyche, white orange tip, yellow orange tip and common jezebel had their larval host plants, mainly *Capparis* spp. and parasites growing on the trees; e.g. *Dendropthoe falcata* was distributed more in deciduous and degraded forest patches. Hence their moderate or weak positive response to forest cover and weak negative impact of anthropogenic habitat cover was not unusual. As these plants were mainly found in low-lying habitats, and they all showed weak negative effect with elevation. In contrast, plum judy was mainly detected in semi-evergreen and deciduous forests than the degraded habitats primarily due to the presence of its larval host plant *Embelia* sp. Hence, the moderate positive effect of forest cover and elevation on plum judy was more likely.

In conclusion, though weak or moderate, most of the species showed positive association with forest and degraded forest which implies that natural forested habitats in this landscape still support the substantial abundance and richness of the butterflies. Though in general anthropogenic habitat had an adverse impact on butterflies, some of the findings indicated increase in butterfly richness in anthropogenic habitat due to the cultivation of exotic or native forest plant species on which larvae or adults of butterflies feed. It would have important implications in the restoration and conservation of the butterfly diversity in this landscape. However, increasing anthropogenic habitats, especially intensive urbanisation of this landscape, could lead to local extinction of habitat specialist butterfly species.

6.5 Results of odonates diversity and other insects

Odonates

A total 34 species of odonates belonging to eight families were recorded. Among them, seven species belonged to suborder Zygoptera (Damselflies) while remaining 27 species belonged to Anisoptera (Dragonflies). Family Libellulidae was the most specious, represented by 20 species. Most of the species were Least Concern as per IUCN red list of threatened species. No odonate is included under Wildlife Protection Act, 1972 (Annexure VI).

Odonates need fresh water for breeding; hence their species richness and abundance peak was observed in post-monsoon season. We observed swarms of wandering wlider or globe skimmer (*Pantala flavescens*) in grasslands as well as at agricultural sites. This species is supposed to migrate over large distances from India to east coast of Africa along with monsoon currents (Anderson 2009). The congregation seen at the study sites could be part of such migration.

Other insects

In total, we observed 53 species belonging to nine orders using light trap. Only those species identified up to genus and species level are given in the annexure VI. Most of them were seen during post-monsoon season which was their peak activity period.

CHAPTER 7
PLANTS

7.1 Sampling design

We randomly selected grids in each habitat for sampling trees (section 2.1.2, Map 3b). The grids demarcated for sampling animal taxa were sampled to obtain attributes of trees in grids as the predictor covariates for animal distributions and to examine the distribution patterns of the trees in this landscape. However, unlike animal sampling, we excluded settlements as habitat for plant sampling because sampling grid selected in this habitat were intensively modified with almost no natural vegetation. Apart from this, some points were not sampled due to accessibility issues. At each random sampling point we laid two 10 X 10 m plots located 100 m from the point but in opposite cardinal directions either NS or EW. In each plot, the number of tree and shrub individuals (GBH > 10 cm), species, girth at breast height (GBH) and height were recorded. Comparatively a few shrubs were observed, hence for simplicity we have used 'tree' throughout the report. Plants were identified using floras (Almeida 1996–1998, Santapau 1954). Total, 228 plots were sampled covering classified habitats such as semi-evergreen forest (n=36), moist-deciduous forest (n=40), scrub (n=38), grassland (n=38), agriculture (n=36) and mangrove (n=40). In addition to this, we conducted ad hoc sampling for listing the herbs and shrubs at these sites. The sampling was carried out from June 2016 to February 2017.

7.2 Data analysis

We computed species accumulation curve and Shannon Diversity Index for each habitat. For characterising species composition of each habitat, we computed Importance Value Index (IVI) for species. IVI for each species was calculated by summing its relative frequency, relative density and relative dominance in each habitat. We used basal area for estimating relative dominance. All statistical analyses were conducted in BiodiversityR (Kindt and Coe 2005) package in the program R (R Development Core Team, 2015).

7.3 Results

In total, 80 genera and 107 species of herb, 4 genera and 6 species of shrub belonging to 44 families were recorded through *ad hoc* sampling in the landscape (Annexure VII). Orchidaceae was represented by 12 species, Poaceae and Fabaceae with 10 species, Acanthaceae with 8 species, Amaranthaceae with 5 species, Araceae, Asparagaceae, Commelinaceae, Euphorbiaceae, Solanaceae with 4 species each and remaining 34 families with less than 4 species. However, in quantitative sampling of228 plots, covering approximately 22.8 ha area, we counted 1346 individuals of trees belongs to 128 species. Among individuals, maximum number were of *Memecylon umbellatum* (170, 12.63%), followed by *Avicennia marina* (113, 8.39%), *Tectona grandis* (79, 5.86%), *Atlantia racemosa* (67, 4.47%), *Butea monosperma* (59, 4.38) and *Terminalia elliptica* (53, 3.93%). Among families, Euphorbiaceae was most specious represented by 10 species, followed by Rubiaceae with 9 species, Fabaceae with 8 species, Combretaceae, Meliaceae and Moraceae with 7 species and Mimosaceae with 5 species.

Apart from overall richness of trees in this landscape, habitats showed varied species richness and diversity – moist-deciduous forest was richest with 56 species followed by scrub with 49 species, semi-evergreen forest with 46 species, agriculture with 20 species, grassland with 13 species and mangrove with 5 species. Similar pattern was exhibited by the species accumulation curve. We generated habitat-wise species-area curve by plotting cumulative number of species against number of quadrates sampled (Fig. 7a). The trajectories of species accumulation clearly exhibited asymptote for agriculture, grassland and mangrove habitat; in contrast, inventory appeared incomplete for scrub and semi-evergreen forest and strongly incomplete for moist-deciduous forest. The plot clearly showed significant difference between mangrove, agriculture and grassland (a group with low species richness) and semi-evergreen forest, moist-deciduous forest and scrub (a group with high species richness). Species richness among habitats looked significantly different for sample size of 30 or more plots, except scrub and semi-evergreen forest, which showed an overlap in confidence interval. Similar pattern was showed by Shannon diversity index – moist-deciduous forest had highest diversity 3.38 ± 0.43 (diversity index ± SD) followed by scrub (3.29 ± 0.68), semi-evergreen forest (2.76 ± 0.52), agriculture (2.73 ± 0.57), grassland (2.48 ± 0.23) and mangrove (0.74 ± 0.30).

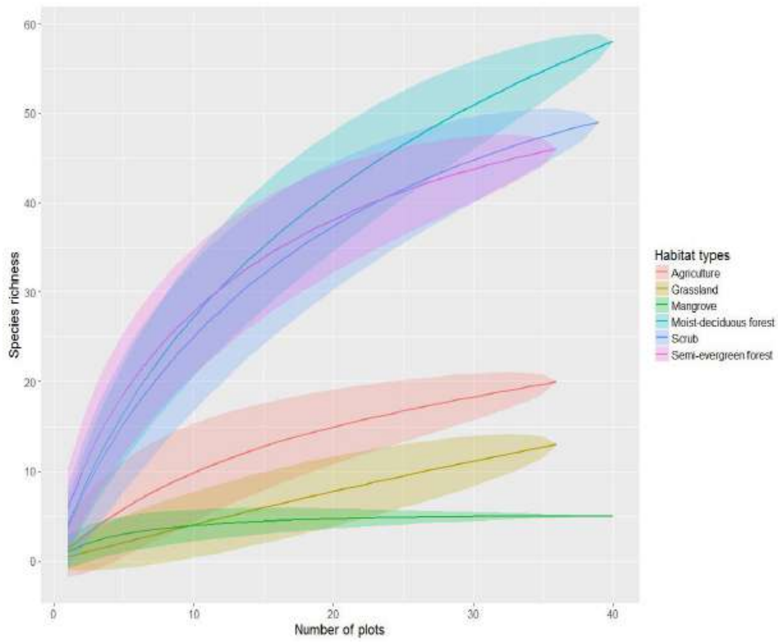


Fig. 7a. Species accumulation curves for different habitats. Dark line is mean and shaded ribbon is confidence interval.

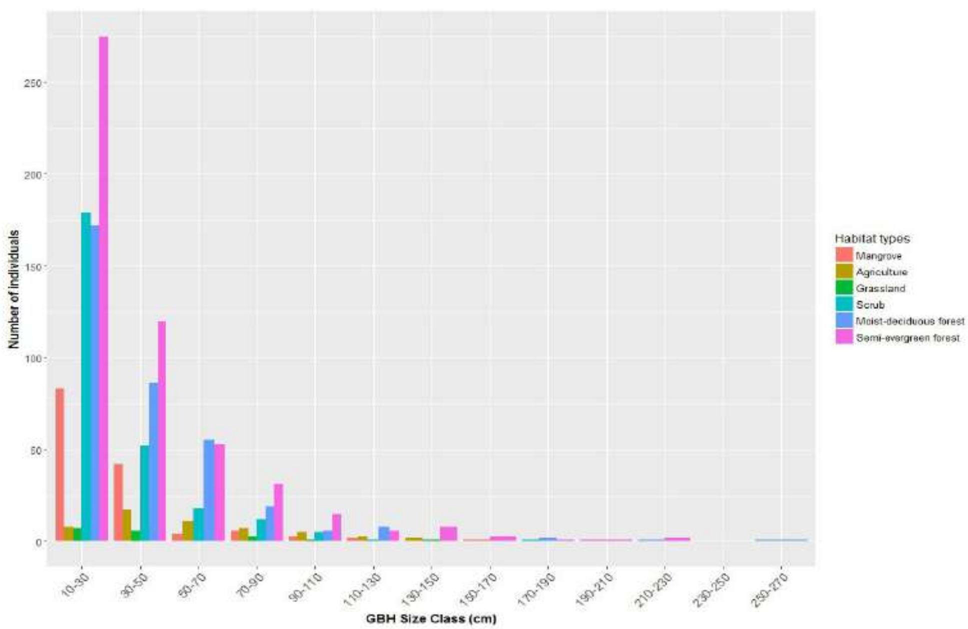


Fig. 7b. GBH class distributions for different habitats.

Like species richness, each habitat showed distinct community structure. Dominant species based on IVI (>20) in various habitat were as follows: in semi-evergreen forest – *M. umbellatum* (80.35), *Olea dioica* (27.60), *Syzygium* spp. (23.93) and *A.*

racemosa (21.45); in moist-deciduous forest – *T. grandis* (29.10), *Ficus racemosa* (23.11) and *Terminalia elliptica* (21.65); in scrub - *Bombax ceiba* (37.42), *B. monosperma* (29.33) and *T. grandis* (21.82); in agriculture - *Dalbergia latifolia* (42.47), *Mangifera indica* (37.60), *Pongamia pinnata* (32.34), *Bombax ceiba* (29.38) and *Acacia catechu* (21.47); in grassland – *M. indica* (88.44), *T. grandis* (27.92), *Macaranga peltata* (26.36), *Acacia auriculiformis* (23.73) and *Tamarindus indica* (23.46); in mangrove – *A. marina* (191.56), *A. officinalis* (53.37), *Sonneratia alba* (34.40) and *Rhizophora* sp. (14.06). In addition to dominant species, semi-evergreen forest seemed to be unique in species composition because it shared only six species with moist-deciduous forest and three species with scrub and grassland. On the contrary, though moist-deciduous forest was most specious it shared 32 species with scrub, 9 species with agriculture and 7 species with grassland.

In contrast to the variations in community structure, distribution of the trees among various girth size classes in almost all habitats showed L shaped curve – more than half (53.83%) of the individuals had < 30cm GBH and additional 24.01% had < 50cm GBH, so collectively about 78% of the individuals had < 50 cm of GBH (Fig. 7b). The basal area estimated was varied from the highest at 28.29m^2/ha for semi-evergreen forest and 17.44m^2/ha for moist-deciduous forest to the lowest at 4.81m^2/ha for grassland.

7.4 Discussion

Richness of the trees in non-degraded habitat, semi-evergreen forest and moist-deciduous forest regions in this landscape(98 species) was less than that recorded at Chandoli National Park (CNP) (120 species, Kanade et al. 2008) in south-west Maharashtra and Tungar Hills (150 species, Veach et al. 2003), Thane, Maharashtra; however, richness of the semi-evergreen forest (46 species) was comparable with Kankumbi Forest (KF) (44 species), Belgaum, north Karnataka (Pascal 1986). In contrast, Shannon diversity index of semi-evergreen forest estimated in our study (2.76) was comparable with the diversity estimated at CNP (3.2–2.2, Kanade et al. 2008) but less than that of KF (4.1, Pascal 1986). Pascal (1986) mentioned that the poor diversity of woody plants in north of northern Western Ghats (NGW) is the outcome of high human disturbance, extreme weather conditions such as heavy rainfall followed by dry period of 6–7 months and aluminium rich soil. However, the diversity of semi-evergreen forest in this study was also lower than the diversity in moist-deciduous forest and scrub, which suggested large number of rare species in semi-evergreen forest – it might be natural pattern or result of past human disturbances.

This forest type is classified as southern hills tropical evergreen forest (1A/C_4 – Champion and Seth 1968), whereas Pascal (1986) treated it as *M. umbellatum* - *Syzygium cumini* – *Actinodaphne angustifolia* type. However, we found that *M. umbellatum, O. dioica, Syzygium* spp. and *A. racemosa* were dominant species, with *M. indica, Litsea wightiana* and *Xantolis tomentosa* as co-dominants. Similar pattern of replacement of *Actinodaphne angustifolia* with *O. dioica* in Chandoli National Park (CNP) and KF is reported; in contrast, *Memecylon–Xantolis–Actinodaphne* type has been observed in Mulshi in NWG (Kanade et al. 2008, Pascal 1986).

These semi-evergreen forests are confined to Matheran and Prabalgad in this landscape and along with Mahabaleshwar they treated separately by Pascal, (1986) based on their low height of species (< 15-20m), poorer floristic composition (e.g. than KF) and comparatively disturbed nature. Pascal (1986) suspected that floristic composition of Matheran was completely transformed through frequent disturbances. While looking at the history of the two areas, Matheran was developed by the British as a hill station in 1850 and Prabalgad was a major fort of Ahmednagar Kingdom in 1458 AD – it appears that they had gone through some major transformation in their vegetation composition. For example, the occurrence of dominant species such as *O. dioica*, along with *Mallotus philippensis, Callicarpa tomentosa*, *Carallia brachiata, Macaranga peltata* in these semi-evergreen forests was indicating the past disturbance history of these sites, because these species are sunlight loving and pioneer and hence mainly found in disturbed forests (Daniels et al. 1995).

In addition to this, non-detection/absence of *Actinodaphne* in Matheran and Prabalgad during our study is interesting because Pascal (1986) stated it was abundant in Matheran; in contrast, it is not recorded from Tungar Hills (Veach et al. 2003), which is similar to our study area. Tungar Hills, Matheran and Prabalgad are small hills in Konkan Plains, located on the west side of the main mountain chain of the NWG; it seems that unfavourable local soil and climatic conditions in the landscape may be one of the reasons for low abundance of *Actinodaphne,* which is very common in the Ghat region. In general, it indicated that local physical and climatic conditions along with human disturbances shaped the forest types and generated variations in local formations.

In contrast to restricted semi-evergreen forest, moist-deciduous forests were widespread in this landscape. Dominant trees were *T. grandis*, *Ficus racemosa*, *Terminalia elliptica* and *Bombax ceiba*, with co-dominants such as *Lagerstroemia parviflora*, *Grewia tilifolia*, *Toona ciliata*, *B. monosperma* and *Careya arborea*. Champion and Seth (1968) described it as moist teak forest (Type 3B/C1b) while Gaussen et al. (1966) described these forests as 'slightly humid' of the series *Tectona-Terminalia-Adina-Anogeissus*. Our floristic composition was similar to this type, except for the absence of *Adina*. Dominance of *Terminalia elliptica* and *Careya arborea* along with *T. bellerica, T. chebula* and *T. paniculata* in moist-deciduous forest suggested the prevalence of fire in the landscape (Daniels et al. 1995). Apart from past extensive slash and burn practices, human induced forest fires in this landscape are very common, mostly in late winter and summer (Mid-January to April). In a similar vein, *Anogeissus latifolia* and *Adina cordifolia* were supposed to be the dominant species in this region, but they are heavily used in fuelwood and timber, e.g. soft wood of *A. cordifolia* is extensively used in making household articles (Anitha et al. 2009). Therefore, low dominance of these species in moist-deciduous forest can be explained by their exploitation for human use.

In general, this kind of exploitation along with other human disturbances transformed the natural forest into scrub and grassland (degraded forest), and agriculture (highly degraded habitat). These habitats had floristic composition characterised by *Bombax ceiba–B. monosperma–T. grandis* in scrub*; M. indica–T. grandis- Macaranga peltata* in grassland*;* and *Dalbergia latifolia – M. indica - Pongamia pinnata–Bombax ceiba–Acacia catechu* in agriculture. These floristic compositions showed similarity with moist-deciduous forest, which was further supported by the species they shared with moist-deciduous forest – 32 (scrub), 7 (grassland) and 11 (agriculture). This clearly indicated that degradation of primary moist-deciduous forest in this landscape created scrub, agriculture and grassland habitats. Natural grasslands were confined to steep slopes, while those on hill tops and low lying flat areas had been formed by clearing primary forest which was indicated by the dominance of sunlight loving species like *Macaranga peltata* in grasslands. In contrast, *M. indica, Madhuca longifolia, Syzygium cumini* are relict of the primary semi-evergreen or moist deciduous forests and their persistence is related with their high human consumptive values. Similarly, occurrence of *A. latifolia* and *A.cordifolia,* climax species of moist-deciduous forest, in scrubs also throw light on the original vegetation of the landscape.

These degraded habitats (except scrub) were low in richness and diversity than non-degraded forest. The higher richness of trees in scrub can be explained by intermediate disturbance hypothesis (Connell 1978). The hypothesis states that as the frequency of the disturbance increase,s the primary species of habitat/area (habitat specialists) will become extinct and generalist species with wide disturbance tolerance will replace them. The forests of this region are heavily exploited for timber extraction (Pereira 1935) and firewood (Veach et al. 2003), which has opened up the forest, reduced its moisture storing capacity, and probably made it vulnerable to fire and drought resistant species. This was supported by the occurrences of fire tolerant species like *T. bellerica* and *T. elliptica,* and drought resistant species such as *Acacia catechu, Gliricidia sepium*, *Madhuca longifolia, Acacia auriculiformis, Tamarindus indica* and *Azadirachta indica*, especially in degraded habitats. These degraded habitats also showed depletion in biomass, 4.81-9.18m^2/ha compared to non-degraded forest (17.44-28.29 m^2/ha). The biomass of degraded habitats was comparable with disturbed habitats (10.22 m^2/ha), while that of non-degraded forest was less than the undisturbed forest (57.16 m^2/ha) estimated at CNP (Kanade et al. 2008). However, almost all habitats were in healthy natural state of regenerations i.e. > 54 % of individuals were in GBH class < 30 cm, but degraded habitats had very few individuals above 110 cm GBH, which further emphasised the heavy extraction of large trees in this landscape.

Similar trend of extraction and regeneration was showed by mangrove. Being a unique habitat, it did not share its species with any other habitats. Only five species were recorded in mangroves and they were characterised by *Avicennia marina–A.*

officinalis–Sonneratia alba–Rhizophora sp. formation. *A. marina* is common throughout its range, fast growing, fast regenerating and hardy species which may explain its importance in the mangrove habitat. In contrast, *Bruguiera gymnorhiza* is uncommon; generally this species is slow growing and has slow regeneration rate, so the least importance of this species was not surprising. Besides, this species requires shade from surrounding trees for survival and its low frequency could be indirectly indicating biotic pressure on mangroves, especially the primary mangroves that have been extracted for various reasons ranging from agriculture to urban development. While the rest of species, *A. officinalis, Rhizophora sp.* and *S. alba,* may have intermediate tolerance and regeneration which suggested their importance between the above mentioned two extreme species (Robertson and Alongi 1992, Peng and Xin-men 1983).

In conclusion, the non-degraded habitats (semi-evergreen forest and moist-deciduous forest) had high tree diversity and uniqueness; in contrast, degraded habitats (scrubs, grasslands and agriculture) were either species poor or had generalist species. Though forest was regenerating, very small fraction of landscape was occupied with non-degraded habitat, while the rest of it was covered with degraded habitats, which had little primary forest owing probably to the effect of cutting and burning and was mainly colonised by fire prone and drought resistant species. We suspect that increasing anthropogenic disturbances would extirpate primary forests from this landscape and replace them with fire prone and drought resistance trees causing local extinction of many primary forest tree species.

CHAPTER 8
FRESHWATER FISHES

8.1 Sampling design

We sampled several primary, secondary and main river channel streams for freshwater fish diversity. Sampling was conducted across watershed areas of different river basins and high elevation streams, covering elevation range between 20–750 m ASL. The study area included high elevation ephemeral streams of Matheran and Prabalgad and northwestern sub-basin of the Patalganga River, which is one of the major river systems in northern Western Ghats, Gadhi River basin and watershed area of the small independent stream near Ransai. Total 10 sampling sites were surveyed across the study area to examine the extant freshwater fish diversity in this region. Details of the sampling sites and fish habitats observed have been provided in Annexure VIII.

Fish collection was carried out by using non-invasive fish catching techniques like hand, scoop and cast net, hook and line, and by using local traps with the help of local fishing communities. Daily fishing efforts of local fishermen across study areas were considered as valid fishing attempt to avoid excessive fishing pressure in study region. Captured fish were identified and photographed and then released back in their natural habitat. Fish specimens were photographed on-site, using the ex-situ tank immersion method described by Sabaj Pérez 2009; whereas, in-situ underwater photo and video documentation were carried out using underwater camera.

Among the captured fish specimen, those with ambiguity in identification were euthenized and preserved in 10% formalin. After euthanization, a small clip of the right side pectoral fin was harvested from all the collected fish specimens for phylogenetic studies. These specimens were deposited in the natural history collection of the Bombay Natural History Society (BNHS), Mumbai. Species identity of the collected fish specimens was evaluated by using integrative taxonomic approach using genetics, external morphometry and osteology (Talwar & Jhingran

1991, Jayaram 1991, 2010, Jayaram & Dhas 2000, Jayaram & Sanyal 2003, Katwate et al. 2014) and we used current taxonomic status by Eschmeyer et al. (2017). We refrerred IUCN red list of threatened species (2017) to determine the status of the fish recorded in this study, except for the newly described species *Pethia lutea* for which the IUCN status is not available, but authors have evaluated the threat status of the species by following IUCN Red List assessment categories and criteria (Katwate et al. 2014).

8.2 Results

Total 36 freshwater fish species were recorded in this study area, including 27 native freshwater fishes belonging to five orders, 13 families and 23 different genera; and nine introduced fish species (Annexure IX). Of the 27 freshwater fish species, 23 species were found to inhabit exclusively freshwater habitats whereas four species recorded are known to inhabit both riverine and estuarine habitats. Seven fish species recorded from the study area are known to be endemic to the Western Ghats a biodiversity hotspot. Highest species richness was recorded from the Gadhi River basin with 25 species, followed by 21 species in parts of the Patalganga River basin and 11 species in the Ransai stream. Globally threatened fish species like *Pethia lutea* and *Monopterus indicus* were recorded from the study area.

Species diversity and spatial distribution

Cypriniformes was found to be the most speciose order with total 12 species, followed by order Perciformes with 7 species, order Siluriformes with 5 species of catfishes, order Synbranchiformes with two species and order Cyprinodontiformes with one species. Among the families, Family Cyprinidae was found to be the most dominant family with nine species followed by Channidae with three species. Maximum species richness was found at sites G4 (20 species) and G3 (15 species); in contrast, sites like G2 (5 species) and R1 (3 species) were species poor.

Among these fishes, almost 85% of the species (23 species) were exclusively found in freshwater; however, four secondary freshwater fish species, which can tolerate freshwater as well as the estuarine water, namely *Pseudetroplus maculatus*, *Eleotris fusca*, *Awaous grammepomus* and *Glossogobius giuris,* were recorded from low altitude sites like P4, G3 and G4. Among 27 native fish species, seven are endemic to the Western Ghats and have very narrow range of distribution. We also found new population of two threatened fish species from this region – the newly described Citron Barb *Pethia lutea* and Bombay Swamp eel *Monopterus indicus*. Citron Barb *Pethia lutea* has been described from the Kundalika River and other west flowing rivers of Raigad and Ratnagiri Districts. The northernmost record of occurrence of this species has been reported from the Vaitarana River, north of Mumbai and southernmost distribution recorded from the Vashishthi River in Ratnagiri. Because of its restricted distribution to the west flowing rivers of northern Western Ghats, fragmented populations and ongoing threats to its habitats *P. lutea* has been assessed as Endangered (EN) fish species based on IUCN Red List criteria's (Katwate et al. 2014). We also found the Vulnerable Bombay swamp eel *M. indicus* from high altitude first order streams of Matheran at site P1.

In this study, we also found a high diversity of alien fish species; total nine introduced fish species were rerecorded throughout the landscape (Annexure X). Maximum number of invasive fish species were recorded at site R2 (9 species), G3 (8 species) and P3 (7 species).

Seasonal distribution

In this study, we also observed the seasonal changes in fish richness across the sampling sites (Annexure XI). Total 19 species were recorded in the monsoon period and 23 species were found in dry or post-monsoon period. Species like *Salmophasia boopis*, *Mystus gulio* and *Monopterus indicus* were recorded only during the monsoon season and monsoon is the breeding period for most of the fish species in the Western Ghats. In the early monsoon period (first week of June) we observed upstream migration of several fish species including *Garra mullya*, *Parapsilorhynchus tentaculatus*, *Rasbora daniconius*, *Salmophasia boopis*, *Systomus sarana subnasutus* and *Mystus gulio*.

8.3 Discussion

The occurrence of endangered species like the Citron Barb *P. lutea* from low altitude basin of the Gadhi River highlighted the potential of this small hydro-basin for freshwater fish conservation. However, habitat loss and invasive fish species in the natural habitat are known to be major threats to local and endemic fish fauna of the

Western Ghats. The species like *Gambusia affinis* has been widely used in urban areas as natural mosquito controller as a remedy to prevent pathogenic diseases like malaria. However, the potential of these exotic fish species in controlling mosquito larvae is not well studied as compared to native insectivorous and larvevorus fishes like *Aplocheilus lineatus* and stream loaches like *Indoreonectes evezardi*. However, the potential negative impacts of invasive fishes like *G. affinis* on local endemic fish species are well known. *G. affinis* posses a big threat to local fish fauna; by overlapping the niche, they act as strong food and habitat resource competitors for native and endemic fish species like *A. lineatus* and *I. evezardi*. In several parts of the northern Western Ghats like Pune metropolitan region and Rajgad, invasive fishes like *Gambusia affinis* and *Poecilia reticulata* have completely extirpated the population of *A. lineatus* and *I. evezardi*. We found the feral population of *G. affinis* at sites P1, P3, P4, G3, G4, R1 and R2.

In addition to *G. affinis,* species like *Catla catla* and *Labeo rohita* are Gangetic in origin and mostly introduced in reservoirs for aquaculture practices. We found these species at site P3 and G3. A Silver carp *Hypophthalmichthys molitrix* native to China was aslo found at site P3, G3 and R1. Although Silver carp *H. molitrix* faces a risk of extinction in its native range, the introduced populations of this species for aquaculture pose a greatest resource competition threat to the local pelagic fish species. Further, the African cichlids like *Oreochromis mossambicus* and *O. niloticus* were recorded from reservoirs but also found in natural water bodies at site P4 and G4. We also found African catfish *Clarias gariepinus* fairly abundant in reservoirs at sites P3, G3 and R2.

In our earlier studies, we have recorded two new introduced Amazonian fishes viz. *Piaractus brachypomus* and *Pygocentrus nattereri* from the natural habitats of the Patalganga River. In this study we did not find any record of *P. nattereri;* however the established populations in natural waters were recorded from site P4 and R2. In the last decade, the Amazonian Red-bellied Pacu *Piaractus brachypomus* was introduced in Raigad District for aquaculture practices; however the demand and delicacy of this fish was not well received in the local consumer market. The local aquaculture demand for *P. brachypomus* has now declined but the established population needs to be eradicated as they can pose a threat to the local fish fauna through food and other resources competition.

Apart from invasive fish species, freshwater fishes of the study area are under major threat of habitat destruction casued by several anthropogenic activities like construction of dams, sand mining, sewage pollution, uncontrolled release of industrial effluents, riparian deforestation, siltation etc. Being an industrialised sector and geographically close to the MMR, the region is going through rapid industrialszation and urbanisation. With the current outburst in urbanisation across the region, demands for the natural resources are potentially high. Construction of dams poses the greatest threat to the fishes through permanent geographical isolation of species populations, thus acting as obstacles in migratory pathways of up and downstream moving fishes and causing habitat destruction due to flooding and draught. Annual fish kill due to the release of toxic industrial waste is also a major problem in several areas near Rasayani in the Patalganga River basin. Illegal sand mining activities were observed in the Gadhi River basin at sites G2 and G4. Use of invasive fishing methods like poisoning, use of bleaching powder and dynamites were observed at site P2 and P3. Therefore, there is an immediate for a strict action to eradicate the invasive fish species and minimise anthopogenic habitat disturbances for the conservation of the fish diversity in this region.

CHAPTER 9
MARINE INVERTEBRATES

9.1 Study area

This study area is bounded by Mumbai harbour to the northwest, Thane district to the north and Arabian Sea to the west. In which, Mora along the Sheva Creek and Karanja along the Dhramtar Creek are the major fish landing centres in the region. The areas sampled during this study were as follows:

Karanja-Mora rocky-sandy shore

The rocky-sandy area is located near Karanja village close to Uran. The southernmost tip of the shore forms the mouth of the Karanja Creek and the northern continuation of the shore extend up to the southward side of the Boripakhadi Creek at Mora. The shore is a mixture of sandy-muddy and rocky substratum. The northward rocky area is formed mainly of cobbles and flat rocky outcrops towards Mora.

The shore type is semi-exposed and the overall slope is gradual.

Texture, stability, fissures and crevices: Rocky substratum starts from the middle of the shore width. Not many crevices were observed. Overall, the shore was stable as loose rocks were comparatively lesser, at least around the surveyed area.

Sediment: Heavy sandy and muddy deposition around the surveyed area.

Wave action: Moderate.

Boripakhadi Creek

The area harbours mangrove patches separated by creeklets and channels on the north and south banks.

Shore type: Mudflats/ Mangrove.

Area of mangroves: 318.33 hectare

Sediment**:** The low tidal area is soft with brown mud. However, as one approached towards the terrestrial region, the strata became dry at places due to bunds and restricted entry to seawater. At the downstream region near the mouth, the mangrove vegetation is extremely dense and intricate, making access difficult. The substratum is brown and absolutely firm.

Mangrove: *Aeluropus lagopoides*, *Sessuvium portulacastrum* and *Acanthus ilicifolius* were seen occupying the dry areas of Boripakhadi. Trees were generally less than 15 ft high, whereas the mature tree strands seen along the deep-water channel with soft mud and low tide margin of the creek were more than 20 ft high. *Sonneratia apetala* and *Avicennia marina* were the dominant tree species seen occupying the saline bunds, intermixed with *Aegiceras corniculata, Salvadora persica and Sedum* sp.

Panvel creek

Narrow mouth carrying seawater becomes broader, and harbours mangrove patches and open mudflats mainly divided into three major regions – northward, central and southward regions.

Area of mangroves: 1847.97 hectare

Shore type: Mudflats/ Mangrove

Sediment characteristics: The northward region consists of constructed bunds, which intersect each other at various lengths. This has resulted in the formation of squarish water-holding pond-like structures, perhaps interconnected where water remains even during low tide. The substratum was brownish black. Comparatively old strands of *Avicennia* were observed along the adjacent area. Grey soft mud was seen completely covered by brown filamentous algal mat. The narrow channels were seen exposed during low tide having rocky or gravel-mixed substratum. Further, towards the direction of the mouth, the substratum was muddy-clay soft greyish.

The central region of the creek was found highly modified for aquaculture ponds and sand mining. The exposed channels and flat areas were muddy sandy.

The southward region was again found modified for aquaculture and constructions. Interconnected bunds were seen turning mudflat areas into dry terrestrial landforms. However, some of the areas were still found harbouring remnants of mangrove vegetation. The substratum was muddy sandy to muddy and gravel mixed at places.

Mangrove: They were seen along the water channels consisted of *Avicennia marina* and *Sonneratia apetala*; mid and high tide zones were dominated by the scrub of *Avicennia marina* was seen intermixed with *Aegiceras corniculata* and *Sonneratia apetala*; *Sonneratia alba* was rarely seen. *Salvadora persica* was found along the bunds.

9.2 Sampling design

We sampled 50 cm X 50 cm quadrants, usually low tides (0.8 m or less) were used for rocky shore studies, followed by sandy shores and mangrove-muddy patches.

In this study, creeks were treated as a unit to analyse the mangrove community. We used Google Earth images to locate large patches of mangroves for survey. At each selected creek, to examine vegetational gradient along the creek, three areas were selected for sampling (at mouth, mid-region and end of the estuary). Herbaceous species were counted in 1 m X 1 m quadrat laid within the larger circular plot but on the boundary of inner circular plot (Fig. 9 a, c).

Sediment shores (sandy shores, mangroves and mudflats)

Macrobenthic samples (25 cm X 25 cm X 10 cm) were collected manually. Depending upon the length of the shore and heterogeneity observed along the shore, sampling transects were laid. In each zone, one sample along with a replicate was collected, sieved and washed on the shore. Sieving was done using standard sieve with 0.5 mm mesh and the mass collected in the sieve was packed in plastic bags and labelled systematically. Those samples were preserved in 10% formaldehyde solution after treatment of 1% Rose Bengal solution. In the case of mangroves/mudflats, the numbers of samples procured were limited to 3 per site (in some cases keeping patch size in mind only 2 samples were collected).

Rocky shores

Sampling was done during best possible low tides (Fig. 9b). Thus 3 samples per transect per zone were collected. Given the structure of the rocky shores along Raigad which was very irregular, it was difficult to demarcate shores in the tidal zones.

Samples collected were first washed and sorted under various taxonomic groups using stereomicroscopes.

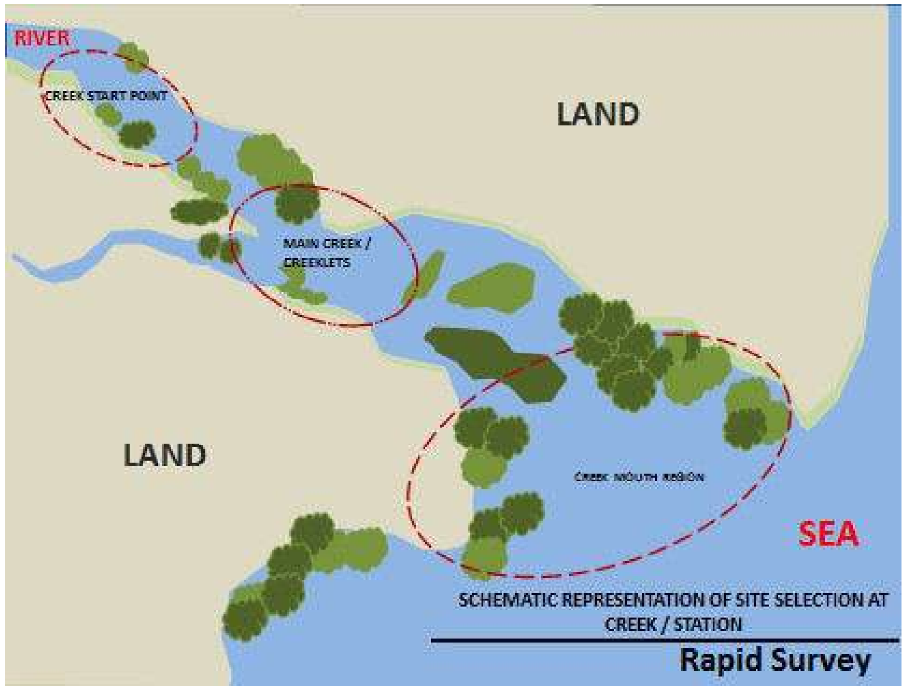


Fig. 9a. Schematic representation of site selection at creek /station.

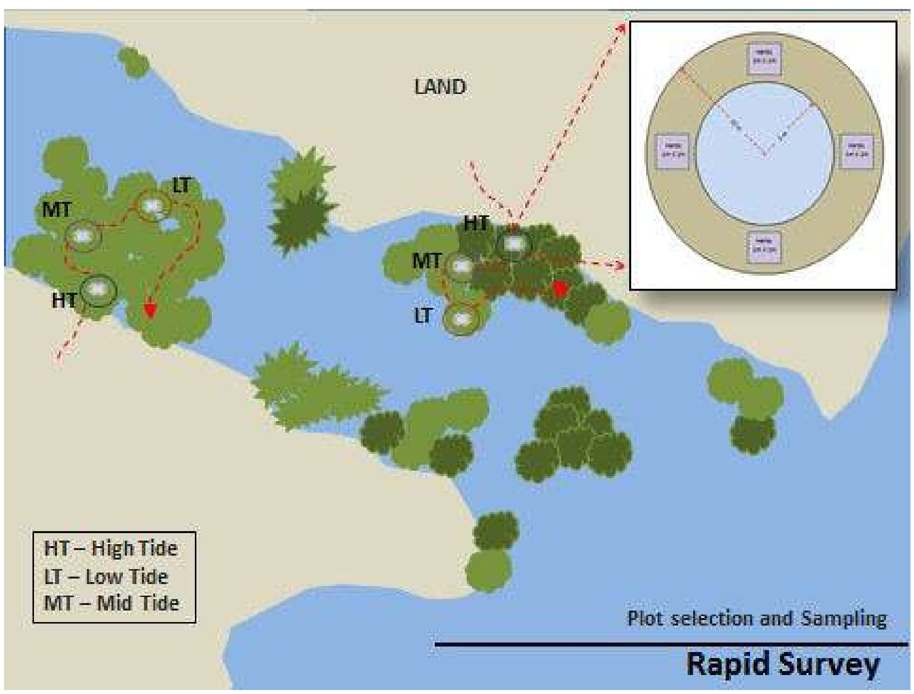


Fig. 9b. Schematic representation of plot selection at creek/ station.

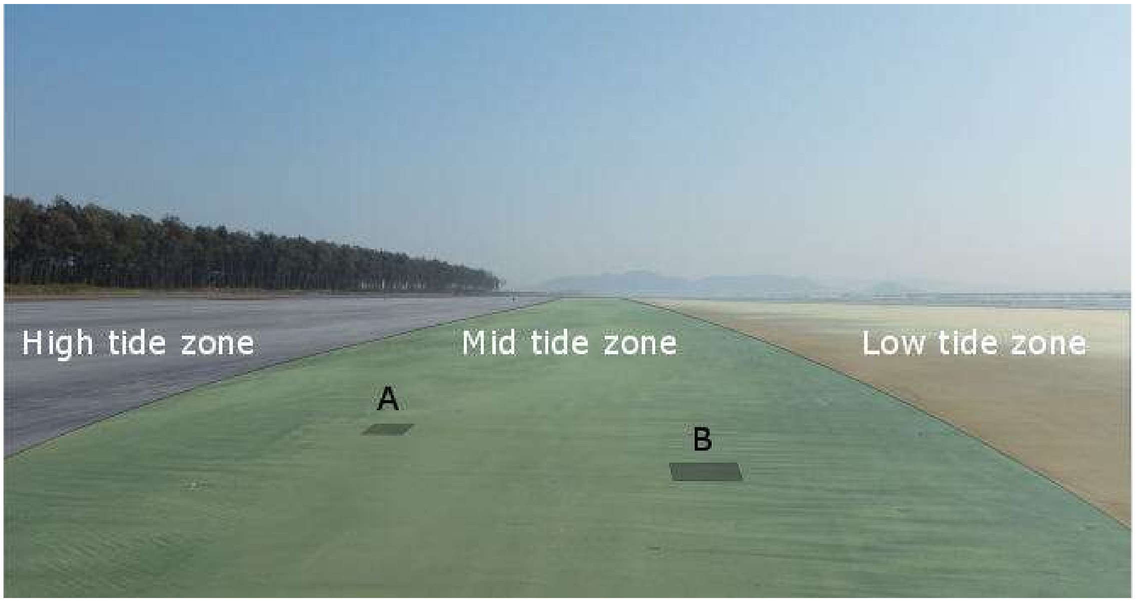


Fig. 9c. Sampling design of a sandy shore (each zone 1 sample)

9.3 Data analysis

Basic cleaning and reconciliation of data to rectify errors/mistakes during data entry was done in OpenRefine. All statistical analyses were carried out in MS Excel.

Density – The number of counting units per unit area were calculated using the following formula.

$$\text{Density (D)} = \frac{\text{Total number of individuals (of a given species) in all plots}}{\text{Total numbers of plots sampled X area of plot}}$$

The fact that the density is reported as a, ‘per area measure’ allows for comparison between sites even if the plot shape used for sampling differs (Elzinga et al. 1998). In addition, normally, density for trees and shrubs are shown in terms of number per hectare (/ha or ha^{-1}) and for herbs it is per square metre (/m^2 or m^{-2}). So, in the context of the present study, Density (D) for trees and shrubs was calculated using the formula,

$$\text{Density}_{\text{trees/shrubs}}\ (D/ha) = \frac{\text{Total number of individuals (of a given species) in all plots}}{\text{Total numbers of plots sampled X area of plot}} \times 10000$$

Where, area of plot for tree was 314 sq. m and for shrubs, 78.57 sq. m.

The density (D) for herbs was calculated as:

$$\text{Density}_{\text{herbs}}\ (D/m^2) = \frac{\text{Total number of individuals (of a given species) in all plots}}{\text{Total numbers of plots (quadrats) sampled}}$$

Frequency – It is a measure of the uniformity of distribution of a species within a stand; therefore, low frequency indicates that a species is either irregularly distributed or rare in a particular stand. Species with equal density but different frequency, more precisely lower value of frequency, denotes unequal (or contiguous) distribution (Whitford 1949). It can be defined as the percentage of possible plots within a sampled area occupied by the target species, that is, the number of times a plant species is present in a given number of quadrats of a particular size or at a given number of sample points (Elzinga et al. 1998). It is usually expressed as a percentage and calculated as:

$$\text{Frequency (\%)} = \frac{\text{Total number of plots in which species occurred}}{\text{Total numbers of plots (quadrats) sampled}} \times 100$$

Relative density is the density of one species as a per cent of total plant density and is calculated as [Relative Density (RD) = species density / total density for all species x 100]

Relative frequency is the frequency of one species as a percentage of total plant frequency and is calculated as: [Relative Frequency (RF) = species frequency / total of frequency values for all species x 100]

9.4 Results

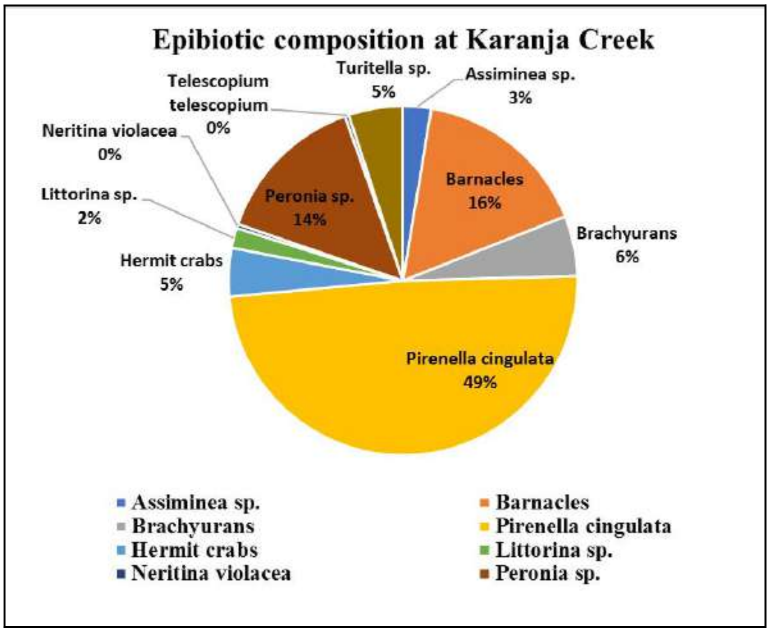


Fig. 9d. Epibiotic composition at Karanja Creek.

Epibiotic composition of mudflats at Karanja Creek was mainly composed of gastropod species (Fig. 9d). *Pirenella cingulata* dominated the assemblage and was found almost throughout the creek. *Peronia* spp. was also abundant especially on moist and substratum with green algal mat. Brachyurance were seen on both dry and moist substratum throughout the creek.

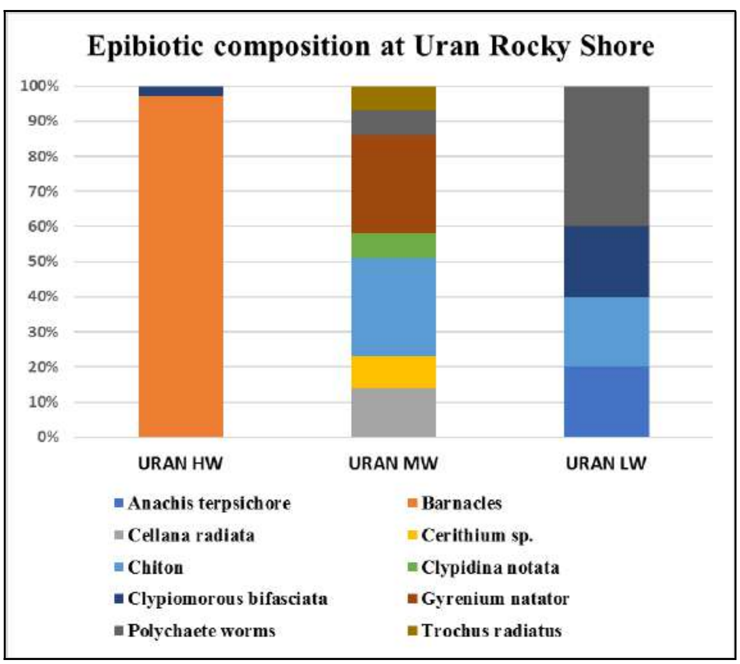


Fig. 9e. Epibiotic composition at Uran Rocky Shore.

High sedimentation was observed at Uran rocky shore (Fig. 9e). Although there was no proper zonation observed due to mixed habitat types, rocky outcrops were occupied by mainly gastropod, polychaete tubes and Barnacles. Outcrops were seen covered by Barnacles towards the higher region. *Cellana radiata*, *Trochus radiatus*, *Gyrenium natator* were mainly observed within meso littoral areas. Polychete worms dominated the lower region of the shore along with *Anachis Terpsichore*, *Ulva lactuca*.

Polychetes dominated the macrobenthic composition at all three creeks (Fig. 9f). Gastropods and pelecypods were also found in considerable numbers. Sea anemones, platyhelminthes, nematelminthes were also observed.

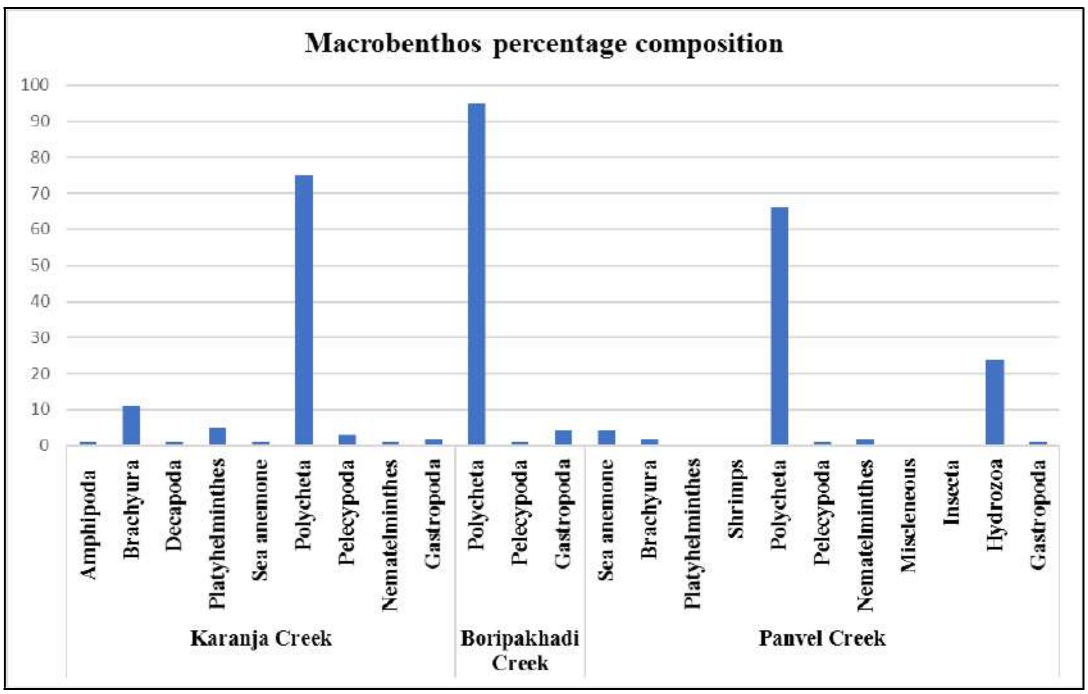


Fig. 9f . Macrobenthos percentage composition.

Floral composition of mangroves

Table 9.1. Creek-wise density, frequency and partial dominance of mangrove species along the Boripakhadi Creek.

Site / Station name	Species Name	Density	Frequency (%)	RD	RF	Partial Dominance
Note: * = Herb; Density = individuals/ha except mentioned as # where density (D=individuals / m^2); RD = Relative Density; RF = Relative Frequency						
BORIPAKHADI CREEK	Trees					
	Avicennia marina	103.50	100	0.54	20	20.54
	Sonneratia apetala	55.73	100	0.29	20	20.29
	Aegiceras corniculata	31.85	100	0.17	20	20.17
	Shrubs/Saplings					
	Avicennia marina	71.66	100	0.33	20	20.33
	Acanthus ilicifolius	143.31	100	0.67	20	20.67

Table 9.2. Density, frequency and partial dominance of mangrove species along the Karanja Creek.

Site / Station name	Species Name	Density	Frequency (%)	RD	RF	Partial Dominance
Note: * = Herb; Density = individuals/ha except mentioned as # where density (D=individuals / m^2); RD = Relative Density; RF = Relative Frequency						
KARANJA CREEK						
	Trees					
	Avicennia marina	143.31	100	0.71	0.46	1.17
	Sonneratia apetala	42.46	67	0.42	0.30	0.73
	Aegiceras corniculata	15.92	50	0.13	0.23	0.36
	Shrubs/Sapling					
	Avicennia marina	100.85	100	0.45	50	50.45
	Acanthus ilicifolius	122.08	100	0.54	50	50.45

Table 9.3. Density, frequency and partial dominance of mangrove species along the Panvel Creek.

Site / Station name	Species Name	Density	Frequency (%)	RD	RF	Partial Dominance
Note: * = Herb; Density = individuals/ha except mentioned as # where density (D=individuals /m^2); RD = Relative Density; RF = Relative Frequency						
PANVEL CREEK	Trees					
	Avicennia marina	162.42	100	1.62	61.57	63.19
	Salvadora persica	9.55	10	0.96	10.47	11.42
	Aegiceras corniculata	25.48	30	0.85	35.33	36.17
	Sonneratia apetala	28.66	50	0.57	87.22	87.80
	Shrubs/ Saplings					0.00
	Avicennia marina	121.02	10	12.10	0.83	12.93
	Derris heterophylla	25.48	30	0.85	35.33	36.17
	Acanthus ilicifolius	130.57	70	1.87	37.53	39.39

9.5 Discussion

This study depicted the presence of typical mud-dwelling fauna and mangrove vegetation at all the creeks studied, however in the patches where normal water flow and natural mudflat was maintained *Pirenella cingulata*, mud dwelling gastropod was abundant. Green mat was also seen over mudflats and supporting typical faunal groups which feed on them. These microalgal feeders such as *Peronia* spp., *Platyvindex* sp. *Ascemenia* sp. were abundantly noticed on the floor occupied by green-brown mat. *Melampus* sp. was also found on these mat areas and on rotting leaf litter. Their common aggregation behaviour was also observed especially on the leaf litter at Panvel Creek. Literature review and annexure based on these literature lists the faunal species reported earlier from the region (Annexure XII).

Rocky, sandy patches were found to be neglected and modified over time. Although heavy sedimentation was observed over the rocky outcrops and loose rocky substratum, typical meso-infra littoral faunal composition was observed.

Reclamation, unregulated trade of natural resources (sand mining), deforestation, aquaculture, sedimentation and debris-pollution were the major issues observed in the studied area. In addition to this, sewage and chemical and/or metal contamination has already been reported in earlier studies. While looking at the current pace of development we must immediately address these threats for conservation of rich marine diversity of this region.

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5. Annexures

I. Checklist of mammals

Sr. No.	Scientific Name	Common Name	WPA schedule	IUCN Status
1	*Muntiacus muntjak*	Barking Deer	III	LC
2	*Macaca radiata*	Bonnet Macaque	II (Part I)	LC
3	*Lepus nigricollis*	Black-naped Hare	IV	LC
4	*Paradoxurus hermaphroditus*	Asian Palm Civet	II (Part I)	LC
5	*Funambulus palmarum*	Indian Palm Squirrel	IV	LC
6	*Tetracerus quadricornis*	Four-horned Antelope	I (Part I)	VU
7	*Rousettus leschenaulti*	Fulvous Fruit Bat	IV	LC
8	*Canis aureus*	Golden Jackal	II (Part I)	LC
9	*Pteropus giganteus*	Indian Flying fox	IV	LC
10	*Mus* spp.	Mice	IV	LC
11	*Herpestes edwardsi*	Indian Grey Mongoose	II (Part I)	LC
12	*Ratufa indica*	Indian Giant Squirrel	II (Part I)	LC
13	*Panthera pardus*	Indian Leopard	I (Part I)	VU
14	*Moschiola indica*	Indian Mouse Deer	I (Part I)	LC
15	*Pipistrellus* sp.	Pipistrelle	IV	LC
16	*Hystrix indica*	Indian Porcupine	IV	LC
17	*Felis chaus*	Jungle Cat	II (Part I)	LC
18	*Bandicota bengalensis*	Lesser Bandicoot Rat	IV	LC
19	*Vandeleuria oleracea*	Long-Tailed Tree Mouse	V	LC
20	*Anathana ellioti*	Madras Tree Shrew	II (Part I)	LC
21	*Herpestes smithii*	Ruddy Mongoose	II (Part I)	LC
22	*Macaca mulatta*	Rhesus macaque	II (Part I)	LC
23	*Prionailurus rubiginosus*	Rusty Spotted Cat	I (Part I)	NT
24	*Viverricula indica*	Small Indian Civet	II (Part I)	LC
25	*Semnopithecus dussumieri*	Southern Plains Gray Langur	II (Part I)	LC
26	*Sus scrofa*	Wild Boar	III	LC

Abbreviations: WPA – Wildlife Protection Act 1972; LC: Least Concern; VU: Vulnerable; NT: Near Threatened.

II. Checklist of birds

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
	Family Podicipedidae					
1	*Tachybaptus ruficollis*	Little Grebe	IV	LC	R	
	Family Phalacrocoracidae					
2	*Phalacrocorax fuscicollis*	Indian Cormorant	IV	LC	R/LM	C
3	*Phalacrocorax carbo*	Great Cormorant	IV	LC	R/LM	
4	*Microcarbo niger*	Little Cormorant	IV	LC	R/LM	C
	Family Ardeidae					
5	*Egretta gularis*	Western Reef-heron	IV	LC	R/LM	
6	*Egretta garzetta*	Little Egret	IV	LC	R/LM	C
7	*Egretta alba*	Great Egret	IV	LC	R	
8	*Egretta intermedia*	Intermediate Egret	IV	LC	R/LM	C
9	*Bubulcus coromandus*	Eastern Cattle Egret	IV	LC	R/LM	C
10	*Ardea cinerea*	Grey Heron	IV	LC	R/LM	
11	*Ardea purpurea*	Purple Heron	IV	LC	R/LM	C
12	*Ardeola grayii*	Indian Pond Heron	IV	LC	R/LM	C
13	*Nycticorax nycticorax*	Black-crowned Night-heron	IV	LC	R/LM	
14	*Butorides striata*	Striated Heron	IV	LC	R	
15	*Dupetor flavicollis*	Black Bittern	IV	LC	R/LM	
16	*Ixobrychus cinnamomeus*	Chestnut Bittern	IV	LC	R/LM	
	Family Ciconiidae					
17	*Anastomus oscitans*	Asian Openbill	IV	LC	R/LM	
18	*Ciconia episcopus*	Woolly-necked Stork	IV	VU	R	
19	*Mycteria leucocephala*	Painted Stork	IV	NT	R/LM	
20	*Ciconia nigra*	Black Stork	IV	LC	M	
	Family Threskiornithidae					
21	*Plegadis falcinellus*	Glossy Ibis	IV	LC	M	
22	*Threskiornis melanocephalus*	Black-headed Ibis	IV	NT	R/LM	C
23	*Platalea leucorodia*	Eurasian Spoonbill	I	LC	R/LM	
24	*Pseudibis papillosa*	Indian Black Ibis	IV	LC	R/LM	
	Family Phoenicopteridae					
25	*Phoenicopterus roseus*	Greater Flamingo	I	LC	LM	
26	*Phoeniconaias minor*	Lesser Flamingo	I	NT	LM	
	Family Anatidae					
27	*Anser anser*	Greylag Goose	IV	LC	M	
28	*Dendrocygna javanica*	Lesser Whistling-duck	IV	LC	R/LM	
29	*Tadorna ferruginea*	Ruddy Shelduck	IV	LC	M	
30	*Sarkidiornis melanotos*	Knob-billed Duck	IV	LC	R	

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
31	*Anas crecca*	Common Teal	IV	LC	M	
32	*Querquedula querquedula*	Garganey	IV	LC	M	
33	*Mareca strepera*	Gadwall	IV	LC	M	
34	*Mareca Penelope*	Eurasian Wigeon	IV	LC	M	
35	*Spatula clypeata*	Northern Shoveler	IV	LC	M	
36	*Anas acuta*	Northern Pintail	IV	LC	M	
37	*Anas poecilorhyncha*	Indian Spot-billed Duck	IV	LC	R	
38	*Anas platyrhynchos*	Mallard	IV	LC	M	
39	*Nettapus coromandelianus*	Cotton Teal	IV	LC	R/LM	
	Family Accipitridae					
40	*Elanus caeruleus*	Black-winged Kite	I	LC	R	C
41	*Haliastur Indus*	Brahminy Kite	I	LC	R	
42	*Milvus migrans migrans/govinda*	Black Kite	I	LC	R	O
43	*Accipiter badius*	Shikra	I	LC	R	C
44	*Pernis ptilorhynchus*	Oriental Honey Buzzard	I	LC	R	C
45	*Butastur teesa*	White-eyed Buzzard	I	LC	R	C
46	*Spilornis cheela*	Crested Serpent Eagle	I	LC	R/LM	C
47	*Aquila rapax*	Tawny Eagle		LC	R	
48	*Circaetus gallicus*	Short-toed Eagle	I	LC	R	
49	*Hieraaetus pennatus*	Booted Eagle	I	LC	M	C
50	*Clanga hastata*	Indian Spotted Eagle	I	VU	R	
51	*Clanga clanga*	Greater Spotted Eagle	I	VU	M	
52	*Aquila nipalensis*	Steppe Eagle	I	NT	M	C
53	*Haliaeetus leucogaster*	White-bellied Sea-eagle	I	LC	R	
54	*Circus pygargus*	Montagu's Harrier	I	LC	M	
55	*Circus macrourus*	Pallid Harrier	I	NT	M	
56	*Circus melanoleucos*	Pied Harrier	I	LC	M	
57	*Circus aeruginosus*	Western Marsh Harrier	I	LC	M	
	Family Pandionidae					
58	*Pandion haliaetus*	Western Osprey	I	LC	M	
	Family Falconidae					
59	*Falco tinnunculus*	Common Kestrel	IV	LC	R/LM	C
60	*Falco peregrinus perigrinator*	Peregrine Falcon (Shaheen)	IV	LC	R/LM	
	Family Phasianidae					
61	*Francolinus pondicerianus*	Grey Francolin	-	LC	R	
62	*Francolinus pictus*	Painted Francolin	-	LC	R	

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
63	*Coturnix coromandelica*	Rain Quail	-	LC	R/LM	
64	*Perdicula asiatica*	Jungle Bush-quail	-	LC	R	
65	*Galloperdix spadicea*	Red Spurfowl	-	LC	R	
66	*Gallus sonneratii*	Grey Junglefowl	-	LC	R	O
67	*Pavo cristatus*	Indian Peafowl	I	LC	R	
	Family Turnicidae					
68	*Turnix tanki*	Yellow-legged Buttonquail	-	LC	R/LM	
	Family Rallidae					
69	*Gallirallus striatus*	Slaty-breasted Rail	IV	LC	R	
70	*Porzana fusca*	Ruddy-breasted Crake	IV	LC	R/LM	I
71	*Porzana akool*	Brown Crake	IV	LC	R	
72	*Amaurornis phoenicurus*	White-breasted Waterhen	IV	LC	R	
73	*Gallicrex cinerea*	Watercock	IV	LC	R/LM	
74	*Porphyrio [porphyrio] poliocephalus*	Purple Swamphen	IV	LC	R	
75	*Gallinula chloropus*	Common Moorhen	IV	LC	R	
76	*Fulica atra*	Eurasian Coot	IV	LC	R/LM	
	Family Jacanidae					
77	*Metopidius indicus*	Bronze-winged Jacana	IV	LC	R	
78	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	IV	LC	R/LM	
	Family Rostratulidae					
79	*Rostratula benghalensis*	Greater Painted Snipe	IV	LC	R	
	Family Charadriidae					
80	*Pluvialis squatarola*	Grey Plover	IV	LC	M	
81	*Pluvialis fulva*	Pacific Golden Plover	IV	LC	M	
82	*Charadrius leschenaultii*	Greater Sand Plover	IV	LC	M	
83	*Charadrius mongolus*	Lesser Sand Plover	IV	LC	M	
84	*Charadrius hiaticula*	Common Ringed Plover	IV	LC	M	
85	*Charadrius dubius jerdoni*	Little Ringed Plover	IV	LC	R	
86	*Charadrius alexandrinus*	Kentish Plover	IV	LC	M	
87	*Vanellus indicus*	Red-wattled Lapwing	IV	LC	R	I
	Family Scolopacidae					
88	*Gallinago gallinago*	Common Snipe	IV	LC	M	
89	*Limosa limosa*	Western Black-tailed Godwit	IV	NT	M	
90	*Numenius arquata*	Eurasian Curlew	IV	NT	M	
91	*Numenius phaeopus*	Whimbrel	IV	LC	M	
92	*Xenus cinereus*	Terek Sandpiper	IV	LC	M	

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
93	*Tringa nebularia*	Common Greenshank	IV	LC	M	
94	*Tringa glareola*	Wood Sandpiper	IV	LC	M	C
95	*Tringa ochropus*	Green Sandpiper	IV	LC	M	
96	*Actitis hypoleucos*	Common Sandpiper	IV	LC	M	
97	*Tringa stagnatilis*	Marsh Sandpiper	IV	LC	M	
98	*Tringa tetanus*	Common Redshank	IV	LC	M	
99	*Tringa erythropus*	Spotted Redshank	IV	LC	M	
100	*Limicola falcinellus*	Broad-billed Sandpiper	IV	LC	M	
101	*Philomachus pugnax*	Ruff	IV	LC	M	
102	*Calidris tenuirostris*	Great Knot	IV	EN	M	
103	*Calidris ferruginea*	Curlew Sandpiper	IV	NT	M	
104	*Ereunetes alpina*	Dunlin	IV	LC	M	
105	*Calidris temminckii*	Temminck's Stint	IV	LC	M	
106	*Calidris minuta*	Little Stint	IV	LC	M	
107	*Ereunetes albus*	Sanderling	IV	LC	M	
	Family Recurvirostridae					
108	*Recurvirostra avosetta*	Pied Avocet	IV	LC	M	
109	*Himantopus himantopus*	Black-winged Stilt	IV	LC	R/LM	C
	Family Phalaropidae					
110	*Phalaropus lobatus*	Red-necked Phalarope	IV	LC	M	
	Family Laridae					
111	*Larus fuscus heuglini*	Heuglin's Gull	IV	LC	M	
112	*Ichthyaetus ichthyaetus*	Great Black-headed Gull	IV	LC	M	
113	*Chroicocephalus genei*	Slender-billed Gull	IV	LC	M	
114	*Larus brunnicephalus*	Brown-headed Gull	IV	LC	M	
115	*Larus ridibundus*	Common Black-headed Gull	IV	LC	M	
116	*Sternula saundersi*	Saunders' Tern	IV	LC	M	
117	*Sterna hirundo*	Common Tern	IV	LC	M	
118	*Sterna repressa*	White-cheeked Tern	IV	LC	M	
119	*Gelochelidon nilotica*	Gull-billed Tern	IV	LC	M	
120	*Sterna aurantia*	River Tern	IV	LC	R/LM	
121	*Hydroprogne caspia*	Caspian Tern	IV	LC	M	
122	*Chlidonias hybridus*	Whiskered Tern	IV	LC	M	C
123	*Thalasseus sandvicensis*	Sandwich Tern	IV	LC	M	
	Family Rynchopidae					
124	*Rynchops albicollis*	Indian Skimmer	IV	VU	R/LM	
	Family Columbidae					
125	*Columba livia*	Blue Rock Pigeon		LC	R	G
126	*Streptopelia senegalensis*	Laughing Dove	IV	LC	R	

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
127	*Streptopelia chinensis*	Spotted Dove	IV	LC	R	G
128	*Streptopelia orientalis*	Oriental Turtle-dove	IV	LC	R	G
129	*Streptopelia decaocto*	Eurasian Collared Dove	IV	LC	R	G
130	*Treron affinis*	Grey-fronted Green-pigeon	IV	LC	R	
131	*Columba elphinstonii*	Nilgiri Wood Pigeon	IV	VU	R	F
132	*Treron phoenicopterus chlorigaster*	Yellow-footed Green-pigeon	IV	LC	R	F
	Family Psittacidae					
133	*Psittacula cyanocephala*	Plum-headed Parakeet	IV	LC	R	F
134	*Psittacula krameri*	Rose-ringed Parakeet	IV	LC	R	F
135	*Psittacula eupatria*	Alexandrine Parakeet	IV	NT	R	
	Family Cuculidae					
136	*Clamator jacobinus*	Jacobin Cuckoo	IV	LC	SM	
137	*Eudynamys scolopaceus*	Asian Koel	IV	LC	R	F
138	*Cuculus micropterus*	Indian Cuckoo	IV	LC	R	
139	*Hierococcyx varius*	Common Hawk-cuckoo	IV	LC	R	
140	*Phaenicophaeus viridirostris*	Blue-faced Malkoha	IV	LC	R	
141	*Taccocua leschenultii*	Sirkeer Malkoha	IV	LC	R	I
142	*Centropus [sinensis] parroti*	Southern Coucal	IV	LC	R	O
	Family Tytonidae					
143	*Tyto alba*	Common Barn-owl	IV	LC	R	
	Family Strigidae					
144	*Bubo bengalensis*	Indian Eagle-owl	IV	LC	R	
145	*Strix ocellata*	Mottled Wood-owl	IV	LC	R	
146	*Athene brama*	Spotted Owlet	IV	LC	R	
147	*Glaucidium radiutum*	Jungle Owlet	IV	LC	R	
	Family Caprimulgidae					
148	*Caprimulgus indicus*	Indian Jungle Nightjar	IV	LC	R	
149	*Caprimulgus asiaticus*	Indian Little Nightjar	IV	LC	R	
	Family Apodidae					
150	*Cypsiurus balasiensis*	Asian Palm-swift		LC	R	I
151	*Tachymarptis melba*	Alpine Swift		LC	R	I
152	*Apus affinis*	Little Swift		LC	R	I
	Family Alcedinidae					
153	*Halcyon smyrnensis*	White-throated Kingfisher	IV	LC	R	C
154	*Alcedo atthis*	Common Kingfisher	IV	LC	R	C
155	*Ceryle rudis*	Lesser Pied Kingfisher	IV	LC	R	

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
156	*Ceyx erithaca*	Black-backed Dwarf Kingfisher	IV	LC	BM	
	Family Meropidae					
157	*Merops persicus*	Blue-cheeked Bee-eater		LC	PM	
158	*Merops philippinus*	Blue-tailed Bee-eater		LC	PM	
159	*Merops orientalis*	Little Green Bee-eater		LC	R	I
	Family Coraciidae					
160	*Coracias garrulus*	European Roller	IV	LC	PM	I
161	*Coracias benghalensis*	Indian Roller	IV	LC	R	
	Family Upupidae					
162	*Upupa epops*	Common Hoopoe		LC	R/LM	I
	Family Bucerotidae					
163	*Ocyceros birostris*	Indian Grey Hornbill	I	LC	R	F
	Family Capitonidae					
164	*Xantholaema haemacephala*	Coppersmith Barbet	IV	LC	R	F
165	*Megalaima viridis*	White-cheeked Barbet	IV	LC	R	F
166	*Megalaima zeylonica*	Brown-headed Barbet	IV	LC	R	F
	Family Picidae					
167	*Hemicircus canente*	Heart-spotted Woodpecker	IV	LC	R	I
168	*Dendrocopos nanus*	Indian Pygmy Woodpecker	IV	LC	R	
169	*Dendrocopos mahrattensis*	Yellow-fronted Pied Woodpecker	IV	LC	R	I
170	*Micropternus brachyurus*	Rufous Woodpecker	IV	LC	R	
171	*Chrysocolaptes guttacristatus*	Greater Flameback	IV	LC	R	I
	Family Pittidae					
172	*Pitta brachyura*	Indian Pitta	IV	LC	BM	
	Family Alaudidae					
173	*Galerida malabarica*	Malabar Lark	IV	LC	R	
174	*Eremopterix griseus*	Ashy-crowned Finch-lark	IV	LC	R	
175	*Ammomanes phoenicura*	Rufous-tailed Lark	IV	LC	R	O
176	*Calendrella brachydactyla*	Greater Short-toed Lark	IV	LC	M	
	Family Hirundinidae					
177	*Ptyonoprogne concolor*	Dusky Crag Martin	IV	LC	R	I
178	*Cecropis daurica*	Red-rumped Swallow		LC	R	I
179	*Hirundo rustica*	Barn Swallow	IV	LC	M	I
180	*Hirundo smithii*	Wire-tailed Swallow	IV	LC	R	I

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
	Family Motacillidae					
181	*Motacilla flava*	Yellow Wagtail	IV	LC	M	
182	*Motacilla cinerea*	Grey Wagtail	IV	LC	M	
183	*Motacilla citreola*	Citrine Wagtail	IV	LC	M	I
184	*Dendronanthus indicus*	Forest Wagtail		LC	M	
185	*Motacilla alba*	White Wagtail	IV	LC	M	
186	*Motacilla maderaspatensis*	White-browed Wagtail	IV	LC	R	
187	*Anthus trivialis*	Tree Pipit	IV	LC	M	I
188	*Anthus hodgsoni*	Olive-backed Pipit	IV	LC	M	I
189	*Anthus rufulus*	Paddyfield Pipit	IV	LC	R	I
	Family Campephagidae					
190	*Tephrodornis pondicerianus*	Common Woodshrike	IV	LC	R	I
191	*Lalage melanoptera*	Black-headed Cuckooshrike	IV	LC	R	I
192	*Coracina macei*	Large Cuckooshrike	IV	LC	R	I
193	*Pericrocotus flammeus*	Orange Minivet	IV	LC	R	I
194	*Pericrocotus cinnamomeus*	Small Minivet	IV	LC	R	I
	Family Pycnonotidae					
195	*Pycnonotus cafer*	Red-vented Bulbul	IV	LC	R	O
196	*Pycnonotus jocosus*	Red-whiskered Bulbul	IV	LC	R	O
197	*Hypsipetes ganeesa*	Square-tailed Bulbul	IV	LC	R	O
198	*Pycnonotus leucotis*	White-eared Bulbul	IV	LC	R	O
	Family Irenidae					
199	*Aegithina tiphia*	Common Iora	IV	LC	R	I
200	*Chloropsis aurifrons*	Gold-fronted Leafbird	IV	LC	R	FN
	Family Laniidae					
201	*Lanius schach erythronotus group*	‘Rufous-backed’Long - tailed Shrike	IV	LC	R/LM	I
202	*Lanius cristatus*	Brown Shrike		LC	M	
203	*Lanius excubitor lahtora/pallidirostris*	Great Grey Shrike	IV	LC	R	I
204	*Lanius isabellinus*	Isabelline Shrike	IV	LC	R	
205	*Lanius vittatus*	Bay-backed Shrike	IV	LC	R	
	Subfamily: Turdinae					
206	*Monticola solitaries*	Blue Rock-thrush	IV	LC	M	
207	*Monticola cinclorhyncha*	Blue-capped Rock Thrush	IV	LC	M	
208	*Geokichla citrine*	Orange-headed Ground Thrush	IV	LC	R/LM	O
209	*Myophonus horsfieldi*	Malabar Whistling Thrush	IV	LC	R	I
210	*Luscinia svecica*	Bluethroat	IV	LC	M	

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
211	*Copsychus saularis*	Oriental Magpie Robin	IV	LC	R	I
212	*Copsychus malabaricus*	White-rumped Shama	IV	LC	R	I
213	*Copsychus fulicatus*	Indian Black Robin	IV	LC	R	I
214	*Phoenicurus ochruros*	Black Redstart	IV	LC	M	
215	*Saxicola caprata*	Pied Bushchat	IV	LC	R	
216	*Saxicola maurus*	Common Stonechat	IV	LC	M	I
217	*Oenanthe isabellina*	Isabelline Wheatear	IV	LC	M	
218	*Oenanthe d. deserti*	Desert Wheatear	IV	LC	M	
	Subfamily: Timaliinae					
219	*Pomatorhinus [schisticeps] horsfieldii*	Indian Scimitar-babbler	IV	LC	R	
220	*Chrysomma sinense*	Yellow-eyed Babbler	IV	LC	R	I
221	*Turdoides striatus*	Jungle Babbler	IV	LC	R	O
222	*Turdoides malcolmi*	Large Grey Babbler	IV	LC	R	I
223	*Pellorneum ruficeps*	Puff-throated Babbler	IV	LC	R	I
224	*Alcippe poioicephala*	Brown-cheeked Fulvetta	IV	LC	R	I
	Subfamily: Sylviinae					
225	*Cisticola juncidis*	Zitting Cisticola	IV	LC	R	
226	*Prinia socialis*	Ashy Prinia	IV	LC	R	I
227	*Prinia hodgsonii*	Grey-breasted Prinia	IV	LC	R	I
228	*Prinia sylvatica*	Jungle Prinia	IV	LC	R	I
229	*Prinia inornata*	Plain Prinia	IV	LC	R	I
230	*Acrocephalus dumetorum*	Blyth's Reed-warbler		LC	M	I
231	*Acrocephalus [stentoreus] brunnescens*	Indian Reed-warbler	IV	LC	R/LM	
232	*Orthotomus sutorius*	Common Tailorbird	IV	LC	R	I
233	*Phylloscopus [collybita]tristis*	Siberian Chiffchaff		LC	M	I
234	*Phylloscopus trochiloides*	Greenish Warbler		LC	M	I
235	*Iduna rama*	Syke's Warbler		LC	M	I
236	*Phylloscopus griseolus*	Sulphur-bellied Warbler		LC	M	
237	*Phylloscopus* sp.	UI Warbler				
238	*Sylvia curruca*	Lesser Whitethroat	IV	LC	M	I
	Subfamily: Muscicapinae					
239	*Cyornis tickelliae*	Tickell's Blue Flycatcher	IV	LC	R/LM	I
240	*Eumyias thalassinus*	Verditer Flycatcher	IV	LC	M	I
241	*Muscicapa dauurica*	Asian Brown Flycatcher	IV	LC	R/LM	
242	*Ficedula parva*	Red-breasted Flycatcher	IV	LC	M	I

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
243	*Culicicapa ceylonensis*	Grey-headed Canary Flycatcher	IV	LC	R/LM	I
	Subfamily: Monarchinae					
244	*Terpsiphone paradise*	Asian Paradise Flycatcher	IV	LC	R/BM	I
245	*Hypothymis azurea*	Black-naped Blue Monarch	IV	LC	R	I
	Subfamily: Rhipidurinae					
246	*Rhipidura aureola*	White-browed Fantail	IV	LC	R	I
247	*Rhipidura albogularis*	White-spotted Fantail	IV	LC	R	I
	Family Dicaeidae					
248	*Dicaeum agile*	Thick-billed Flowerpecker	IV	LC	R	FN
249	*Dicaeum erythrorhynchos*	Pale-billed Flowerpecker	IV	LC	R	N
	Family Nectariniidae					
250	*Cinnyris asiatica*	Purple Sunbird	IV	LC	R	FN
251	*Leptocoma zeylonica*	Purple-rumped Sunbird	IV	LC	R	FN
252	*Leptocoma minima*	Crimson-backed Sunbird	IV	LC	R	IN
253	*Aethopyga vigorsii*	Vigors's Sunbird	IV	LC	R	IN
254	*Cinnyris lotenius*	Loten's Sunbird	IV	LC	R	N
	Family Emberizidae					
255	*Emberiza melanocephala*	Black-headed Bunting	IV	LC	M	G
256	*Emberiza bruniceps*	Red-headed Bunting	IV	LC	M	
	Family Fringillidae					
257	*Fringilla coelebs*	Common Rosefinch	IV	LC	M	G
	Family Estrildidae					
258	*Amandava amandava*	Red Avadavat	IV	LC	R	G
259	*Lonchura punctulata*	Scaly-breasted Munia	IV	LC	R	G
260	*Lonchura malacca*	Black-headed Munia	IV	LC	R	G
261	*Lonchura striata*	White-rumped Munia	IV	LC	R	G
	Subfamily Passerinae					
262	*Passer domesticus*	House Sparrow	IV	LC	R	G
263	*Gymnoris xanthocollis*	Yellow-throated Sparrow	IV	LC	R	O
	Subfamily Ploceinae					
264	*Ploceus philippinus*	Indian Baya Weaver	IV	LC	R	G
265	*Ploceus manyar*	Streaked Weaver	IV	LC	R	
266	*Ploceus benghalensis*	Black-breasted Weaver	IV	LC	R	
	Family Sturnidae					
267	*Pastor roseus*	Rosy Starling	IV	LC	M	

Sr. No.	Scientific names	Common Name	WPA schedule	IUCN status	R/M	Guild
268	*Sturnia pagodarum*	Brahminy Starling	IV	LC	R	
269	*Gracupica contra*	Asian Pied Starling	IV	LC	R	
270	*Acridotheres tristis*	Common Myna	IV	LC	R	O
	Family Oriolidae					
271	*Oriolus kundoo*	Indian Golden Oriole	IV	LC	R/LM	O
272	*Oriolus xanthornus*	Black-hooded Oriole	IV	LC	R	F
	Family Dicruridae					
273	*Dicrurus macrocercus*	Black Drongo	IV	LC	R	O
274	*Dicrurus leucophaeus*	Ashy Drongo	IV	LC	M	I
275	*Dicrurus aeneus*	Bronze Drongo	IV	LC	R	I
276	*Dicrurus caerulescens*	White-bellied Drongo	IV	LC	R	I
277	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	IV	LC	R	I
	Family Corvidae					
278	*Corvus splendens*	House Crow	V	LC	R	O
279	*Corvus [macrorhynchos] culminatus*	Indian Jungle Crow	IV	LC	R	O
280	*Dendrocitta vagabunda*	Rufous Treepie	IV	LC	R	O

Abbreviations: R: Resident; M: Winter Migrant; LM: Local Migrant; SM: Summer Migrant; BM: Breeding Migrant; PM: Passage Migrant; EN: Endangered; LC: Least Concern; VU: Vulnerable; NT: Near Threatened; I: Insetivorous, O: Omnivorous, F: Frugivorous; N: Nectarivorous; G: Granivorous; C: Carnivorous.

III. List of tidal and non-tidal birds

Sr. No.	Non Tidal Birds	Sr. No.	Tidal Birds
1	Asian Openbill *Anastomus oscitans*	1	Brown-headed Gull *Larus brunnicephalus*
2	Black-crowned Night Heron *Nycticorax nycticorax*	2	Black-headed Ibis *Threskiornis melanocephalus*
3	Bronze-winged Jacana *Metopidius indicus*	3	Common tern *sterna hirundo*
4	Black-winged Stilt *Himantopus himantopus*	4	Common Black-headed Gull *Larus ridibundus*
5	Common Snipe *Gallinago gallinago*	5	Common Greenshank *Tringa nebularia*
6	Common Kingfisher *Alcedo atthis*	6	Common Redshank *Tringa tetanus*
7	Common Moorhen *Gallinula chloropus*	7	Common Ringed Plover *Charadrius hiaticula*
8	Common Teal *Anascrecca*	8	Curlew Sandpiper *Calidris ferruginea*
9	Eurasian Coot *Fulica atra*	9	Caspian Tern *Hydroprogne caspia*
10	Eurasian Spoonbill *Platalea leucorodia*	10	Eurasian Curlew *Numenius arquata*
11	Eurasian Wigeon *Mareca Penelope*	11	Gull-billed Tern *Gelochelidon nilotica*
12	Gadwall *Mareca strepera*	12	Great Cormorant *Phalacrocorax carbo*
13	Greater Flamingo *Phoenicopterus roseus*	13	Great Egret *Egretta alba*
14	Grey Heron *Ardea cinerea*	14	Grey Plover *Pluvialis squatarola*
15	Glossy Ibis *Plegadis falcinellus*	15	Green Sandpiper *Tringa ochropus*
16	Garganey *Querquedula querquedula*	16	Heuglin's Gull *Larus fuscus heuglini*
17	Indian Skimmer*Rynchops albicollis*	17	Intermediate Egret *Egretta intermedia*
18	Indian Black Ibis *Pseudibis papillosa*	18	Little Egret *Egretta garzetta*
19	Indian Pond-heron *Ardeola grayii*	19	Lesser Flamingo *Phoeniconaias minor*
20	Indian Shag *Phalacrocorax fuscicollis*	20	Whimbrel *Numenius phaeopus*
21	Indian Spot-billed Duck *Anaspoecilorhyncha*	21	Marsh Sandpiper *Tringa stagnatilis*
22	Little Cormorant *Microcarbo niger*	22	Pied Avocet *Recurvirostra avosetta*
23	Little Grebe *Tachybaptus ruficollis*	23	Pacific Golden Plover *Pluvialis fulva*
24	Lesser Pied Kingfisher *Ceryle rudis*	24	Sandwich Tern *Thalasseus sandvicensis*
25	Lesser Whistling-duck *Dendrocygna javanica*	25	Waders
26	Northern Pintail *Anas acuta*	26	Western Reef-heron *Egretta gularis*
27	Northern Shoveler *Spatula clypeata*	27	Wood Sandpiper *Tringa glareola*
28	Purple Heron *Ardea purpurea*	28	Whiskered Tern *Chlidonias hybridus*
29	Painted Stork *Mycteria leucocephala*		
30	Pheasant-tailed Jacana *Hydrophasianus chirurgus*		
31	Ruff *Philomachus pugnax*		
32	Ruddy Shelduck *Tadorna ferruginea*		
33	River Tern *Sterna aurantia*		
34	Red-wattled Lapwing *Vanellus* indicus		

Sr. No.	**Non Tidal Birds**	**Sr. No.**	**Tidal Birds**
35	Western Black-tailed Godwit *Limosa limosa*		
36	White-breasted Waterhen *Amaurornis phoenicurus*		
37	Woolly-necked Stork *Ciconia episcopus*		
38	Purple Swamphen *Porphyrio* [*porphyrio*] *poliocephalus*		

IV. Checklist of amphibians

Sr. No	Families	*Scientific name*	Common name	WPA Schedule	IUCN status
Order: Gymnophiona					
1	Indotyphlidae	*Indotyphlus battersbyi*	Battersby's Caecilian	IV	DD
Order: Anura					
2	Bufonidae	*Duttaphrynus melanostictus*	Asian Common Toad	IV	LC
3	Dicroglossidae	*Euphlyctis cynophlyctis*	Skittering Frog	IV	LC
4	Dicroglossidae	*Hoplobatrachus tigerinus*	Indian Bull Frog	IV	LC
5	Dicroglossidae	*Sphaerotheca breviceps*	Indian Burrowing Frog	IV	LC
6	Dicroglossidae	*Fejervarya sp.1*	Cricket Frog	-	-
7	Dicroglossidae	*Fejervarya sp.2*	Cricket Frog	-	-
8	Microhylidae	*Uperodon mormorata*	-	IV	EN
9	Microhylidae	*Uperodon globulosus*	Balloon Frog	-	LC
10	Microhylidae	*Microhyla ornata*	Ornate Narrow Mouth Frog	IV	LC
11	Ranidae	*Hydrophlylax bahuvistara*	Fungoid Frog	-	NA
12	Ranixalidae	*Indirana leithii*	Leith's Leaping Frog		VU
13	Nyctibatrachidae	*Nyctibatrachus humayuni*	Bombay night frog	-	VU
14	Rhacophoridae	*Polypedates maculatus*	Common Indian Tree Frog	IV	LC
15	Rhacophoridae	*Raorchestes ghatei*	Ghate's shrub Frog	IV	NA
16	Rhacophoridae	*Raorchestes cf. bombayensis*	Bombay bush Frog	IV	LC

Abbreviations: DD: Data Deficient; LC: Least Concern; T: Threatened; NA: Not Assessed; EN: Endangered; VU: Vulnerable

V. Checklist of reptiles

Sr. No.	Families	Scientific name	Common name	WPA Schedule	IUCN status
Order Sauria					
1	Agamidae	*Calotes rouxii*	Forest Calotes	IV	LC
2	Agamidae	*Calotes versicolor*	Garden Calotes	IV	NA
3	Agamidae	*Sitana spinaecephalus*	Fan-throated Lizard	IV	LC
4	Chamaeleonidae	*Chamaeleo zeylanicus*	Indian Chameleon	II	LC
5	Gekkonidae	*Cyrtodactylus deccanensis*	Deccan Ground Gecko	IV	LC
6	Gekkonidae	*Hemidactylus cf brookii*	Brook's Gecko	IV	LC
7	Gekkonidae	*Hemidactylus leschenaultii*	Leschenault's Bark Gecko	IV	NA
8	Gekkonidae	*Hemidactylus maculatus*	Rock Gecko	IV	LC
9	Gekkonidae	*Hemidactylus frenatus*	House Gecko	-	LC
10	Lacertidae	*Ophisops jerdoni*	Jerdon's Snake Eye		
11	Scincidae	*Eutropis allapallensis*	-	IV	LC
12	Scincidae	*Eutropis carinata*	Many Keeled Grass Skink	IV	LC
13	Scincidae	*Eutropis macularia*	Bronze Skink	IV	NA
14	Scincidae	*Lygosoma lineata*	Lined Supple Skink	IV	LC
15	Varanidae	*Varanus bengalensis*	Monitor lizard	IV	LC
Order Serpentes					
16	Boidae	*Eryx conicus*	Common Sand Boa	IV	NA
17	Boidae	*Eryx johnii*	John's Sand Boa		
18	Colubridae	*Ahaetulla nasuta*	Green Vine Snake	IV	NA
19	Colubridae	*Boiga beddomei*	Beddome's Cat Snake	IV	LC
20	Colubridae	*Coelognathus helena monticollaris*	Montane Trinket	IV	NA
21	Colubridae	*Dendrelaphis tristis*	Common Bronze Back Tree Snake	IV	NA
22	Colubridae	*Lycodon aulicus*	Common Wolf Snake	IV	NA
23	Colubridae	*Oligodon taeniolatus*	Russell's Kukri	IV	LC
24	Colubridae	*Oligodon arnensis*	Banded Kukri		
25	Colubridae	*Ptyas mucosa*	Indian Rat Snake	IV	NA
26	Elapidae	*Bungarus caeruleus*	Common Krait	IV	NA
27	Elapidae	*Naja naja*	Spectacled Cobra	IV	-
28	Homalopsidae	*Cerberus rynchops*	Dog-faced Water Snake	-	LC
29	Natracidae	*Amphiesma stolatum*	Buff-striped Keelback	IV	NA

Sr. No.	Families	Scientific name	Common name	WPA Schedule	IUCN status
30	Natracidae	*Xenochrophis piscator*	Checkered Keelback	IV	NA
31	Pythonidae	*Python molurus*	Indian Rock Python	I (Part II)	LC
32	Typhlopidae	*Indotyphlops braminus*	Blind snake	-	LC
33	Uropeltidae	*Uropeltis macrolepis*	Large-scaled Shieldtail		
34	Viperidae	*Echis carinatus*	Saw Scale Viper	IV	NA
35	Viperidae	*Daboia russelli*	Russell's Viper	IV	NA
36	Viperidae	*Trimeresurus gramineus*	Bamboo Pit Viper	IV	LC

Abbreviations: LC: Least Concern; NA: Not Assessed.

VI. Checklist of insects

Sr. no.	Order	Family	Scientific Name	Common Name	WPA Status	IUCN status
1	Blattodea	Blattidae	*Blatta orientalis*	Oriental Cockroach	__	NA
2	Blattodea	Blattidae	*Periplaneta americana*	American Cockroach	__	NA
3	Coleoptera	Cerambycidae	*Batocera* sp.	__	__	NA
4	Coleoptera	Cerambycidae	*Celosterna scabrator*	Long-horned beetle	__	NA
5	Coleoptera	Dytiscidae	*Cybister* sp.	__	__	NA
6	Coleoptera	Elateridae	*Lanelater* sp.	Click beetle	__	NA
7	Diptera	Culicidae	*Anopheles* sp.	Anopheles Mosquito	__	NA
8	Diptera	Muscidae	*Musca domestica*	Housefly	__	NA
9	Diptera	Sarcophagidae	*Sarcophaga* sp.	__	__	NA
10	Hemiptera	Cicadidae	*Platyplura* sp.	Cicada	__	NA
11	Hemiptera	Coreidae	*Dalader* sp.	__	__	NA
12	Hemiptera	Pentatomidae	*Erthesina* fullo	Stink bug	__	NA
13	Hemiptera	Scutelleridae	*Chrysocoris* sp.	Jewel bug	__	NA
14	Hymenoptera	Apidae	*Apis cerana*	Indian Honey Bee	__	NA
15	Hymenoptera	Formicidae	*Camponotus compressus*	Godzilla Ant	__	NA
16	Hymenoptera	Formicidae	*Crematogaster* sp.	Pagoda Ant	__	NA
17	Hymenoptera	Formicidae	*Oecophylla smaragdina*	Weaver Ant	__	NA
18	Hymenoptera	Formicidae	*Pheidole* sp.	Harvester Ant	__	NA
19	Hymenoptera	Vaspidae	*Vespa* sp.	__	__	NA
20	Lepidoptera	Erebidae	*Amata* sp.	Tiger moth	__	NA
21	Lepidoptera	Erebidae	*Erebus macrops*	Owl Moth	__	NA
22	Lepidoptera	Erebidae	*Creatonotos gangis*	__	__	NA
23	Lepidoptera	Erebidae	*Olepa ricini*	Tiger moth	__	NA
24	Lepidoptera	Crambidae	*Eoophyla conjunctalis*	__	__	NA
25	Lepidoptera	Crambidae	*Paraponyx* sp.	__	__	NA
26	Lepidoptera	Crambidae	*Parotis* sp.	__	__	NA
27	Lepidoptera	Crambidae	*Maruca vitrata*	__	__	NA
28	Lepidoptera	Crambidae	*Sameodes* sp.	__	__	NA
29	Lepidoptera	Geometridae	*Dysphania percota*	Blue Tiger Moth	__	NA
30	Lepidoptera	Hesperiidae	*Arnetta vindhiana*	Vindhyan Bob	__	NA
31	Lepidoptera	Hesperiidae	*Badamia exclamationis*	Brown Awl	__	NA
32	Lepidoptera	Hesperiidae	*Bibasis sena*	Orangetail Awl	II	NA
33	Lepidoptera	Hesperiidae	*Borbo cinnara*	Rice Swift	__	NA
34	Lepidoptera	Hesperiidae	*Borbo* sp.	Unid Hesperiid sp.1	__	NA
35	Lepidoptera	Hesperiidae	*Borbo* sp.	Unid Hesperiid sp.2	__	NA
36	Lepidoptera	Hesperiidae	*Burara jaina*	Orange Awlet	__	NA

Sr. no.	Order	Family	Scientific Name	Common Name	WPA Status	IUCN status
37	Lepidoptera	Hesperiidae	*Caprona ransonnettii*	Golden Angle	__	NA
38	Lepidoptera	Hesperiidae	*Celaenorrhinus ambareesa*	Malabar Spotted Flat	__	NA
39	Lepidoptera	Hesperiidae	*Celaenorrhinus leucocera*	Common Spotted Flat	__	NA
40	Lepidoptera	Hesperiidae	*Hasora chromus*	Common Banded Awl	__	NA
41	Lepidoptera	Hesperiidae	*Imbrix salsala*	Chestnut Bob	__	NA
42	Lepidoptera	Hesperiidae	*Sarangesa dasahara*	Common Small Flat	__	NA
43	Lepidoptera	Hesperiidae	*Sarangesa purendra*	Spotted Small Flat	__	NA
44	Lepidoptera	Hesperiidae	*Spialia galba*	Indian Skipper	__	NA
45	Lepidoptera	Hesperiidae	*Suastus gremius*	Indian Palm Bob	__	NA
46	Lepidoptera	Hesperiidae	*Tagiades litigiosa*	Water Snow Flat	__	NA
47	Lepidoptera	Hesperiidae	*Telicota* sp.	Palm dart	__	NA
48	Lepidoptera	Hesperiidae	*Udaspes folus*	Grass Demon	__	NA
49	Lepidoptera	Lycaenidae	*Acytolepis puspa*	Common Hedge Blue	__	NA
50	Lepidoptera	Lycaenidae	*Amblypodia anita*	Purple Leaf Blue	__	NA
51	Lepidoptera	Lycaenidae	*Azanus* sp.	Babul Blue	__	NA
52	Lepidoptera	Lycaenidae	*Caleta decidia*	Angled Pierrot	__	NA
53	Lepidoptera	Lycaenidae	*Castalius rosimon*	Common Pierrot	I	NA
54	Lepidoptera	Lycaenidae	*Catochrysops strabo*	Forget Me Not	__	NA
55	Lepidoptera	Lycaenidae	*Chilades lajus*	Lime Blue	__	NA
56	Lepidoptera	Lycaenidae	*Chilades pandava*	Plains Cupid	__	NA
57	Lepidoptera	Lycaenidae	*Chilades parrhasius*	Small Cupid	__	NA
58	Lepidoptera	Lycaenidae	*Chilades* sp.	Unid Cupid	__	NA
59	Lepidoptera	Lycaenidae	*Curetis thetis*	Indian Sunbeam	__	NA
60	Lepidoptera	Lycaenidae	*Euchrysops cnejus*	Gram Blue	__	NA
61	Lepidoptera	Lycaenidae	*Everes lacturnus*	Indian Cupid	__	NA
62	Lepidoptera	Lycaenidae	*Freyeria trochylus*	Grass Jewel	__	NA
63	Lepidoptera	Lycaenidae	*Jamides celeno*	Common Cerulean	__	NA
64	Lepidoptera	Lycaenidae	*Lampides boeticus*	Pea Blue	__	NA
65	Lepidoptera	Lycaenidae	*Leptotes plinius*	Zebra Blue	__	NA
66	Lepidoptera	Lycaenidae	*Loxura atymnus*	Yamfly	__	NA
67	Lepidoptera	Lycaenidae	*Megisba malaya*	Malayan	__	NA
68	Lepidoptera	Lycaenidae	*Prosotas dubiosa*	Tailless Lineblue	__	NA
69	Lepidoptera	Lycaenidae	*Prosotas nora*	Common Lineblue	__	NA
70	Lepidoptera	Lycaenidae	*Prosotas* sp.	Unid Lineblue	__	NA
71	Lepidoptera	Lycaenidae	*Pseudozizeeria maha*	Pale Grass Blue	__	NA
72	Lepidoptera	Lycaenidae	*Rapala iarbus*	Common Redflash	__	NA
73	Lepidoptera	Lycaenidae	*Rathinda amor*	Monkey Puzzle	__	NA
74	Lepidoptera	Lycaenidae	*Spindasis vulcanus*	Common Silverline	__	NA

Sr. no.	Order	Family	Scientific Name	Common Name	WPA Status	IUCN status
75	Lepidoptera	Lycaenidae	*Tarucus nara*	Rounded Pierrot	__	NA
76	Lepidoptera	Lycaenidae	*Zizeeria karsandra*	Dark Grass Blue	__	NA
77	Lepidoptera	Lycaenidae	*Zizula hylax*	Tiny Grass Blue	__	NA
78	Lepidoptera	Nymphalidae	*Acraea terpsicore*	Tawny Coster	__	NA
79	Lepidoptera	Nymphalidae	*Ariadne ariadne*	Angled Castor	__	NA
80	Lepidoptera	Nymphalidae	*Ariadne merione*	Common Castor	__	NA
81	Lepidoptera	Nymphalidae	*Charaxes bernardus*	Tawny Rajah	__	NA
82	Lepidoptera	Nymphalidae	*Charaxes bharata*	Common Nawab	__	NA
83	Lepidoptera	Nymphalidae	*Charaxes solon*	Black Rajah	__	NA
84	Lepidoptera	Nymphalidae	*Cupha erymanthis*	Rustic	__	NA
85	Lepidoptera	Nymphalidae	*Danaus chrysippus*	Plain Tiger	__	NA
86	Lepidoptera	Nymphalidae	*Danaus genutia*	Striped Tiger	__	NA
87	Lepidoptera	Nymphalidae	*Euploea core*	Common Crow	__	LC
88	Lepidoptera	Nymphalidae	*Euthalia aconthea*	Common Baron	__	NA
89	Lepidoptera	Nymphalidae	*Hypolimnas bolina*	Great Eggfly	__	NA
90	Lepidoptera	Nymphalidae	*Hypolimnas misippus*	Danaid Eggfly	I	NA
91	Lepidoptera	Nymphalidae	*Junonia almana*	Peacock Pansy	__	LC
92	Lepidoptera	Nymphalidae	*Junonia atlites*	Grey Pansy	__	NA
93	Lepidoptera	Nymphalidae	*Junonia hierta*	Yellow Pansy	__	LC
94	Lepidoptera	Nymphalidae	*Junonia iphita*	Chocolate Pansy	__	NA
95	Lepidoptera	Nymphalidae	*Junonia lemonias*	Lemon Pansy	__	NA
96	Lepidoptera	Nymphalidae	*Junonia orithya*	Blue Pansy	__	NA
97	Lepidoptera	Nymphalidae	*Kallima horsefieldii*	Blue Oakleaf	__	NA
98	Lepidoptera	Nymphalidae	*Lethe rohria*	Common Treebrown	__	NA
99	Lepidoptera	Nymphalidae	*Libythea myrrha*	Club Beak	__	NA
100	Lepidoptera	Nymphalidae	*Melanitis leda*	Common Evening Brown	__	NA
101	Lepidoptera	Nymphalidae	*Mycalensis perseus*	Common Bushbbrown	__	NA
102	Lepidoptera	Nymphalidae	*Neptis hylas*	Common Sailer	__	NA
103	Lepidoptera	Nymphalidae	*Neptis jumbah*	Chestnut-streaked Sailer	I	NA
104	Lepidoptera	Nymphalidae	*Parantica aglea*	Glassy Tiger	__	NA
105	Lepidoptera	Nymphalidae	*Phalanta phalantha*	Common Leopard	__	NA
106	Lepidoptera	Nymphalidae	*Rohana parisatis*	Black Prince	__	NA
107	Lepidoptera	Nymphalidae	*Symphaedra nais*	Baronet	__	NA
108	Lepidoptera	Nymphalidae	*Tirumala limniace*	Blue Tiger	__	NA
109	Lepidoptera	Nymphalidae	*Vanessa cardui*	Painted Lady	__	NA
110	Lepidoptera	Nymphalidae	*Ypthima asterope*	Common Threering	__	NA
111	Lepidoptera	Nymphalidae	*Ypthima baldus*	Common Fivering	__	NA
112	Lepidoptera	Papilionidae	*Graphium agamemnon*	Tailed Jay	__	NA

Sr. no.	Order	Family	Scientific Name	Common Name	WPA Status	IUCN status
113	Lepidoptera	Papilionidae	*Graphium doson*	Common Jay	__	NA
114	Lepidoptera	Papilionidae	*Graphium nomius*	Spot Swordtail	__	NA
115	Lepidoptera	Papilionidae	*Graphium sarpedon*	Common Bluebottle	__	NA
116	Lepidoptera	Papilionidae	*Pachliopta aristolochiae*	Common Rose	__	NA
117	Lepidoptera	Papilionidae	*Pachliopta hector*	Crimson Rose	I	NA
118	Lepidoptera	Papilionidae	*Papilio demoleus*	Lime Butterfly	__	NA
119	Lepidoptera	Papilionidae	*Papilio helenus*	Red Helen	__	NA
120	Lepidoptera	Papilionidae	*Papilio polymnestor*	Blue Mormon	__	NA
121	Lepidoptera	Papilionidae	*Papilio polytes*	Common Mormon	__	NA
122	Lepidoptera	Pieridae	*Catopsilia pomona*	Common Emigrant	__	NA
123	Lepidoptera	Pieridae	*Catopsilia pyranthe*	Mottled Emigrant	__	NA
124	Lepidoptera	Pieridae	*Cepora nerissa*	Common Gull	II	NA
125	Lepidoptera	Pieridae	*Colotis amata*	Small Salmon Arab	__	NA
126	Lepidoptera	Pieridae	*Colotis fausta*	Large Salmon Arab	__	NA
127	Lepidoptera	Pieridae	*Delias eucharis*	Common Jezebel	__	NA
128	Lepidoptera	Pieridae	*Eurema brigitta*	Small Grass Yellow	__	LC
129	Lepidoptera	Pieridae	*Eurema hecabe*	Common Grass Yellow	__	NA
130	Lepidoptera	Pieridae	*Eurema laeta*	Spotless Grass Yellow	__	NA
131	Lepidoptera	Pieridae	*Ixias marianne*	White Orange Tip	__	NA
132	Lepidoptera	Pieridae	*Ixias pyrene*	Yellow Orange Tip	__	NA
133	Lepidoptera	Pieridae	*Leptosis nina*	Psyche	__	NA
134	Lepidoptera	Pieridae	*Pareronia hippia*	Common Wanderer	__	NA
135	Lepidoptera	Riodinidae	*Abisara echerius*	Plum Judy	__	NA
136	Odonata	Aeshnidae	*Anax immaculifrons*	Blue Darner	__	LC
137	Odonata	Aeshnidae	*Anax guttatus*	Blue-tailed Green Darner	__	LC
138	Odonata	Aeshnidae	*Anax* sp.1	Darner sp. 1	__	__
139	Odonata	Aeshnidae	*Anax* sp.2	Darner sp. 2	__	__
140	Odonata	Aeshnidae	*Gynacantha* sp.	Darner sp. 3	__	LC
141	Odonata	Calopterygidae	*Vestalis gracilis*	Clear-winged Forest Glory	__	LC
142	Odonata	Coenagrionidae	*Ceriagrion coromandelianum*	Coromandel Marsh Dart	__	LC
143	Odonata	Coenagrionidae	*Agriocnemis pygmaea*	Pygmy Dartlet	__	LC
144	Odonata	Coenagrionidae	*Ischnura senegalensis*	Senegal Golden Dartlet	__	LC

Sr. no.	Order	Family	Scientific Name	Common Name	WPA Status	IUCN status
145	Odonata	Gomphidae	*Ictinogomphus rapax*	Common Clubtail	__	LC
146	Odonata	Gomphidae	*Paragomphus lineatus*	Common Hooktail	__	LC
147	Odonata	Lestidae	*Lestes* sp.	Spreadwing	__	LC
148	Odonata	Libellulidae	*Trithemis festiva*	Black Stream Glider	__	LC
149	Odonata	Libellulidae	*Orthetrum glaucum*	Blue Marsh Hawk	__	LC
150	Odonata	Libellulidae	*Orthetrum triangulare*	Blue-tailed Forest Hawk	__	LC
151	Odonata	Libellulidae	*Tholymis tillarga*	Coral-tailed Cloudwing	__	LC
152	Odonata	Libellulidae	*Trithemis aurora*	Crimson Marsh Glider	__	LC
153	Odonata	Libellulidae	*Orthetrum pruinosum*	Crimson-tailed Marsh Hawk	__	LC
154	Odonata	Libellulidae	*Brachythemis contaminata*	Ditch Jewel	__	LC
155	Odonata	Libellulidae	*Neurothemis fulvia*	Fulvous Forest Skimmer	__	LC
156	Odonata	Libellulidae	*Trithemis* sp. 1	Glider	__	__
157	Odonata	Libellulidae	*Bradinopyga geminata*	Granite Ghost	__	LC
158	Odonata	Libellulidae	*Orthetrum sabina*	Green Marsh Hawk	__	LC
159	Odonata	Libellulidae	*Diplacodes trivialis*	Ground Skimmer	__	LC
160	Odonata	Libellulidae	*Trithemis pallidinervis*	Long-legged Marsh Glider	__	LC
161	Odonata	Libellulidae	*Orthetrum* sp.	Marsh Hawk	__	__
162	Odonata	Libellulidae	*Tramea basilaris*	Red Marsh Trotter	__	LC
163	Odonata	Libellulidae	*Crocothemis servilia*	Ruddy Marsh Skimmer	__	LC
164	Odonata	Libellulidae	*Rhodothemis rufa*	Rufous Marsh Glider	__	LC
165	Odonata	Libellulidae	*Trithemis* sp. 2	Glider	__	__
166	Odonata	Libellulidae	*Orthetrum* sp. 2	Unid Libellulid 2	__	__
167	Odonata	Libellulidae	*Pantala flavescens*	Wandering Glider	__	LC
168	Odonata	Platycnemididae	*Disparoneura quadrimaculata*	Blackwinged Bambootail	__	LC
169	Odonata	Platycnemididae	*Copera* sp.	Bush Dart	__	LC
170	Odonata	Platystictidae	*Protosticta* sp.	Reedtail	__	__
171	Orthoptera	Acrididae	*Acrida exaltata*	__	__	NA
172	Orthoptera	Acrididae	*Cyrtacanthacris tatarica*	__	__	NA
173	Orthoptera	Acrididae	*Hieroglyphus banian*	__	__	NA
174	Orthoptera	Gryllidae	*Acheta domesticus*	House Cricket	__	NA

Sr. no.	Order	Family	Scientific Name	Common Name	WPA Status	IUCN status
175	Orthoptera	Gryllidae	*Gryllus bimaculatus*	__	__	NA
176	Orthoptera	Tettigoniidae	*Callimenellus apterus*	—	—	NA

Abbreviations: LC: Least Concern; NA: Not Assessed

VII. Checklist of plants

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
1	Acanthaceae	*Andrographis paniculata* (Burm.f.) Nees	Kalmegh	Herb	NA
2	Acanthaceae	*Barleria* sp.	--	Herb	NA
3	Acanthaceae	*Gomphrena globosa* L.	Jafrigundi	Herb	NA
4	Acanthaceae	*Haplanthodes verticillatus* (Roxb.) R.B.Majumdar	Kateri	Herb	NA
5	Acanthaceae	*Neuracanthus sphaerostachys* Dalzell	--	Herb	NA
6	Acanthaceae	*Rostellularia crinita* Nees	--	Herb	NA
7	Acanthaceae	*Ruellia* sp.	--	Herb	NA
8	Acanthaceae	*Rungia* sp.	--	Herb	NA
9	Amaranthaceae	*Achyranthes aspera* L.	Aghada	Herb	NA
10	Amaranthaceae	*Achyranthes porphyristachya* Wall. ex Moq.	--	Herb	NA
11	Amaranthaceae	*Alternanthera sessilis* (L.) R.Br. ex DC.	--	Herb	LC
12	Amaranthaceae	*Amaranthus spinosus* L.	Katemath	Herb	NA
13	Amaranthaceae	*Celosia argentea* L.	Kurdu	Herb	NA
14	Amaryllidaceae	*Crinum latifolium* L.	--	Herb	NA
15	Anacardiaceae	*Holigarna grahamii* (Wight) Kurz	Hulgeri	Tree	NA
16	Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Moyin	Tree	NA
17	Anacardiaceae	*Mangifera indica* L.	Amba	Tree	DD
18	Anacardiaceae	*Rhus sinuata* Thunb.	Amani, Amboni	shrub	NA
19	Annonaceae	Annonaceae sp. 1	--	Tree	NA
20	Annonaceae	*Miliusa tomentosa* (Roxb.) J.Sinclair	Humb	Tree	NA
21	Annonaceae	*Polyalthia cerasoides* (Roxb.) Bedd.	Humb, Vabbina	Tree	NA
22	Apiaceae	*Pinda concanensis* (Dalzell) P.K. Mukh. & Constance	--	Herb	NA
23	Apocynaceae	*Ceropegia attenuata* Hook.	Tilori	Herb	NA

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
24	Apocynaceae	*Ceropegia bulbosa* Roxb.	Khapparkadu	Herb	NA
25	Apocynaceae	*Ceropegia vincifolia* Hook.	Khapar Khutti	Herb	NA
26	Apocynaceae	*Holarrhena pubescens* Wall. ex G.Don	Kuda	Tree	LC
27	Apocynaceae	*Tabernaemontana alternifolia* L.	Nag kuda	Tree	NA
28	Apocynaceae	*Wrightia arborea* (Dennst.) Mabb.	Tambda kuda	Tree	NA
29	Apocynaceae	*Wrightia tinctoria* R.Br.	Kala kuda	Tree	NA
30	Araceae	*Amorphophallus bulbifera*	Ran-suran	Herb	LC
31	Araceae	*Amorphophallus* sp.	--	Herb	NA
32	Araceae	*Arisaema* sp.	--	Herb	NA
33	Araceae	*Arisaema tortuosum* (Wall.) Schott	Sardacha-jad	Herb	NA
34	Arecaceae	*Caryota urens* L.	Bherlimad	Tree	LC
35	Asparagaceae	*Chlorophytum borivilianum* Santapau & R.R.Fern.	Safed musli	Herb	CR
36	Asparagaceae	*Chlorophytum breviscapum* Dalzell	--	Herb	NA
37	Asparagaceae	*Chlorophytum tuberosum* (Roxb.) Baker	Kuli	Herb	LC
38	Asparagaceae	*Dipcadi montanum* (Dalzell) Baker	--	Herb	NA
39	Asteraceae	*Elephantopus scaber* L.	--	Herb	NA
40	Asteraceae	*Tridax procumbens* (L.) L.	Dagadi pala	Herb	NA
41	Avicenniaceae	*Avicennia marina* (Forssk.) Vierh.	Tivar	Tree	LC
42	Avicenniaceae	*Avicennia officinalis* L.	Tivar	Tree	LC
43	Begoniaceae	*Begonia crenata* Dryand.	Amabadi	Herb	NA
44	Bignoniaceae	*Dolichandrone falcata* (Wall. ex DC.) Seem.	Medh–Shingi, Medsing	Tree	NA
45	Bignoniaceae	*Heterophragma quadriloculare* (Roxb.) K.Schum.	Varas	Tree	NA
46	Bombacaceae	*Bombax ceiba* L.	Katesavar	Tree	NA
47	Boraginaceae	*Heliotropium indicum* L.	Bhurundi	Herb	NA
48	Boraginaceae	*Cordia* sp	--	Tree	NA
49	Caesalpiniaceae	*Cassia kleinii* Wight & Arn.	--	Herb	NA
50	Caesalpiniaceae	*Cassia mimosoides* L.	--	Herb	NA
51	Caesalpiniaceae	*Cassia tora* L.	Takla	Herb	NA
52	Caesalpiniaceae	*Bauhinia racemosa* Lam.	Apta	Tree	NA
53	Caesalpiniaceae	*Cassia fistula* L.	Bahava	Tree	NA
54	Caesalpiniaceae	*Tamarindus indica* L.	Chinch	Tree	NA
55	Campanulaceae	*Wahlenbergia marginata* (Thunb.) A.DC.	--	Herb	NA
56	Celasteraceae	*Arnicratea grahamii* (Wight) N.Hallé	Daushir	Shrub	NA
57	Cleomaceae	*Cleome burmanni* Wight & Arn.	--	Herb	NA

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
58	Cleomaceae	*Cleome speciosa* Raf.	--	Herb	NA
59	Cleomaceae	*Cleome viscosa* L.	Pivli–Tilwan	Herb	NA
60	Clusiaceae	*Garcinia indica* (Thouars) Choisy	Kokam, Ratamba	Tree	V
61	Cochlospermaceae	*Cochlospermum religiosum* (L.) Alston	Ganeri	Tree	NA
62	Colchicaceae	*Iphigenia indica* (L.) A.Gray ex Kunth	--	Herb	NA
63	Combretaceae	*Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guillem. & Perr.	Dhavda	Tree	NA
64	Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Baheda	Tree	NA
65	Combretaceae	*Terminalia chebula* Retz.	Harda	Tree	NA
66	Combretaceae	*Terminalia cuneata* Roth	Arjun sadada	Tree	NA
67	Combretaceae	*Terminalia elliptica* Willd.	Ain	Tree	NA
68	Combretaceae	*Terminalia paniculata* Roth	Kinjal	Tree	NA
69	Combretaceae	*Terminalia* sp	--	Tree	NA
70	Commelinaceae	*Commelina* sp.	--	Herb	NA
71	Commelinaceae	*Cyanotis cristata* (L.) D.Don	Nabhali	Herb	LC
72	Commelinaceae	*Cyanotis fasciculata* (B.Heyne ex Roth) Schult. & Schult.f.	Nilwanti	Herb	LC
73	Commelinaceae	*Cyanotis* sp.	--	Herb	NA
74	Costaceae	*Cheilocostus speciosus* (J.Koenig) C.D.Specht	Pev	Herb	NA
75	Cypraceae	*Fimbristylis lawiana* (Boeckeler) J.Kern	--	Herb	LC
76	Dilleniaceae	*Dillenia pentagyna* Roxb.	Karmal, Karmvel	Tree	NA
77	Ebenaceae	*Diospyros melanoxylon* Roxb.	Temru	Tree	NA
78	Ebenaceae	*Diospyros* sp	--	Tree	NA
79	Eriocaulaceae	*Eriocaulon*sp.	--	Herb	NA
80	Euphorbiaceae	*Acalypha fruticosa* Forssk.	--	Herb	NA
81	Euphorbiaceae	*Acalypha malabarica* Müll.Arg.	--	Herb	NA
82	Euphorbiaceae	*Euphorbia hirta* L.	--	Herb	NA
83	Euphorbiaceae	*Phyllanthus* sp.	--	Herb	NA
84	Euphorbiaceae	*Antidesma ghaesembilla* Gaertn.	Bujada, Jondhra	Tree	NA
85	Euphorbiaceae	*Bridelia retusa* (L.) A.Juss.	Asana	Tree	NA
86	Euphorbiaceae	*Dimorphocalyx lawianus* Hook.f.	--	Tree	NA
87	Euphorbiaceae	Euphorbiaceae sp 1	--	Tree	NA
88	Euphorbiaceae	Euphorbiaceae sp 2	--	Tree	NA
89	Euphorbiaceae	Euphorbiaceae sp 3	--	Tree	NA
90	Euphorbiaceae	Euphorbiaceae sp 4	--	Tree	NA
91	Euphorbiaceae	*Glochidion ellipticum* Wight	Bhoma,	Tree	NA

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
			Kalbaya		
92	Euphorbiaceae	*Macaranga peltata* (Roxb.) Müll.Arg.	Chanda	Tree	NA
93	Euphorbiaceae	*Mallotus philippensis* (Lam.) Müll.Arg.	Kumkum	Tree	NA
94	Fabaceae	*Alysicarpus* sp.	--	Herb	NA
95	Fabaceae	*Crotalaria filipes* Benth.	Phatphati	Herb	NA
96	Fabaceae	*Crotalaria juncea* L.	Tagada	Herb	NA
97	Fabaceae	*Desmodium* sp.	--	Herb	NA
98	Fabaceae	*Desmodium triangulare* (Retz.) Merr.	Lapoti	Shrub	NA
99	Fabaceae	*Desmodium umbellatum* (L.) DC.	--	Shrub	NA
100	Fabaceae	*Indigofera cordifolia* Roth	Bechka	Herb	NA
101	Fabaceae	*Indigofera linifolia* (L.f.) Retz.	Pandarphali	Herb	NA
102	Fabaceae	*Indigofera* sp.	--	Herb	NA
103	Fabaceae	*Smithia* sp.	--	Herb	NA
104	Fabaceae	*Butea monosperma* (Lam.) Taub.	Palas	Tree	NA
105	Fabaceae	*Dalbergia latifolia* Roxb.	Shisham	Tree	V
106	Fabaceae	*Dalbergia sissoo* DC.	Shisham, Sisvi	Tree	NA
107	Fabaceae	*Erythrina* sp	--	Tree	NA
108	Fabaceae	*Erythrina stricta* Roxb.	Pangara	Tree	NA
109	Fabaceae	*Gliricidia sepium* (Jacq.) Walp.	Giripushpa	Tree	NA
110	Fabaceae	*Pongamia pinnata* (L.) Pierre	Karanj	Tree	LC
111	Fabaceae	*Pterocarpus marsupium* Roxb.	Bivla	Tree	V
112	Flacourtiaceae	*Casearia championii* Thwaites	Khul khulta, Kirmira	Tree	NA
113	Flacourtiaceae	*Casearia graveolens* Dalzell	Bokhada, Kirmira	Tree	NA
114	Flacourtiaceae	*Flacourtia* sp	--	Tree	NA
115	Gentianaceae	*Canscora diffusa* (Vahl) R.Br. ex Roem. & Schult.	--	Herb	NA
116	Hypoxidaceae	*Curculigo orchioides* Gaertn.	Kali musli	Herb	NA
117	Lamiaceae	*Orthosiphon rubicundus* (D.Don) Benth.	--	Herb	NA
118	Lauraceae	*Beilschmiedia dalzellii* (Meisn.) Kosterm.	Umber	Tree	NA
119	Lauraceae	*Litsea* sp	--	Tree	NA
120	Lauraceae	*Litsea wightiana* (Nees) Hook. f.	--	Tree	NA
121	Lecythidaceae	*Careya arborea* Roxb.	Kumbhi	Tree	NA
122	Leeaceae	*Leea indica* (Burm. f.) Merr.	Dinda	Shrub	NA
123	Liliaceae	*Ledebouria revoluta* (L.f.) Jessop	--	Herb	NA
124	Linderniaceae	*Bonnaya oppositifolia* Spreng.	--	Herb	NA
125	Lythraceae	*Ammannia baccifera* L.	--	Herb	NA

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
126	Lythraceae	*Lagerstroemia parviflora* Roxb.	Bondara	Tree	NA
127	Lythraceae	*Woodfordia fruticosa* (L.) Kurz	Dhayti	shrub	LC
128	Malvaceae	*Sida acuta* Burm.f.	Bala	Herb	NA
129	Malvaceae	*Sida rhombifolia* L.	--	Herb	NA
130	Malvaceae	*Urena lobata* L.	--	Herb	NA
131	Malvaceae	*Kydia calycina* Roxb.	Bhoti	Tree	NA
132	Malvaceae	*Thespesia populnea* (L.) Sol. ex Corrêa	Bhend	Tree	NA
133	Melastomataceae	*Memecylon umbellatum* Burm. f.	Anjani	Tree	NA
134	Meliaceae	*Aglaia lawii* (Wight) C.J.Saldanha	Burumb, Kat	Tree	LC
135	Meliaceae	*Aglaia* sp	--	Tree	NA
136	Meliaceae	*Aphanamixis* sp	--	Tree	NA
137	Meliaceae	*Azadirachta indica* A.Juss.	Kaduneem	Tree	NA
138	Meliaceae	*Dysoxylum binectariferum* (Roxb.) Hook.f. ex Bedd.	Kauti, Yerindi	Tree	NA
139	Meliaceae	Meliaceae sp 1	--	Tree	NA
140	Meliaceae	*Toona hexandra* M.Roem.	Kudak, Mahanim	Tree	NA
141	Mimosaceae	*Acacia auriculiformis* Benth.	Australian babhul	Tree	LC
142	Mimosaceae	*Acacia catechu* (L.f.) Willd.	Khair	Tree	NA
143	Mimosaceae	*Acacia chundra* (Rottler) Willd.	Khair, Lal–khair	Tree	NA
144	Mimosaceae	*Albizia saman* (Jacq.) Merr.	--	Tree	NA
145	Mimosaceae	*Pithecellobium dulce* (Roxb.) Benth.	Vilayati chinch	Tree	NA
146	Moraceae	*Ficus benghalensis* L.	Vad	Tree	NA
147	Moraceae	*Ficus hispida* L.f.	Bhui–-umbar, Kala-umber	Tree	NA
148	Moraceae	*Ficus racemosa* L.	Umber	Tree	NA
149	Moraceae	*Ficus rumphii* Blume	Ashta, Pair	Tree	NA
150	Moraceae	Ficus sp 1	--	Tree	NA
151	Moraceae	Ficus sp 2	--	Tree	NA
152	Moraceae	Ficus sp 3	--	Tree	NA
153	Myristicaceae	*Knema attenuata* Warb.	Ran–Jayphal	Tree	LC
154	Myrtaceae	*Syzygium cumini* (L.) Skeels	Jambhul	Tree	NA
155	Myrtaceae	*Syzygium laetum* (Buch.-Ham.) Gandhi	--	Tree	NA
156	Myrtaceae	*Syzygium* sp	--	Tree	NA
157	Myrtaceae	*Syzygium* sp 2	--	Tree	NA
158	Nyctaginaceae	*Boerhavia diffusa* L.	Punarnava	Herb	NA
159	Oleaceae	*Olea dioica* Roxb.	Karamb, Parjambul	Tree	NA

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
160	Orchidaceae	*Aerides maculosa* Lindl.	--	Herb	NA
161	Orchidaceae	*Habenaria commelinifolia* (Roxb.) Wall. ex Lindl.	Komal-amri	Herb	NA
162	Orchidaceae	*Habenaria digitata* Lindl.	Hirvi Habe-amri	Herb	NA
163	Orchidaceae	*Habenaria foliosa* A.Rich.	--	Herb	NA
164	Orchidaceae	*Habenaria longicorniculata* J.Graham	Sheput habe-amri	Herb	NA
165	Orchidaceae	*Habenaria marginata* Colebr.	Pivali habe amri	Herb	NA
166	Orchidaceae	*Habenaria ovalifolia* Wight	Uncha habe-amr	Herb	NA
167	Orchidaceae	*Malaxis versicolor* (Lindl.) Abeyw.	--	Herb	NA
168	Orchidaceae	*Nervilia plicata* (Andrews) Schltr.	--	Herb	NA
169	Orchidaceae	*Peristylus lawii* Wight	--	Herb	NA
170	Orchidaceae	*Peristylus plantagineus* (Lindl.) Lindl.	--	Herb	NA
171	Orchidaceae	*Peristylus* sp.	--	Herb	NA
172	Orobanchaceae	*Aeginetia indica* L.	--	Herb	NA
173	Orobanchaceae	*Sopubia delphinifolia* G.Don	Dudhali	Herb	NA
174	Oxaliodaceae	*Oxalis corniculata* L.	Ambuti	Herb	NA
175	Papaveraceae	*Argemone mexicana* L.	Pivla dhotra	Herb	NA
176	Pedaliaceae	*Sesamum orientale* L.	Til	Herb	NA
177	Phyllanthaceae	*Breynia retusa* (Dennst.) Alston	Dolfodi	Shrub	NA
178	Piperaceae	*Peperomia pellucida* (L.) Kunth	--	Herb	NA
179	Poaceae	*Apluda mutica* L.	--	Herb	NA
180	Poaceae	*Arundinella metzii* Hochst. ex Miq.	--	Herb	NA
181	Poaceae	*Brachiaria*sp.	--	Herb	NA
182	Poaceae	*Chloris*sp.	--	Herb	NA
183	Poaceae	*Cynodon dactylon* (L.) Pers.	Durva	Herb	NA
184	Poaceae	*Eleusine indica* (L.) Gaertn.	--	Herb	NA
185	Poaceae	*Eragrostis unioloides* (Retz.) Nees ex Steud.	--	Herb	NA
186	Poaceae	*Ischaemum indicum* (Houtt.) Merr.	--	Herb	NA
187	Poaceae	*Oplismenus burmanni* (Retz.) P.Beauv.	--	Herb	NA
188	Poaceae	*Sorghum halepense* (L.) Pers.	--	Herb	NA
189	Portulacaceae	*Portulaca oleracea* L.	Ghol	Herb	NA
190	Rhamnaceae	*Ziziphus mauritiana* Lam.	Bor	Tree	NA
191	Rhamnaceae	*Ziziphus xylopyrus* (Retz.) Willd.	Ghat bor	shrub	NA
192	Rhizophoraceae	*Bruguiera gymnorhiza* (L.) Lam.	--	Tree	LC
193	Rhizophoraceae	*Carallia brachiata* (Lour.) Merr.	Phanshi	Tree	NA
194	Rhizophoraceae	*Rhizophora* sp	--	Tree	NA

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
195	Rubiaceae	*Eclipta prostrata* (L.) L.	Maka	Herb	NA
196	Rubiaceae	*Oldenlandia corymbosa* L.	Pitpapda	Herb	NA
197	Rubiaceae	*Canthium dicoccum* var. *umbellatum* (Wight) Sant. & Merch.	Arsul, Tupa	Tree	NA
198	Rubiaceae	*Catunaregam spinosa* (Thunb.) Tirveng.	Ghela, Gel	Tree	NA
199	Rubiaceae	*Haldina cordifolia* (Roxb.) Ridsdale	Haldu	Tree	NA
200	Rubiaceae	*Ixora brachiata* Roxb.	--	Tree	NA
201	Rubiaceae	*Ixora* sp	--	Tree	NA
202	Rubiaceae	*Meyna laxiflora* Robyns	Alu	Tree	NA
203	Rubiaceae	*Mitragyna parvifolia* (Roxb.) Korth.	Kalam	Tree	NA
204	Rubiaceae	*Morinda pubescens* Sm.	Bartondi	Tree	NA
205	Rubiaceae	Rubiaceae sp 1 (spines)	--	Tree	NA
206	Rutaceae	*Atalantia racemosa* Wight ex Hook.	Makad limbu	Tree	NA
207	Rutaceae	*Atlantia* sp	--	Tree	NA
208	Rutaceae	Rutaceae sp (with spines)	--	Tree	NA
209	Rutaceae	Rutaceae sp 1	--	Tree	NA
210	Sapindaceae	*Schleichera oleosa* (Lour.) Merr.	Kusum	Tree	NA
211	Sapotaceae	*Madhuca longifolia* var. *latifolia* (Roxb.) A.Chev.	Moha	Tree	NA
212	Sapotaceae	*Xantolis tomentosa* (Roxb.) Raf.	‘Kunvala	Tree	NA
213	Solanaceae	*Physalis minima* L.	Chirboti	Herb	NA
214	Solanaceae	*Scoparia dulcis* L.	--	Herb	NA
215	Solanaceae	*Solanum indicum* L.	Ran vangi	Shrub	NA
216	Solanaceae	*Solanum torvum* Sw.	--	Shrub	NA
217	Sonneratiaceae	*Sonneratia alba* Sm.	--	Tree	LC
218	Sterculiaceae	*Melochia corchorifolia* L.	--	Herb	NA
219	Sterculiaceae	*Eriolaena quinquelocularis* (Wight & Arn.) Wight	Badjar–dhaman, Bothi	Tree	NA
220	Sterculiaceae	*Helicteres isora* L.	Murud sheng	Shrub	NA
221	Sterculiaceae	*Sterculia guttata* Roxb. ex G.Don	Golder, Kukar	Tree	NA
222	Tiliaceae	*Corchorus olitorius* L.	Chichuria	Herb	NA
223	Tiliaceae	*Triumfetta pentandra* A.Rich.	Nichardi	Herb	NA
224	Tiliaceae	*Grewia* sp 2	--	Tree	NA
225	Tiliaceae	*Grewia tiliifolia* Vahl	--	Tree	NA
226	Ulmaceae	*Holoptelea integrifolia* Planch.	Vavla, Papada	Tree	NA
227	Ulmaceae	*Trema orientalis* (L.) Blume	Ghol	Tree	NA
228	Urticaceae	*Boehmeria caudata* Sw.	--	Herb	NA
229	Urticaceae	*Laportea interrupta* (L.) Chew	Aagya	Herb	NA

Sr. no.	Family	Botanical name	Common name	Habit	IUCN status
230	Verbenaceae	*Callicarpa tomentosa* (L.) L.	Aisar	Tree	NA
231	Verbenaceae	*Gmelina arborea* Roxb.	Shivam	Tree	NA
232	Verbenaceae	*Tectona grandis* L.f.	Sag	Tree	NA
233	Verbenaceae	*Vitex negundo* L.	Nirgudi	shrub	NA
234	Zingiberaceae	*Curcuma pseudomontana* J.Graham	Ran halad	Herb	V
235	Zingiberaceae	*Zingiber nimmonii* (J.Graham) Dalzell	--	Herb	NA
236		Unidentified sp 1	--	Tree	NA
237		Unidentified sp 2	--	Tree	NA
238		Unidentified sp 3	--	Tree	NA
239		Unidentified sp 4	--	Tree	NA
240		Unidentified sp 5	--	Tree	NA
241		Unidentified sp 6	--	Tree	NA

Abbreviations: LC: Least Concern; CR: Critically Endangered; V: Vulnerable; NA: Not Assessed; DD: Data Deficient

VIII. Sampling sites for freshwater fishes studied across different river basins.

Name of the Watershed/ River	**Sampling sites**	**Area/ nearby location**	**Geographical position – Altitude (m ASL)**	**Habitat**	**Anthropogenic activities observed**
Patalganga River	P1	Charlotte lake and streams near Pisarnath Mahadev Temple, Matheran	18.979099°N & 73.264290°E	Small reservoir, ephemeral and intermittent stream	Plastic waste litter mostly dumped by tourists
	P2	Umbarne Wadi	18.969479°N & 73.244552°E	Intermittent streams and perennial main river channel, run, cascade, pools	Destructive fishing method by local communities by using detergent, boric acid powder and natural plant toxins Plastic waste litter carried downstream by upstream headwaters of Matheran
	P3	Morbe Dam	18.914282°N & 73.242618°E	Man made reservoir	Introduced alien fish species for aquaculture, dam wall acts as a barrier for seasonal fish migration in breeding period especially at the time of onset of monsoon
	P4	Waveghar-Ambivalli, Rasayani	18.888234°N & 73.168634°E	Perennial main river channel	Discharge of potentially toxic industrial waste

Gadhi River	G1	Dodhani Waterfall	19.004021°N&73.266657°E	Ephemeral streams, waterfall	Plastic waste litter carried downstream by upstream headwaters of Matheran
	G2	Dodhani Village – Adiwasi Wadi	19.018489°N &73.259549°E	Ephemeral main river channel, cascades, deep pools	High scale local sand mining, sewage from nearby villages
	G3	Gadheshwar/ Dehrang Dam	19.034647°N &73.242564°E	Man made reservoir	Introduced alien fish species for aquaculture, sewage waste release in dam water, pesticides runoff from cultivations made across the backwater slope, dam wall acts as a barrier for seasonal fish migration in breeding period especially at the time of onset of monsoon
	G4	Umroli-Dehrang Road	19.024871°N &73.197933°E	Intermittent main river channel, riffles, small waterlogged pools	Sand mining, sewage release, plastic waste
Ransai stream - Chirner	R1	Ransai upstream area - Chirner	18.900281°N &73.092924°E	Small ephemeral stream	Sewage waste release
	R2	Ransai Dam and	18.897728°N &73.071592°E	Man made reservoir	Introduced invasive fish species for aquaculture, sewage waste release in dam

					water, pesticides runoff from cultivations made across the backwater slope, dam wall acts as a barrier for seasonal fish migration in breeding period especially at the time of onset of monsoon

IX. Checklist of freshwater fish species and their spatial distribution across study area

Species	Remarks*	Selected watershed area/ River								Ransai stream		IUCN Status
		Patalganga				Gadhi						
		P1	P2	P3	P4	G1	G2	G3	G4	R1	R2	
Order Cypriniformes												
Family Cobitidae												
Lepidocephalichthys thermalis (Valenciennes, 1846)		+	+	-	-	-	+	-	+	+	-	LC
Family Cyprinidae												
Devario aequipinnatus (McClelland, 1839)		-	+	+	-	+	+	+	+	-	-	LC
Garra mullya (Sykes, 1839)		-	+	+	-	+	+	-	+	-	-	LC
Parapsilorhynchus tentaculatus (Annandale, 1919)		+	+	-	-	+	-	-	-	-	-	LC
Pethia lutea Katwate, Katwate, Raghavan, Paingankar & Dahanukar, 2014	e	-	-	-	-	-	-	-	+	-	-	EN [B2ab(iii)]
Puntius mahecola (Valenciennes, 1844)	e	-	-	-	-	-	-	+	+	-	-	DD
Puntius sophore (Hamilton, 1822)		-	-	+	-	-	-	+	-	-	-	LC
Rasbora daniconius (Hamilton, 1822)		-	+	+	-	+	+	+	+	+	-	LC
Salmophasia boopis (Day, 1874)	e	-	-	-	-	-	-	+	+	-	-	LC
Systomus sarana subnasutus (Valenciennes, 1842)	e	-	-	+	-	-	-	+	+	-	+	NE
Family Nemacheilidae												
Indoreonectes evezardi (Day, 1872)	e	+	-	-	-	+	-	-	-	-	-	LC

Schistura denisoni (Day, 1867)		+	+	-	-	+	+	-	+	+	-	LC
Order Cyprinodontiformes												
Family Aplocheilidae												
Aplocheilus lineatus (Valenciennes, 1846)		-	-	-	-	-	-	+	+	-	+	LC
Order Perciformes												
Family Channidae												
Channa punctata (Bloch, 1793)		-	-	+	+	-	-	+	-	-	-	LC
Channa striata (Bloch, 1793)		-	-	-	+	-	-	+	+	-	+	LC
Channa cf. gachua (Hamilton, 1822)		+	-	-	-	-	-	-	+	-	-	LC
Family Cichlidae												
Pseudetroplus maculatus (Bloch, 1795)	s	-	-	-	-	-	-	-	+	-	-	LC
Family Eleotridae												
Eleotris fusca (Forster, 1801)	s	-	-	-	+	-	-	-	+	-	-	LC
Family Gobiidae												
Awaous grammepomus (Bleeker, 1849)	s	-	-	-	+	-	-	+	-	-	+	LC
Glossogobius giuris (Hamilton, 1822)	s	-	-	-	+	-	-	-	+	-	-	LC
Order Siluriformes												
Family Bagridae												
Mystus gulio (Hamilton, 1822)		-	-	-	+	-	-	-	+	-	-	LC
Mystus malabaricus (Jerdon, 1849)	e	-	+	+	-	-	-	+	+	-	+	NT
Family Heteropneustidae												
Heteropneustes fossilis (Bloch, 1794)		-	-	-	-	-	-	+	+	-	-	LC
Family Siluridae												

Ompok bimaculatus (Bloch, 1794)		-	-	+	-	-	-	+	+	-	+	NT
Wallago attu (Bloch & Schneider, 1801)		-	-	+	-	-	-	+	-	-	+	NT
Order Synbranhiformes												
Family Mastacembelidae												
Mastacembelus armatus (Lacepède, 1800)		-	-	+	-	-	-	+	+	-	+	LC
Family Synbranchidae												
Monopterus indicus (Silas & Dawson, 1961)	e	+	-	-	-	-	-	-	-	-	-	VU [B2ab(iii)]

* s = can live in brackish and marine habitats as well, e = endemic to Western Ghats assessment region. IUCN Red list threat status, LC - Least Concern; DD - Data Deficient; NT - Near Threatened; VU - Vulnerable; EN – Endangered; NE - Not Evaluated. Fishing/sampling sites abbreviations are as per annexure VIII.

X. List of introduced or alien fish species recorded

Introduced/ Alien fish species	Patalganga River				Gadhi River				Ransai stream	
	P1	P2	P3	P4	G1	G2	G3	G4	R1	R2
Catla catla (Hamilton, 1822)	-	-	+	-	-	-	+	-	-	+
Cyprinus carpio Linnaeus, 1758	-	-	+	-	-	-	+	-	-	+
Labeo rohita (Hamilton, 1822)	-	-	+	-	-	-	+	-	-	+
Oreochromis mossambicus (Peters, 1852)	-	-	+	+	-	-	+	+	+	+
Oreochromis niloticus (Linnaeus, 1758)	-	-	-	-	-	-	+	-	-	+
Hypophthalmichthys molitrix (Valenciennes, 1844)	-	-	+	-	-	-	+	-	-	+
Clarias gariepinus (Burchell, 1822)	-	-	+	-	-	-	+	-	-	+
Gambusia affinis (Baird & Girard, 1853)	+	-	+	+	-	-	+	+	+	+
Piaractus brachypomus (Cuvier, 1818)	-	-	-	+	-	-	-	-	-	+

XI. Seasonal distribution of the fish species

Species	Seasonal distribution of fish species	
	Monsoon	**Post-monsoon**
Order Cypriniformes		
Family Cobitidae		
Lepidocephalichthys thermalis (Valenciennes, 1846)	P1, P2	P2, G2, G4, R1
Family Cyprinidae		
Devario aequipinnatus (McClelland, 1839)	P2, G1, G2, G3, G4	P2, P3, G3, G4
Garra mullya (Sykes, 1839)	P2, G1, G2	P2, P3, G4
Parapsilorhynchus tentaculatus (Annandale, 1919)	P1, P2, G1	P2, G1
Pethia lutea Katwate, Katwate, Raghavan, Paingankar & Dahanukar, 2014	-	G4
Puntius mahecola (Valenciennes, 1844)	-	G3, G4
Puntius sophore (Hamilton, 1822)	P3	P3, G3
Rasbora daniconius (Hamilton, 1822)	P3, G1, G2	P2, P3, G3, G4, R1
Salmophasia boopis (Day, 1874)	G3, G4	-
Systomus sarana subnasutus (Valenciennes, 1842)	G4	P3, G3, G4
Family Nemacheilidae		
Indoreonectes evezardi (Day, 1872)	-	P1, G1
Schistura denisoni (Day, 1867)	P1, P2, G1, G2	P2, G2, G4, R1
Order Cyprinodontiformes		
Family Aplocheilidae		
Aplocheilus lineatus (Valenciennes, 1846)	-	G3, G4, R2
Order Perciformes		
Family Channidae		
Channa punctata (Bloch, 1793)	-	P3, P4, G3
Channa striata (Bloch, 1793)	R2	P4, G3, G4
Channa cf. gachua (Hamilton, 1822)	P1, G4	-
Family Cichlidae		
Pseudetroplus maculatus (Bloch, 1795)	-	G4
Family Eleotridae		
Eleotris fusca (Forster, 1801)	-	P4, G4

Family Gobiidae		
Awaous grammepomus (Bleeker, 1849)	G3	P4, G3, R2
Glossogobius giuris (Hamilton, 1822)	G4	P4, G4
Order Siluriformes		
Family Bagridae		
Mystus gulio (Hamilton, 1822)	P4, G4	-
Mystus malabaricus (Jerdon, 1849)	P2	P2, P3, G3, G4, R2
Family Heteropneustidae		
Heteropneustes fossilis (Bloch, 1794)	-	G3, G4
Family Siluridae		
Ompok bimaculatus (Bloch, 1794)	P3, G3, G4	P3, R2
Wallago attu (Bloch & Schneider, 1801)	P3, G3	P3, G3, R2
Order Synbranchiformes		
Family Mastacembelidae		
Mastacembelus armatus (Lacepède, 1800)	P3, G3, G4, R2	P2, G3, G4, R2
Family Synbranchidae		
Monopterus indicus (Silas & Dawson, 1961)	P1	-

XII. Checklist of marine invertebrates

Sr. no.	Phylum	Class	Family	Valid Name	Location
1	Annelida	Polychaeta	Nereididae	*Perinereis cultrifera*	Karanja creek
2	Annelida	Polychaeta	Nereididae	*Perinereis vancaurica*	Karanja creek, Alibag
3	Annelida	Polychaeta	Nereididae	*Pseudonereis anomala*	Karanja creek
4	Arthropoda	Malacostraca	Grapsidae	*Grapsus albolineatus*	Uran
5	Arthropoda	Malacostraca	Menippidae	*Myomenippe hardwickii*	Uran
6	Arthropoda	Malacostraca	Paguridae	*Pagurus prideaux*	Uran
7	Arthropoda	Malacostraca	Palinuridae	*Panulirus polyphagus*	Uran
8	Arthropoda	Malacostraca	Penaeidae	*Metapenaeopsis stridulans*	Uran
9	Arthropoda	Malacostraca	Penaeidae	*Parapenaeopsis sculptilis*	Uran
10	Arthropoda	Malacostraca	Penaeidae	*Penaeus indicus*	Uran
11	Arthropoda	Malacostraca	Penaeidae	*Penaeus merguiensis*	Uran
12	Arthropoda	Malacostraca	Penaeidae	*Penaeus monodon*	Uran
13	Arthropoda	Malacostraca	Penaeidae	*Penaeus penicillatus*	Uran
14	Arthropoda	Malacostraca	Portunidae	*Charybdis (Charybdis) feriata*	Uran
15	Arthropoda	Malacostraca	Portunidae	*Charybdis (Charybdis) orientalis*	Uran
16	Arthropoda	Malacostraca	Portunidae	*Scylla tranquebarica*	Uran
17	Arthropoda	Malacostraca	Varunidae	*Pseudograpsus intermedius*	Uran
18	Arthropoda	Malacostraca	Varunidae	*Varuna litterata*	Uran
19	Arthropoda	Malacostraca	Xanthidae	*Leptodius exaratus*	Uran
20	Arthropoda	Malacostraca	Squillidae	*Squilla mantis*	Uran
21	Cnidaria	Anthozoa	Dendrophylliidae	*Turbinaria stellulata*	Borli coast, Uran
22	Echinodermata	Crinoidea	Antedonidae	*Antedon bifida*	Karanja creek
23	Echinodermata	Crinoidea	Antedonidae	*Antedon petasus*	Karanja creek
24	Echinodermata	Echinoidea	Echinidae	*Echinus esculentus*	Karanja creek
25	Mollusca	Bivalvia	Pharidae	*Siliqua radiata*	Raigad
26	Mollusca	Bivalvia	Solenidae	*Solen ceylonensis*	Raigad
27	Mollusca	Bivalvia	Arcidae	*Mesocibota bistrigata*	Raigad

Sr. no.	Phylum	Class	Family	Valid Name	Location
28	Mollusca	Bivalvia	Arcidae	*Tegillarca granosa*	Lada, Uran
29	Mollusca	Bivalvia	Mytilidae	*Brachidontes pharaonis*	Raigad
30	Mollusca	Bivalvia	Ostreidae	*Saccostrea cucullata*	Raigad
31	Mollusca	Bivalvia	Anomiidae	*Anomia achaeus*	Raigad
32	Mollusca	Bivalvia	Placunidae	*Placuna placenta*	Uran, Lada, Harihareshwar, Jivanbandar, borli coast, Karanja creek, Kudgaon
33	Mollusca	Bivalvia	Cardiidae	*Vasticardium flavum*	Uran; Harihareshwar, Lada, Jivanba ndar
34	Mollusca	Bivalvia	Veneridae	*Callista erycina*	Uran
35	Mollusca	Bivalvia	Veneridae	*Dosinia cretacea*	Uran
36	Mollusca	Bivalvia	Veneridae	*Gafrarium divaricatum*	Harihareshwar, Jivanbandar, Uran
37	Mollusca	Bivalvia	Veneridae	*Meretrix casta*	Uran
38	Mollusca	Bivalvia	Veneridae	*Meretrix lyrata*	Uran
39	Mollusca	Bivalvia	Veneridae	*Meretrix meretrix*	Lada, Uran
40	Mollusca	Bivalvia	Veneridae	*Paphia rotundata*	Raigad
41	Mollusca	Bivalvia	Veneridae	*Paratapes textilis*	Raigad
42	Mollusca	Bivalvia	Veneridae	*Pelecyora nana*	Uran
43	Mollusca	Bivalvia	Veneridae	*Protapes gallus*	Raigad
44	Mollusca	Bivalvia	Veneridae	*Sunetta effossa*	Raigad
45	Mollusca	Cephalopoda	Loliginidae	*Loligo vulgaris*	Uran
46	Mollusca	Cephalopoda	Amphitretidae	*Amphitretus pelagicus*	Uran
47	Mollusca	Cephalopoda	Octopodidae	*Octopus cyanea*	Uran
48	Mollusca	Cephalopoda	Sepiidae	*Sepia officinalis*	Uran
49	Mollusca	Gastropoda	Cerithiidae	*Cerithidium cerithinum*	Uran
50	Mollusca	Gastropoda	Cerithiidae	*Cerithium*	Raigad
51	Mollusca	Gastropoda	Cerithiidae	*Cerithium traillii*	Raigad
52	Mollusca	Gastropoda	Cerithiidae	*Clypeomorus bifasciata*	Raigad
53	Mollusca	Gastropoda	Cerithiidae	*Rhinoclavis*	Raigad
54	Mollusca	Gastropoda	Planaxidae	*Planaxis*	Raigad
55	Mollusca	Gastropoda	Planaxidae	*Planaxis sulcatus*	Borli coast, Karanja creek, Uran

Sr. no.	Phylum	Class	Family	Valid Name	Location
56	Mollusca	Gastropoda	Planaxidae	*Supplanaxis niger*	Raigad
57	Mollusca	Gastropoda	Potamididae	*Pirenella cingulata*	Karanja creek, Uran
58	Mollusca	Gastropoda	Potamididae	*Telescopium telescopium*	Uran
59	Mollusca	Gastropoda	Thiaridae	*Melanoides tuberculata*	Raigad
60	Mollusca	Gastropoda	Turritellidae	*Turritella attenuata*	Raigad
61	Mollusca	Gastropoda	Turritellidae	*Turritella bacillum*	Raigad
62	Mollusca	Gastropoda	Turritellidae	*Turritella columnaris*	Raigad
63	Mollusca	Gastropoda	Turritellidae	*Turritella duplicata*	Raigad
64	Mollusca	Gastropoda	Turritellidae	*Turritella terebra*	Raigad
65	Mollusca	Gastropoda	Ellobiidae	*Cassidula nucleus*	Raigad
66	Mollusca	Gastropoda	Neritidae	*Clithon oualaniense*	Raigad
67	Mollusca	Gastropoda	Neritidae	*Nerita albicilla*	Uran
68	Mollusca	Gastropoda	Neritidae	*Nerita chamaeleon*	Raigad
69	Mollusca	Gastropoda	Neritidae	*Nerita essingtoni*	Raigad
70	Mollusca	Gastropoda	Neritidae	*Nerita histrio*	Raigad
71	Mollusca	Gastropoda	Neritidae	*Nerita oryzarum*	Borli coast, Karanja creek, Uran
72	Mollusca	Gastropoda	Neritidae	*Nerita planospira*	Raigad
73	Mollusca	Gastropoda	Neritidae	*Nerita plicata*	Raigad
74	Mollusca	Gastropoda	Neritidae	*Neripteron violaceum*	Uran
75	Mollusca	Gastropoda	Bursidae	*Bufonaria echinata*	Uran
76	Mollusca	Gastropoda	Bursidae	*Tutufa (Tutufa) bubo*	Karanja creek, Uran
77	Mollusca	Gastropoda	Cypraeidae	*Erosaria lamarckii*	Uran
78	Mollusca	Gastropoda	Cypraeidae	*Mauritia arabica*	Raigad
79	Mollusca	Gastropoda	Ficidae	*Ficus gracilis*	Uran
80	Mollusca	Gastropoda	Littorinidae	*Echinolittorina malaccana*	Raigad
81	Mollusca	Gastropoda	Littorinidae	*Echinolittorina vidua*	Raigad
82	Mollusca	Gastropoda	Littorinidae	*Littoraria intermedia*	Raigad
83	Mollusca	Gastropoda	Littorinidae	*Littoraria scabra*	Raigad
84	Mollusca	Gastropoda	Naticidae	*Natica maculosa*	Karanja creek, Uran

Sr. no.	Phylum	Class	Family	Valid Name	Location
85	Mollusca	Gastropoda	Naticidae	*Natica picta*	Karanja creek, Uran
86	Mollusca	Gastropoda	Naticidae	*Natica vitellus*	Raigad
87	Mollusca	Gastropoda	Naticidae	*Neverita didyma*	Raigad
88	Mollusca	Gastropoda	Naticidae	*Tanea lineata*	Raigad
89	Mollusca	Gastropoda	Ranellidae	*Gyrineum natator*	Karanja creek, Uran
90	Mollusca	Gastropoda	Ranellidae	*Monoplex nicobaricus*	Raigad
91	Mollusca	Gastropoda	Rostellariidae	*Tibia curta*	Karanja creek, Uran
92	Mollusca	Gastropoda	Tonnidae	*Tonna tessellata*	Raigad
93	Mollusca	Gastropoda	Babyloniidae	*Babylonia spirata*	Uran
94	Mollusca	Gastropoda	Buccinidae	*Cantharus spiralis*	Uran
95	Mollusca	Gastropoda	Buccinidae	*Engina zea*	Raigad
96	Mollusca	Gastropoda	Cancellariidae	*Scalptia scalariformis*	Uran
97	Mollusca	Gastropoda	Clavatulidae	*Turricula javana*	Uran
98	Mollusca	Gastropoda	Columbellidae	*Anachis terpsichore*	Raigad
99	Mollusca	Gastropoda	Conidae	*Conus figulinus*	Raigad
100	Mollusca	Gastropoda	Conidae	*Conus hyaena*	Uran
101	Mollusca	Gastropoda	Costellariidae	*Vexillum ebenus*	Raigad
102	Mollusca	Gastropoda	Drilliidae	*Clavus aglaia*	Uran
103	Mollusca	Gastropoda	Muricidae	*Chicoreus brunneus*	Karanja creek, Uran
104	Mollusca	Gastropoda	Muricidae	*Chicoreus torrefactus*	Raigad
105	Mollusca	Gastropoda	Muricidae	*Indothais blanfordi*	Raigad
106	Mollusca	Gastropoda	Muricidae	*Indothais lacera*	Uran
107	Mollusca	Gastropoda	Muricidae	*Indothais sacellum*	Uran
108	Mollusca	Gastropoda	Muricidae	*Mancinella echinata*	Raigad
109	Mollusca	Gastropoda	Muricidae	*Morula nodicostata*	Raigad
110	Mollusca	Gastropoda	Muricidae	*Murex carbonnieri*	Raigad
111	Mollusca	Gastropoda	Muricidae	*Tribulus*	Uran
112	Mollusca	Gastropoda	Muricidae	*Neothais marginatra*	Raigad
113	Mollusca	Gastropoda	Muricidae	*Purpura bufo*	Raigad
114	Mollusca	Gastropoda	Muricidae	*Purpura persica*	Raigad
115	Mollusca	Gastropoda	Muricidae	*Semiricinula tissoti*	Raigad
116	Mollusca	Gastropoda	Muricidae	*Tenguella granulata*	Raigad
117	Mollusca	Gastropoda	Muricidae	*Thalessa virgata*	Raigad

Sr. no.	Phylum	Class	Family	Valid Name	Location
118	Mollusca	Gastropoda	Nassariidae	*Bullia melanoides*	Raigad
119	Mollusca	Gastropoda	Nassariidae	*Nassarius*	Raigad
120	Mollusca	Gastropoda	Nassariidae	*Nassarius dorsatus*	Raigad
121	Mollusca	Gastropoda	Nassariidae	*Nassarius exilis*	Raigad
122	Mollusca	Gastropoda	Nassariidae	*Nassarius gaudiosus*	Raigad
123	Mollusca	Gastropoda	Nassariidae	*Nassarius jacksonianus*	Raigad
124	Mollusca	Gastropoda	Nassariidae	*Nassarius nodifer*	Raigad
125	Mollusca	Gastropoda	Nassariidae	*Nassarius olivaceus*	Raigad
126	Mollusca	Gastropoda	Nassariidae	*Nassarius pullus*	Raigad
127	Mollusca	Gastropoda	Nassariidae	*Nassarius reeveanus*	Raigad
128	Mollusca	Gastropoda	Nassariidae	*Nassarius splendidulus*	Raigad
129	Mollusca	Gastropoda	Nassariidae	*Nassarius stolatus*	Raigad
130	Mollusca	Gastropoda	Nassariidae	*Nassarius sufflatus*	Raigad
131	Mollusca	Gastropoda	Nassariidae	*Nassarius vittatus*	Raigad
132	Mollusca	Gastropoda	Olividae	*Agaronia gibbosa*	Raigad
133	Mollusca	Gastropoda	Olividae	*Oliva oliva*	Raigad
134	Mollusca	Gastropoda	Turridae	*Turris amicta*	Uran
135	Mollusca	Gastropoda	Onchidiidae	*Onchidium daemellii*	Uran
136	Mollusca	Gastropoda	Onchidiidae	*Onchidium tenerum*	Raigad
137	Mollusca	Gastropoda	Onchidiidae	*Onchidium tigrinum*	Raigad
138	Mollusca	Gastropoda	Onchidiidae	*Peronia peronii*	Uran
139	Mollusca	Gastropoda	Onchidiidae	*Peronia verruculata*	Uran
140	Mollusca	Gastropoda	Onchidiidae	*Platevindex* sp.	Uran
141	Mollusca	Gastropoda	Chilodontidae	*Euchelus asper*	Karanja creek, Uran
142	Mollusca	Gastropoda	Chilodontidae	*Euchelus atratus*	Raigad
143	Mollusca	Gastropoda	Fissurellidae	*Emarginula obovata*	Raigad
144	Mollusca	Gastropoda	Nacellidae	*Cellana radiata*	Raigad
145	Mollusca	Gastropoda	Siphonariidae	*Siphonaria laciniosa*	Uran
146	Mollusca	Gastropoda	Tegulidae	*Tectus tentorium*	Uran
147	Mollusca	Gastropoda	Trochidae	*Clanculus ceylonicus*	Karanja creek, Uran
148	Mollusca	Gastropoda	Trochidae	*Trochus radiatus*	Karanja creek, Uran

Sr. no.	Phylum	Class	Family	Valid Name	Location
149	Mollusca	Gastropoda	Trochidae	*Umbonium vestiarium*	Raigad
150	Mollusca	Gastropoda	Turbinidae	*Turbo bruneus*	Raigad
151	Mollusca	Gastropoda	Ranellidae	*Gyranium natator*	Karanja creek, Uran
152	Mollusca	Gastropoda	Muricidae	*Drupa konkanensis*	Raigad
153	Mollusca	Gastropoda	Trochidae	*Euchelus tricarinatus*	Raigad
154	Mollusca	Gastropoda	Trochidae	*Trochus stellatus*	Karanja creek, Uran
155	Mollusca	Scaphopoda	Dentaliidae	*Dentalium elph*	Raigad
156	Porifera	Calcarea	Leucosoleniidae	*Leucosolenia complicata*	Karanja
157	Tracheophyta		Euphorbiaceae	*Excoecaria agallocha*	Kamothe
158	Tracheophyta		Combretaceae	*Lumnitzera racemosa*	Kamothe
159	Mollusca	Gastropoda	Turbinidae	*Astralium semicostatum*	Raigad
160	Mollusca	Bivalvia	Veneridae	*Marcia opima*	Raigad
161	Mollusca	Gastropoda	Cerithiidae	*Cerithium gennesi*	Raigad
162	Mollusca	Bivalvia	Pectinidae	*Chlamys singaporina*	Uran
163	Mollusca	Bivalvia	Pectinidae	*Chlamys tranquebaricus*	Raigad
164	Mollusca	Gastropoda	Neritidae	*Clithon meticularis*	Raigad
165	Mollusca	Gastropoda	Neritidae	*Clithon smithi*	Raigad
166	Mollusca	Gastropoda	Cerithiidae	*Clypeomorous betilliraeformis*	Raigad
167	Mollusca	Gastropoda	Cerithiidae	*Clypeomorous bitasciata*	Raigad
168	Mollusca	Gastropoda	Cerithiidae	*Clypeomorous spp*	Raigad
169	Mollusca	Gastropoda	Trochidae	*Calliostoma helicus*	Raigad
170	Mollusca	Gastropoda	Muricidae	*Cornia contract*	Raigad
171	Mollusca	Gastropoda	Muricidae	*Cornia konkanensis*	Raigad
172	Mollusca	Bivalvia	Ostreidae	*Crassostrea cuttackensis*	Raigad
173	Mollusca	Bivalvia	Veneridae	*Dosinia cretacea*	Uran
174	Mollusca	Gastropoda	Neritidae	*Dostia violacea*	Raigad
175	Mollusca	Bivalvia	Pharidae	*Ensiculus cultellus*	Raigad
176	Mollusca	Gastropoda	Ranellidae	*Gyranium natator*	Raigad
177	Mollusca	Gastropoda	Melongenidae	*Hemifusus cochlidium*	Uran

Sr. no.	Phylum	Class	Family	Valid Name	Location
178	Mollusca	Gastropoda	Melongenidae	*Hemifuus pugilinus*	Uran
179	Mollusca	Bivalvia	Psammobiidae	*Hiatula diphos*	Raigad
180	Mollusca	Bivalvia	Veneridae	*Marcia opima*	Uran
181	Mollusca	Gastropoda	Littorinidae	*Littoria melanostoma*	Raigad
182	Mollusca	Gastropoda	Littorinidae	*Littoria undulata*	Raigad
183	Mollusca	Bivalvia	Mactridae	*Mactra antiquata*	Uran
184	Mollusca	Bivalvia	Pholadidae	*Martesia fragilis*	Raigad
185	Mollusca	Bivalvia	Mytilidae	*Modiolus siriatulus*	Raigad
186	Mollusca	Bivalvia	Mytilidae	*Modiolus undulatus*	Raigad
187	Mollusca	Gastropoda	Trochidae	*Monilea warnefordi*	Raigad
188	Mollusca	Gastropoda	Nassariidae	*Nassaria suturalis*	Raigad
189	Mollusca	Gastropoda	Nassariidae	*Nassarius pullus*	Raigad
190	Mollusca	Bivalvia	Trapezidae	*Neotrapezium sublaevigatum*	Raigad
191	Mollusca	Gastropoda	Muricidae	*Ocinebra bombayana*	Uran
192	Annelida	Polychaeta	Spionidae	*Paraprionospio cristata*	Alibag
193	Mollusca	Bivalvia	Corbiculidae	*Polymesoda maxima*	Raigad
194	Mollusca	Bivalvia	Corbulidae	*Potamocorbula abbreviata*	Raigad
195	Mollusca	Bivalvia	Solenidae	*Solen vagina*	Raigad
196	Mollusca	Bivalvia	Veneridae	*Sunetta scripta*	Raigad
197	Mollusca	Bivalvia	Semelidae	*Theora opalina*	Raigad
198	Mollusca	Bivalvia	Corbiculidae	*Villorita cyprinoides*	Uran
199	Mollusca	Gastropoda	[unassigned] Pyramidelloidea	*Microthyca crenellifera*	Raigad
200	Cnidaria	Anthozoa	Rhizangiidae	*Turbinaria stellulata*	Raigad
201	Mollusca	Gastropoda	Neritidae	*Neripteron violaceum*	Raigad
202	Mollusca	Gastropoda	Fissurellidae	*Scutus unguis*	Raigad
203	Mollusca	Gastropoda	Fissurellidae	*Diodora lima*	Raigad
204	Mollusca	Gastropoda	Cypraeidae	*Mauritia eglantina*	Raigad
205	Mollusca	Gastropoda	Cypraeidae	*Mauritia histrio*	Raigad
206	Mollusca	Gastropoda	Ovulidae	*Phenacovolva rosea*	Raigad
207	Mollusca	Gastropoda	Ficidae	*Ficus variegata*	Raigad
208	Mollusca	Gastropoda	Ranellidae	*Monoplex pilearis*	Raigad
209	Mollusca	Gastropoda	Ranellidae	*Monoplex aquatilis*	Raigad

Sr. no.	Phylum	Class	Family	Valid Name	Location
210	Mollusca	Gastropoda	Ranellidae	*Linatella caudata*	Raigad
211	Mollusca	Gastropoda	Naticidae	*Notocochlis tigrina*	Raigad
212	Mollusca	Gastropoda	Naticidae	*Polinices mammilla*	Raigad
213	Mollusca	Gastropoda	Planaxidae	*Supplanaxis acutus*	Raigad
214	Mollusca	Gastropoda	Cerithiidae	*Cerithium echinatum*	Raigad
215	Mollusca	Gastropoda	Cerithiidae	*Clypeomorus bifasciata*	Raigad
216	Mollusca	Gastropoda	Costellariidae	*Vexillum obeliscus*	Raigad
217	Mollusca	Gastropoda	Mitridae	*Mitra scutulata*	Raigad
218	Mollusca	Gastropoda	Mitridae	*Mitra ambigua*	Raigad
219	Mollusca	Gastropoda	Muricidae	*Chicoreus maurus*	Raigad
220	Mollusca	Gastropoda	Conidae	*Conus biliosus*	Raigad
221	Mollusca	Gastropoda	Clavatulidae	*Turricula tornata fulminata*	Raigad
222	Mollusca	Gastropoda	Drilliidae	*Clavus aglaia*	Raigad
223	Mollusca	Gastropoda	Buccinidae	*Engina zea*	Raigad
224	Mollusca	Gastropoda	Olividae	*Oliva nebulosa*	Raigad
225	Mollusca	Gastropoda	Nassariidae	*Cyllene fuscata*	Raigad
226	Mollusca	Gastropoda	Nassariidae	*Bullia mauritiana*	Raigad
227	Mollusca	Gastropoda	Columbellidae	*Zafra atrata*	Raigad
228	Mollusca	Gastropoda	Melongenidae	*Volegalea cochlidium*	Raigad
229	Mollusca	Gastropoda	Haliotidae	*Haliotis varia*	Raigad
230	Mollusca	Gastropoda	Ellobiidae	*Ellobium aurisjudae*	Raigad
231	Mollusca	Gastropoda	Ellobiidae	*Melampus sincaporensis*	Raigad
232	Mollusca	Gastropoda	Bullidae	*Bulla ampulla*	Raigad
233	Mollusca	Bivalvia	Pectinidae	*Amusium pleuronectes*	Raigad
234	Mollusca	Bivalvia	Carditidae	*Cardites antiquatus*	Raigad
235	Mollusca	Bivalvia	Cardiidae	*Vasticardium flavum*	Raigad
236	Mollusca	Bivalvia	Veneridae	*Sunetta donacina*	Raigad
237	Mollusca	Bivalvia	Veneridae	*Dosinia prostrata*	Raigad
238	Mollusca	Bivalvia	Veneridae	*Dosinia cretacea*	Raigad

6. APPENDICES

Mean, standard deviation, and 95% credible intervals for species-specific probabilities of occupancy, detection and the values of the habitat covariates (elevation, forest cover and anthropogenic habitation cover on the logit scale), as estimated using the hierarchical community models. Also included are the number of sites species present, naïve occupancy and number of detections.

I. MAMMALS

							Occupancy			Detection			Slope parameter Elevation (α1)				Slope parameter Forest (α2)				Slope parameter Anthropogenic habitat cover (α3)			
Sr. No.	Abbr	Scientific Name	Common Name	Pre	Naïve occupancy	Det	Mean	95% CI		Mean	95% CI		Mean	95% CI			Mean	95% CI			Mean	95% CI		
1	B_Dr	*Muntiacus muntjak*	Barking Deer	11	0.44	50	0.46	0.13	0.86	0.276	0.213	0.344	-0.624	-2.789	1.588	*	3.442	1.386	5.918	***	-1.816	-3.753	-0.233	***
2	B_Mq	*Macaca radiata*	Bonnet Macaque	17	0.68	111	0.89	0.54	0.99	0.441	0.374	0.505	-0.726	-3.021	1.57	*	3.12	0.684	6.009	***	-2.233	-4.425	-0.94	***
3	BN_Hr	*Lepus nigricollis*	Black-naped Hare	24	0.96	83	0.995	0.93	1	0.272	0.224	0.326	-1.684	-4.645	1.299	*	0.837	-2.071	4.061	*	-1.25	-2.798	0.763	**
4	C_PCv	*Paradoxurus hermaphroditus*	Asian Palm Civet	10	0.4	42	0.36	0.07	0.81	0.253	0.19	0.324	-0.253	-2.452	2.159	*	3.821	1.751	6.378	***	-1.799	-3.966	-0.126	***
5	C_PSq	*Funambulus palmarum*	Indian Palm Squirrel	19	0.76	52	0.986	0.84	1	0.184	0.143	0.234	-0.228	-2.876	2.68	*	2.223	-0.772	5.452	**	-2.131	-4.232	-0.712	***
6	F_FBt	*Rousettus leschenaulti*	Fulvous Fruit Bat	3	0.12	8	0.01	0	0.18	0.127	0.053	0.242	1.16	-0.79	3.684	*	2.021	-0.41	4.887	**	-1.611	-3.715	0.602	**
7	G_Jl	*Canis aureus*	Golden Jackal	2	0.08	2	0.39	0.01	1	0.031	0.007	0.124	-1.394	-4.816	1.673	*	0.655	-2.658	4.879	*	-1.868	-4.317	-0.014	***
8	I_FFx	*Pteropus giganteus*	Indian Flying Fox	16	0.64	37	0.95	0.64	1	0.14	0.099	0.187	0.121	-2.461	3.004	*	2.607	-0.123	5.784	**	-2.343	-4.957	-0.899	***
9	I_FMs	*Mus spp*	Mice	20	0.8	45	0.97	0.81	1	0.182	0.135	0.234	-2.305	-5.335	-0.064	*	-0.825	-3.608	2.091	*	-1.193	-2.653	0.849	**
10	I_GMg	*Herpestes edwardsi*	Indian Grey Mongoose	16	0.64	22	0.94	0.63	1	0.097	0.063	0.142	-2.967	-5.871	-0.527	*	-0.614	-3.234	2.208	*	-1.525	-3.143	0.473	**
11	I_GSq	*Ratufa indica*	Indian Giant Squirrel	5	0.2	13	0.01	0	0.2	0.151	0.088	0.238	2.011	-0.018	4.504	*	2.359	0.035	5.12	***	-1.647	-3.918	0.55	**
12	I_Lp	*Panthera pardus*	Indian Leopard	4	0.16	5	0.03	0	0.75	0.06	0.024	0.132	1.387	-1.429	4.143	*	2.655	-0.136	6.12	**	-1.708	-4.214	0.55	**
13	I_MDr	*Moschiola indica*	Indian Mouse Deer	7	0.28	15	0.04	0	0.43	0.126	0.074	0.199	0.796	-1.277	3.353	*	3.884	1.589	6.752	***	-1.712	-3.825	0.308	**
14	I_Ple	*Pipistrellus* sp	Indian Pipistrelle	17	0.68	29	0.98	0.72	1	0.107	0.074	0.147	0.011	-2.897	2.885	*	2.048	-0.715	5.321	**	-2.416	-4.865	-1.004	***
15	I_Pn	*Hystrix indica*	Indian Porcupine	3	0.12	3	0.13	0.01	0.93	0.042	0.012	0.117	-1.919	-5.16	1.832	*	2.938	0.296	6.091	***	-1.788	-4.036	0.078	**
16	J_Ct	*Felis chaus*	Jungle Cat	9	0.36	17	0.82	0.23	1	0.079	0.047	0.131	-0.416	-3.248	2.545	*	2.58	-0.287	5.841	**	-2.057	-4.336	-0.472	***
17	L_BRt	*Bandicota bengalensis*	Lesser Bandicoot Rat	17	0.68	36	0.98	0.71	1	0.134	0.093	0.187	-1.834	-4.725	0.838	*	0.6	-2.07	4.133	*	-1.072	-2.659	1.162	*
18	LT_TMs	*Vandeleuria oleracea*	Long-Tailed Tree Mouse	9	0.36	16	0.23	0.02	0.8	0.107	0.066	0.161	-0.058	-2.563	2.66	*	4.512	2.07	7.436	***	-1.801	-4.114	0.068	**
19	M_TShw	*Anathana ellioti*	Madras Tree Shrew	11	0.44	24	0.62	0.18	0.96	0.126	0.082	0.181	-0.738	-3.219	1.901	*	3.791	1.494	6.692	***	-1.725	-3.73	-0.065	***
20	R_Mg	*Herpestes smithii*	Ruddy Mongoose	9	0.36	41	0.19	0.02	0.71	0.277	0.212	0.352	-0.078	-2.441	2.302	*	4.589	2.26	7.474	***	-1.81	-4.136	0.115	**
21	R_Mq	*Macaca mulatta*	Rhesus Macaque	4	0.16	31	0.01	0	0.12	0.456	0.334	0.58	0.156	-1.135	1.578	*	2.286	0.41	4.617	***	-1.686	-3.887	0.315	**
22	R_SCt	*Prionailurus rubiginosus*	Rusty Spotted Cat	6	0.24	7	0.82	0.13	1	0.038	0.017	0.079	-0.051	-3.047	2.893	*	2.462	-1.056	6.14	*	-1.945	-4.366	-0.108	***
23	S_ICv	*Viverricula indica*	Small Indian Civet	9	0.36	19	0.53	0.11	0.96	0.104	0.062	0.164	-0.637	-3.151	1.886	*	2.786	0.551	5.517	***	-1.834	-4.056	-0.147	***
24	SP_GLr	*Semnopithecus dussumieri*	Southern Plains Gray Langur	17	0.68	104	0.92	0.57	0.99	0.425	0.363	0.489	0.739	-1.64	3.49	*	2.789	0.356	5.806	***	-2.06	-4.18	-0.745	***
25	W_Br	*Sus scrofa*	Wild Boar	15	0.6	55	0.81	0.4	0.98	0.231	0.177	0.291	-0.417	-2.64	1.892	*	2.709	0.495	5.383	***	-2.138	-4.357	-0.778	***

Abbr – Abbreviation; Pre – Presence; Det – Detections; CI – Credible interval; *- Weak effect; ** - Moderate effect; *** - Strong effect

II. BIRDS

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr	Scientific Name	Common Name	Pre	Naïve occupancy	det	*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*			*Mean*	*95% CI*			*Mean*	*95% CI*		
1	AS	*Tachymarptis melba*	Alpine Swift	6	0.17	7	0.73	0.2	1	0.03	0	0.1	0.52	-2.8	3.71	*	-0.11	-1.5	0.9	**	-0.41	-2.1	1.22	*
2	AD	*Dicrurus leucophaeus*	Ashy Drongo	8	0.23	12	0.6	0.1	1	0.06	0	0.2	1.3	-0.7	3.43	**	0.26	-0.7	1.3	**	-0.34	-2.2	1.32	*
3	AP	*Prinia socialis*	Ashy Prinia	17	0.49	52	0.54	0.3	0.8	0.24	0.2	0.4	-1.71	-3.8	0.04	**	0.13	-0.7	1.1	**	-0.52	-1.7	0.44	**
4	ABF	*Muscicapa dauurica*	Asian Brown Flycatcher	1	0.03	1	0.12	0	0.9	0.03	0	0.2	1.21	-1.1	3.69	*	0.27	-0.7	1.5	**	-0.67	-2.8	1.25	*
5	AK	*Eudynamys scolopaceus*	Asian Koel	15	0.43	22	0.88	0.5	1	0.07	0	0.1	-1.05	-3.9	2.08	*	0.16	-0.9	1.1	**	-0.6	-2.2	1.04	*
6	APS	*Cypsiurus balasiensis*	Asian Palm-swift	12	0.34	12	0.94	0.6	1	0.04	0	0.1	-0.7	-3.7	2.4	*	0.03	-1.2	1.1	*	-0.3	-2	1.37	*
7	AP_F	*Terpsiphone paradise*	Asian Paradise Flycatcher	9	0.26	13	0.85	0.4	1	0.04	0	0.1	0.42	-1.7	2.77	*	0.17	-0.9	1.3	**	0.09	-1.8	1.97	*
8	BS	*Hirundo rustica*	Barn Swallow	4	0.11	5	0.4	0.1	0.9	0.04	0	0.1	0.04	-1.8	2.19	*	0.32	-0.6	1.4	**	-1.33	-3.2	0.31	**
9	BD	*Dicrurus macrocercus*	Black Drongo	23	0.66	71	0.74	0.5	0.9	0.35	0.3	0.4	-0.67	-1.9	0.37	**	-0.14	-1.1	0.6	**	-0.93	-2.1	0.06	**
10	BK	*Milvus migrans migrans/govinda*	Black Kite	11	0.31	16	0.33	0.1	0.8	0.1	0	0.2	-2.52	-5.3	-0.2	***	0.25	-0.6	1.3	**	0.99	-0.4	2.54	**
11	B_HB	*Megalaima zeylanica*	Brown-headed Barbet	11	0.31	31	0.25	0.1	0.6	0.24	0.1	0.4	1.27	-0.1	3.21	**	0.47	-0.3	1.4	**	-1.56	-3.4	-0.1	***
12	B_HC	*Lalage melanoptera*	Black-headed Cuckooshrike	8	0.23	13	0.41	0.1	0.9	0.09	0	0.2	-0.76	-3.2	2.19	*	0.13	-0.8	1.1	**	-1.48	-3.2	-0.1	***
13	B_HI	*Threskiornis melanocephalus*	Black-headed Ibis	2	0.06	2	0.29	0	0.9	0.02	0	0.1	-1.65	-4.7	1.36	*	0.25	-0.7	1.3	**	-0.65	-2.6	1.18	*
14	B_HM	*Lonchura malacca*	Black-headed Munia	1	0.03	1	0.21	0	0.9	0.02	0	0.1	-1.05	-4.4	2.06	*	0.09	-1	1.1	*	0.07	-1.8	1.99	*
15	B_HO	*Oriolus xanthornus*	Black-hooded Oriole	5	0.14	11	0.12	0	0.4	0.18	0.1	0.4	-0.55	-2.4	1.84	*	0.2	-0.6	1.1	**	-1.62	-3.5	-0.2	***
16	B_NM	*Hypothymis azurea*	Black-naped Blue Monarch	2	0.06	3	0.18	0	0.9	0.04	0	0.2	0.73	-1.5	3.36	*	0.3	-0.7	1.5	**	-0.99	-3	0.76	**
17	B_WK	*Elanus caeruleus*	Black-winged Kite	1	0.03	1	0.22	0	0.9	0.02	0	0.1	-0.75	-4	2.49	*	0.06	-1.1	1.1	*	-0.93	-3	1.04	*
18	B_WS	*Himantopus himantopus*	Black-winged Stilt	1	0.03	2	0.09	0	0.8	0.05	0	0.3	-1.27	-4.2	1.4	*	0.03	-1.1	0.9	*	-0.73	-2.6	1.1	*
19	BRP	*Columba livia*	Blue Rock Pigeon	12	0.34	37	0.23	0.1	0.6	0.16	0.1	0.3	-2.54	-5.1	-0.3	***	0.17	-0.6	1	**	0.73	-0.3	1.82	**
20	B_CRT	*Monticola cinclorhyncha*	Blue-capped Rock Thrush	4	0.11	6	0.35	0	0.9	0.04	0	0.2	0.73	-1.4	3.3	*	0.18	-0.8	1.2	**	-1.13	-3.2	0.68	**
21	BR_W	*Acrocephalus dumetorum*	Blyth's Reed-warbler	2	0.06	5	0.05	0	0.3	0.16	0	0.4	-1.56	-4.2	0.61	*	-0.05	-1.1	0.8	**	-1.02	-2.6	0.38	**
22	BE	*Hieraaetus pennatus*	Booted Eagle	3	0.09	3	0.63	0.1	1	0.02	0	0.1	-0.1	-3.5	3.39	*	0.09	-1	1.2	*	-0.37	-2.1	1.3	*
23	B_D	*Dicrurus aeneus*	Bronze Drongo	2	0.06	2	0.28	0	0.9	0.02	0	0.1	-1.06	-4.2	2.5	*	0.34	-0.6	1.6	**	-1.15	-3.3	0.79	**
24	B_S	*Lanius cristatus*	Brown Shrike	2	0.06	2	0.34	0	1	0.02	0	0.1	-1.24	-4.2	2.07	*	-0.01	-1.3	1	*	-1.01	-3	1.01	*
25	B_CF	*Alcippe poioicephala*	Brown-cheeked Fulvetta	8	0.23	12	0.47	0.1	0.9	0.07	0	0.2	1.54	-0.7	4.23	**	-0.08	-1.3	0.9	**	-1.41	-3.4	0.24	**
26	BHB	*Emberiza melanocephala*	Black-headed Bunting	1	0.03	1	0.2	0	1	0.02	0	0.1	-0.83	-4.2	2.37	*	0.09	-1	1.1	*	0.27	-1.6	2.13	*
27	C_W	*Motacilla citreola*	Citrine Wagtail	1	0.03	1	0.22	0	1	0.02	0	0.1	-1.17	-4.4	1.92	*	0.07	-1	1.1	*	-0.22	-2.2	1.82	*
28	CH	*Upupa epops*	Common Hoopoe	1	0.03	1	0.2	0	0.9	0.02	0	0.1	0.75	-2.5	3.96	*	0.06	-1.2	1.1	*	-0.92	-3	0.91	**
29	CI	*Aegithina tiphia*	Common Iora	13	0.37	18	0.82	0.4	1	0.08	0	0.1	-0.29	-2.3	2.43	*	0.1	-1	1.2	*	-1.09	-2.8	0.64	**
30	C_K	*Falco tinnunculus*	Common Kestrel	1	0.03	1	0.24	0	0.9	0.02	0	0.1	-0.67	-3.9	2.68	*	0.07	-1.1	1.1	*	-0.95	-3	0.99	**
31	CK	*Alcedo atthis*	Common Kingfisher	5	0.14	5	0.52	0.1	1	0.03	0	0.1	-0.38	-3.1	2.65	*	0.37	-0.5	1.5	**	-1.61	-3.6	0.24	**
32	CM	*Acridotheres tristis*	Common Myna	22	0.63	55	0.89	0.7	1	0.16	0.1	0.3	-0.11	-2.1	2.01	*	0.06	-0.9	1	*	0.54	-1	2.01	**
33	CR	*Fringilla coelebs*	Common Rosefinch	4	0.11	7	0.28	0.1	0.9	0.06	0	0.2	-1.49	-4.3	1.01	*	0.25	-0.7	1.3	**	-0.07	-1.6	1.6	*
34	CS	*Saxicola maurus*	Common Stonechat	6	0.17	6	0.8	0.2	1	0.02	0	0.1	-0.94	-3.9	2.18	*	-0.08	-1.5	0.9	*	-0.51	-2.5	1.48	*

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr	Scientific Name	Common Name	Pre	Naïve occupancy	det	*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*			*Mean*	*95% CI*			*Mean*	*95% CI*		
35	CTB	*Orthotomus sutorius*	Common Tailorbird	16	0.46	26	0.88	0.5	1	0.09	0.1	0.2	-1.4	-4.1	1.48	*	0.09	-1	1.1	*	-0.37	-2	1.32	*
36	CW	*Tephrodornis pondicerianus*	Common Woodshrike	2	0.06	2	0.37	0	1	0.02	0	0.1	-1.52	-4.6	1.74	*	0.22	-0.8	1.3	**	-0.54	-2.5	1.38	*
37	CB	*Xantholaema haemacephala*	Coppersmith Barbet	5	0.14	5	0.49	0.1	1	0.03	0	0.1	-1.99	-5	0.84	**	0.34	-0.6	1.5	**	0.36	-1.3	2.04	*
38	CSE	*Spilornis cheela*	Crested Serpent Eagle	7	0.2	10	0.45	0.1	0.9	0.06	0	0.2	1.17	-1.4	4.4	*	0.22	-0.7	1.3	**	-1.46	-3.4	0.19	**
39	DC_M	*Ptyonoprogne concolor*	Dusky Crag Martin	2	0.06	2	0.36	0	0.9	0.02	0	0.1	0.64	-2.6	3.97	*	0.03	-1.2	1.1	*	-1.22	-3.3	0.6	**
40	ECE	*Bubulcus coromandus*	Eastern Cattel Egret	22	0.63	48	0.86	0.6	1	0.16	0.1	0.2	-1.56	-4.3	1.06	*	-0.26	-1.6	0.7	**	0.09	-1.3	1.62	*
41	ES_BD	*Anas poecilorhyncha*	Eastern Spot-billed Duck	1	0.03	2	0.08	0	0.8	0.05	0	0.3	-1.16	-3.9	1.61	*	0.05	-1.1	1	*	-0.79	-2.7	0.93	**
42	ECD	*Streptopelia decaocto*	Eurasian Collared Dove	1	0.03	1	0.24	0	1	0.02	0	0.1	-1.05	-4.3	2.32	*	0.08	-1.1	1.1	*	0.03	-1.9	2.03	*
43	ER	*Coracias garrulous*	European Roller	1	0.03	1	0.23	0	0.9	0.02	0	0.1	0.52	-2.7	3.74	*	0.08	-1	1.2	*	-0.92	-3	1.02	*
44	G_FL	*Chloropsis aurifrons*	Golden-fronted Leafbird	10	0.29	18	0.35	0.1	0.8	0.14	0.1	0.3	-0.55	-2.9	3.35	*	0.1	-0.8	1	*	-2.13	-4	-0.7	***
45	GF	*Chrysocolaptes guttacristatus*	Greater Flameback	1	0.03	1	0.17	0	0.9	0.02	0	0.1	-0.86	-3.9	2.35	*	0.35	-0.6	1.6	**	-0.95	-2.9	0.98	**
46	GRTD	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	7	0.2	9	0.62	0.1	1	0.03	0	0.1	0.03	-2.1	3.25	*	0.46	-0.5	1.8	**	-1.48	-3.6	0.38	**
47	GW	*Phylloscopus trochiloides*	Greenish Warbler	1	0.03	1	0.12	0	0.9	0.03	0	0.2	1.17	-1.2	3.75	*	0.26	-0.7	1.4	**	-0.68	-2.6	1.18	*
48	GJF	*Gallus sonneratii*	Grey Junglefowl	2	0.06	2	0.25	0	0.9	0.03	0	0.2	0.63	-1.6	3.08	*	0.38	-0.6	1.7	**	-1.05	-3.1	0.69	**
49	G_BP	*Prinia hodgsonii*	Grey-breasted Prinia	4	0.11	6	0.32	0.1	0.9	0.05	0	0.2	0.5	-2.3	3.54	*	-0.12	-1.4	0.9	**	-1.56	-3.5	-0	***
50	G_HCF	*Culicicapa ceylonensis*	Grey-headed Canary Flycatcher	3	0.09	3	0.21	0	0.9	0.04	0	0.2	1.4	-0.8	3.74	**	0.36	-0.6	1.6	**	-1.01	-3.1	0.67	**
51	H_SW	*Hemicircus canente*	Heart-spotted Woodpecker	2	0.06	3	0.2	0	0.9	0.04	0	0.2	-1.77	-4.6	0.75	**	0.18	-0.8	1.2	**	-0.47	-2.3	1.33	*
52	HC	*Corvus splendens*	House Crow	24	0.69	78	0.81	0.5	1	0.28	0.2	0.4	-1.72	-3.7	0.25	**	0.15	-0.7	1.1	**	0.53	-0.8	1.96	**
53	HS	*Passer domesticus*	House Sparrow	6	0.17	23	0.06	0	0.3	0.28	0.1	0.5	-1.31	-3.9	0.87	**	0	-1.1	0.8	*	1.32	0.21	2.59	***
54	IBW	*Ploceus philippinus*	Indian Baya Weaver	1	0.03	1	0.22	0	0.9	0.02	0	0.1	-1.15	-4.4	1.97	*	0.08	-1.1	1.1	*	0.1	-1.8	2.05	*
55	IBR	*Copsychus fulicatus*	Indian Black Robin	9	0.26	11	0.8	0.3	1	0.04	0	0.1	-1.3	-4.4	1.95	*	-0.05	-1.4	1	*	-0.13	-1.9	1.67	*
56	IC	*Phalacrocorax fuscicollis*	Indian Cormorant	5	0.14	9	0.15	0	0.6	0.08	0	0.2	-2.51	-5.2	-0	**	0.29	-0.5	1.3	**	-0.61	-1.9	0.67	**
57	IGO	*Oriolus kundoo*	Indian Golden Oriole	9	0.26	14	0.29	0.1	0.8	0.1	0.1	0.2	-2.59	-5.1	-0.2	**	0.27	-0.6	1.3	**	-1.7	-3.3	-0.4	***
58	IGH	*Ocyceros birostris*	Indian Grey Hornbill	1	0.03	1	0.18	0	0.9	0.02	0	0.2	-0.88	-4	2.6	*	0.32	-0.6	1.6	**	-0.91	-3.1	0.96	**
59	IJC	*Corvus [macrorhynchos] culminatus*	Indian Jungle Crow	25	0.71	50	0.91	0.7	1	0.2	0.2	0.3	-1.01	-2.6	0.82	**	0.22	-0.8	1.2	**	-0.99	-2.6	0.58	**
60	IPH	*Ardeola grayii*	Indian Pond Heron	10	0.29	20	0.21	0.1	0.6	0.18	0.1	0.3	-2.85	-5.5	-0.7	***	0.3	-0.5	1.3	**	0.17	-0.9	1.55	**
61	IR_W	*Acrocephalus [stentoreus] brunnescens*	Indian Reed-warbler	6	0.17	20	0.1	0	0.3	0.21	0.1	0.4	-2.59	-5.2	-0.4	***	0.36	-0.4	1.4	**	-1.14	-2.4	-0	***
62	I_R	*Coracias benghalensis*	Indian Roller	1	0.03	1	0.22	0	1	0.02	0	0.1	-0.93	-4.1	2.26	*	0.1	-1	1.2	*	0.27	-1.6	2.12	*
63	IME	*Egretta intermedia*	Intermediate Egret	1	0.03	2	0.08	0	0.7	0.05	0	0.3	-1.22	-4.1	1.47	*	0.03	-1.1	0.9	*	-0.75	-2.6	0.98	**
64	JB	*Turdoides striatus*	Jungle Babbler	4	0.11	5	0.39	0.1	0.9	0.04	0	0.1	-2.13	-5.1	0.39	**	0.02	-1.1	1	*	-0.86	-2.7	1.06	*
65	JP	*Prinia sylvatica*	Jungle Prinia	5	0.14	5	0.61	0.1	1	0.03	0	0.1	-1.39	-4.4	1.81	*	0.02	-1.1	1	*	-1.17	-3.1	0.78	**
66	LC	*Microcarbo niger*	Little Cormorant	8	0.23	13	0.5	0.2	1	0.08	0	0.2	-0.63	-2.3	1.2	*	0.43	-0.4	1.6	**	0.08	-1.6	1.68	*
67	LGB	*Turdoides malcolmi*	Large Grey Babbler	7	0.2	8	0.45	0.1	0.9	0.05	0	0.1	-1.4	-4.4	2.28	*	-0.07	-1.5	1	*	-1.85	-3.8	0.07	**
68	LW	*Sylvia curruca*	Lesser Whitethroat	1	0.03	1	0.2	0	0.9	0.02	0	0.1	-1.25	-4.4	1.81	*	0.11	-1	1.2	*	-0.91	-3	1.07	*
69	L_C	*Coracina macei*	Large Cuckooshrike	1	0.03	1	0.14	0	0.9	0.02	0	0.2	1.11	-1.3	3.78	*	0.26	-0.7	1.4	**	-0.66	-2.7	1.27	*

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr	Scientific Name	Common Name	Pre	Naïve occupancy	det	*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*			*Mean*	*95% CI*			*Mean*	*95% CI*		
70	LE	*Egretta garzetta*	Little Egret	5	0.14	8	0.24	0	0.8	0.06	0	0.2	-2.17	-4.8	0.27	**	0.23	-0.6	1.2	**	-1.17	-2.9	0.33	**
71	LGB_E	*Merops orientalis*	Little Green Bee-eater	22	0.63	49	0.77	0.5	0.9	0.25	0.2	0.3	-2.76	-4.7	-1.2	*	-0.03	-1.1	0.9	*	-2.07	-3.6	-0.8	***
72	LS	*Apus affinis*	Little Swift	8	0.23	11	0.77	0.3	1	0.05	0	0.1	0.44	-2.1	3.05	*	-0.07	-1.3	0.9	*	-0.06	-2	1.59	*
73	L_TS	*Lanius vittatus*	Bay-backed Shrike	1	0.03	2	0.11	0	0.9	0.04	0	0.2	-0.61	-3.7	2.48	*	0.12	-1	1.1	**	0.3	-1.4	2.02	*
74	L_S	*Cinnyris lotenius*	Loten's Sunbird	1	0.03	1	0.13	0	0.9	0.02	0	0.2	1.16	-1.1	3.72	*	0.25	-0.7	1.4	**	-0.66	-2.7	1.31	*
75	MWT	*Myophonus horsfieldi*	Malabar Whistling Thrush	5	0.14	7	0.11	0	0.8	0.05	0	0.2	2.2	0.18	4.42	***	0.31	-0.6	1.4	**	-0.64	-2.8	1.18	*
76	NWP	*Columba elphinstonii*	Nilgiri Wood Pigeon	4	0.11	6	0.1	0	0.8	0.05	0	0.2	2.04	0.11	4.32	***	0.29	-0.6	1.4	**	-0.6	-2.6	1.28	*
77	O_BP	*Anthus hodgsoni*	Olive-backed Pipit	1	0.03	1	0.1	0	0.8	0.03	0	0.2	1.38	-0.9	4.03	**	0.26	-0.7	1.4	**	-0.69	-2.8	1.25	*
78	OM	*Pericrocotus flammeus*	Orange Minivet	1	0.03	1	0.25	0	0.9	0.02	0	0.1	-0.37	-3.7	3.2	*	0.12	-1	1.2	**	-0.99	-3.1	0.9	**
79	O_HGT	*Geokichla citrine*	Orange-headed Ground Thrush	6	0.17	15	0.12	0	0.6	0.1	0	0.3	1.97	0.45	3.84	***	0.19	-0.8	1.2	**	-0.8	-2.8	0.9	**
80	OHB	*Pernis ptilorhynchus*	Oriental Honey Buzzard	3	0.09	3	0.62	0.1	1	0.02	0	0.1	-0.31	-3.4	2.85	*	-0.01	-1.3	1	*	0.1	-1.8	2.03	*
81	OMR	*Copsychus saularis*	Oriental Magpie Robin	16	0.46	26	0.84	0.5	1	0.1	0.1	0.2	-1.17	-3.8	1.86	*	0.16	-0.8	1.2	**	-0.91	-2.6	0.74	**
82	OT_D	*Streptopelia orientalis*	Oriental Turtle-dove	2	0.06	2	0.11	0	0.9	0.04	0	0.2	1.62	-0.5	3.98	**	0.3	-0.6	1.5	**	-0.65	-2.8	1.34	*
83	PP	*Anthus rufulus*	Paddyfield Pipit	4	0.11	5	0.42	0.1	0.9	0.04	0	0.1	0.63	-2.3	3.63	*	0.34	-0.6	1.5	**	-1.37	-3.3	0.27	**
84	P_BF	*Dicaeum erythrorhynchos*	Pale-billed Flowerpecker	1	0.03	1	0.18	0	0.9	0.02	0	0.1	-1.19	-4.3	1.93	*	0.29	-0.6	1.4	**	-0.92	-2.9	1	*
85	P_P	*Prinia inornata*	Plain Prinia	27	0.77	75	0.96	0.8	1	0.23	0.2	0.3	-0.97	-3.1	1.59	*	0.07	-1	1.1	*	-0.73	-2.3	0.84	**
86	P_HP	*Psittacula cyanocephala*	Plum-headed Parakeet	2	0.06	5	0.1	0	0.8	0.09	0	0.4	-1.09	-3.6	0.83	**	0.17	-0.8	1.1	**	-1.09	-3	0.59	**
87	P_TB	*Pellorneum ruficeps*	Puff-throated Babbler	6	0.17	13	0.47	0.1	1	0.04	0	0.1	0.03	-1.8	1.52	*	-0.04	-1.3	1	*	-1.08	-3.2	0.91	**
88	PH	*Ardea purpurea*	Purple Heron	1	0.03	1	0.16	0	0.9	0.02	0	0.1	-1.16	-4.1	1.89	*	0.33	-0.7	1.6	**	-0.84	-2.9	1.09	*
89	PS	*Cinnyris asiatica*	Purple Sunbird	28	0.8	59	0.97	0.8	1	0.2	0.2	0.3	-0.42	-2.2	1.88	*	0.25	-0.7	1.3	**	-0.31	-1.8	1.3	*
90	P_RSB	*Leptocoma zeylonica*	Purple-rumped Sunbird	5	0.14	5	0.71	0.2	1	0.03	0	0.1	-0.29	-2.4	2.1	*	0.42	-0.5	1.7	**	-0.02	-1.7	1.63	*
91	RA	*Amandava amandava*	Red Avadavat	1	0.03	1	0.2	0	0.9	0.02	0	0.1	-1.27	-4.3	1.69	*	0.07	-1.1	1	*	-0.81	-2.9	1.07	*
92	R_BF	*Ficedula parva*	Red-breasted Flycatcher	5	0.14	7	0.18	0	0.8	0.06	0	0.2	1.75	-0.2	4.26	**	0.36	-0.6	1.6	**	-0.91	-3	0.84	**
93	R_RS	*Cecropis daurica*	Red-rumped Swallow	2	0.06	2	0.3	0	0.9	0.02	0	0.1	-1.08	-4.2	2.14	*	0.25	-0.7	1.4	**	-1.21	-3.2	0.76	**
94	R_VB	*Pycnonotus cafer*	Red-vented Bulbul	23	0.66	48	0.84	0.6	1	0.22	0.2	0.3	-1.25	-2.8	0.13	**	0.16	-0.7	1.1	**	-1	-2.5	0.44	**
95	R_WL	*Vanellus indicus*	Red-wattled Lapwing	5	0.14	9	0.11	0	0.5	0.11	0	0.3	-1.52	-4.3	0.78	**	-0.05	-1.2	0.8	*	1.1	-0.3	2.77	**
96	R_WB	*Pycnonotus jocosus*	Red-whiskered Bulbul	33	0.94	93	0.98	0.9	1	0.32	0.3	0.4	0.06	-1.9	2.47	*	0.13	-0.9	1.2	**	-0.55	-2.2	1.16	*
97	R_RP	*Psittacula krameri*	Rose-ringed Parakeet	11	0.31	13	0.86	0.4	1	0.06	0	0.1	-1.62	-4.4	1.72	*	0	-1.2	0.9	*	-0.11	-1.7	1.56	*
98	R_BC	*Porzana fusca*	Ruddy-breasted Crake	1	0.03	1	0.13	0	0.9	0.02	0	0.1	-1.13	-4.2	2	*	0.37	-0.5	1.6	**	-0.98	-3	0.87	**
99	RT	*Dendrocitta vagabunda*	RufousTreepie	5	0.14	8	0.23	0	0.8	0.08	0	0.2	-1.16	-3.9	2.07	*	0.25	-0.6	1.2	**	-1.61	-3.4	-0.1	***
100	R_BL_TS	*Lanius schach erythronotus group*	Rufous-backed' Long-tailed Shrike	5	0.14	5	0.72	0.2	1	0.02	0	0.1	-0.6	-3.5	2.3	*	0.23	-0.8	1.3	**	-1.02	-2.9	0.74	**
101	R_TL	*Ammomanes phoenicura*	Rufous-tailed Lark	5	0.14	7	0.64	0.1	1	0.03	0	0.1	-0.2	-3.3	2.88	*	-0.08	-1.4	0.9	*	0	-1.8	1.74	*
102	S_BM	*Lonchura punctulata*	Scaly-breasted Munia	6	0.17	7	0.63	0.1	1	0.03	0	0.1	-1.73	-4.9	1.55	*	-0.1	-1.5	0.9	*	-0.32	-2	1.49	*
103	S	*Accipiter badius*	Shikra	10	0.29	12	0.7	0.2	1	0.05	0	0.1	-1.25	-3.9	1.52	*	0.18	-0.8	1.2	**	-1.34	-2.9	0.37	**
104	SC	*Centropus [sinensis] parroti*	Southern Coucal	21	0.6	38	0.87	0.6	1	0.17	0.1	0.2	-0.93	-2.8	1.76	*	0.17	-0.8	1.3	**	-1.12	-2.7	0.42	**
105	SM	*Taccocua leschenultii*	SirkeerMalkoha	4	0.11	5	0.54	0.1	1	0.04	0	0.2	0.31	-1.9	2.94	*	0.24	-0.7	1.4	**	-0.49	-2.3	1.14	*

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	**Abbr**	**Scientific Name**	**Common Name**	**Pre**	**Naïve occupancy**	**det**	***Mean***	***95% CI***		***Mean***	***95% CI***		***Mean***	***95% CI***			***Mean***	***95% CI***			***Mean***	***95% CI***		
106	S_M	*Pericrocotus cinnamomeus*	Small Minivet	4	0.11	4	0.69	0.1	1	0.02	0	0.1	0.19	-2.2	2.99	*	0.26	-0.8	1.4	**	-0.49	-2.4	1.3	*
107	SS	*Leptocoma minima*	Small Sunbird	3	0.09	4	0.39	0	1	0.03	0	0.1	0.37	-2.2	3.37	*	0.32	-0.6	1.6	**	-1.18	-3.3	0.66	**
108	S_C	*Phyloscopus [collybita] tristis*	Siberian Chiffchaff	4	0.11	5	0.27	0	0.9	0.04	0	0.1	-2.15	-5.1	0.85	**	0.3	-0.6	1.4	**	-1.02	-2.8	0.72	**
109	SGS	*Laniusmeridionalis*	Southern Grey Shrike	3	0.09	3	0.5	0.1	1	0.02	0	0.1	-1.54	-4.8	1.61	*	0.01	-1.2	1	*	-0.09	-2	1.85	*
110	SD	*Streptopelia chinensis*	Spotted Dove	17	0.49	38	0.51	0.2	0.8	0.2	0.1	0.3	-2.97	-5.6	-1	***	0.1	-0.8	1	**	-1.03	-2.2	0.27	**
111	S_TB	*Hypsipetes ganeesa*	Square-tailed Bulbul	3	0.09	7	0.1	0	0.8	0.04	0	0.2	1.61	-0.4	4	**	0.27	-0.7	1.4	**	-0.6	-2.6	1.28	*
112	SE	*Aquila nipalensis*	Steppe Eagle	1	0.03	1	0.17	0	0.9	0.02	0	0.1	-0.79	-4.1	2.57	*	0.37	-0.6	1.6	**	-0.93	-3	0.83	**
113	SW	*Iduna rama*	Sykes's Warbler	2	0.06	2	0.2	0	0.9	0.02	0	0.1	-1.49	-4.4	1.45	*	0.46	-0.4	1.8	**	-0.98	-3.1	0.89	**
114	T_BF	*Dicaeum agile*	Thick-billed Flowerpecker	4	0.11	6	0.27	0	0.9	0.06	0	0.2	0.41	-1.7	3.03	*	0.35	-0.5	1.4	**	-1.29	-3.2	0.31	**
115	TBF	*Cyornis tickelliae*	Tickell's Blue Flycatcher	5	0.14	5	0.76	0.2	1	0.02	0	0.1	-0.49	-2.5	2.12	*	0.26	-0.8	1.4	**	-0.61	-2.4	1.23	*
116	TP	*Anthus trivialis*	Tree Pipit	3	0.09	4	0.41	0.1	1	0.03	0	0.1	-1.06	-4.2	1.97	*	0	-1.2	1	*	-0.57	-2.3	1.19	*
117	UI	*Phylloscopus* sp.	UI Warbler	2	0.06	2	0.45	0	1	0.02	0	0.1	-1.11	-4.5	2.18	*	0.03	-1.3	1.1	*	-0.41	-2.4	1.38	*
118	VF	*Eumyias thalassinus*	Verditer Flycatcher	1	0.03	2	0.07	0	0.8	0.04	0	0.3	0.96	-1.1	3.57	*	0.23	-0.8	1.3	**	-0.62	-2.7	1.3	*
119	VS	*Aethopyga vigorsii*	Vigors's Sunbird	4	0.11	4	0.48	0.1	1	0.03	0	0.1	0.88	-1.4	3.43	*	0.3	-0.6	1.5	**	-1.17	-3.1	0.64	**
120	WT	*Chlidonias hybridus*	Whiskered Tern	1	0.03	1	0.21	0	0.9	0.02	0	0.1	-1.25	-4.3	2.14	*	0.09	-1.1	1.2	*	-0.8	-2.9	1.06	*
121	W_BD	*Dicrurus caerulescens*	White-bellied Drongo	2	0.06	2	0.34	0	1	0.02	0	0.1	0.85	-1.5	3.61	*	0.11	-1	1.1	**	-0.96	-3.1	0.88	**
122	W_BF	*Rhipidura aureola*	White-browed Fantail	5	0.14	8	0.37	0.1	0.9	0.07	0	0.2	-0.24	-2	1.86	*	0.46	-0.4	1.7	**	-0.94	-2.7	0.48	**
123	W_CB	*Megalaima viridis*	White-cheeked Barbet	4	0.11	8	0.07	0	0.6	0.07	0	0.3	1.95	0.24	4.08	***	0.27	-0.7	1.4	**	-0.53	-2.6	1.36	*
124	W_EB	*Pycnonotus leucotis*	White-eared Bulbul	6	0.17	19	0.1	0	0.3	0.21	0.1	0.4	-2.64	-5.2	-0.5	***	0.36	-0.4	1.3	**	-1.08	-2.3	0.04	**
125	W_EBZ	*Butastur teesa*	White-eyed Buzzard	1	0.03	1	0.23	0	0.9	0.02	0	0.1	-0.67	-4.1	2.62	*	0.06	-1.1	1.1	*	-0.91	-3	1.06	*
126	W_RM	*Lonchura striata*	White-rumpedMunia	3	0.09	4	0.31	0	0.9	0.03	0	0.1	-0.09	-2.1	2.7	*	0.35	-0.6	1.6	**	-1.11	-3.1	0.75	**
127	W_RS	*Copsychus malabaricus*	White-rumpedShama	6	0.17	13	0.17	0	0.8	0.07	0	0.2	2.26	0.34	4.63	***	0.25	-0.7	1.3	**	-0.82	-2.9	0.98	**
128	W_SF	*Rhipidura albogularis*	White-spotted Fantail	2	0.06	2	0.3	0	1	0.02	0	0.1	-1.32	-4.5	1.69	*	0.06	-1.1	1.1	*	0.39	-1.4	2.42	*
129	W_TK	*Halcyon smyrnensis*	White-throated Kingfisher	12	0.34	20	0.52	0.2	0.9	0.06	0	0.1	-2.55	-5.4	-0	***	0.36	-0.6	1.5	**	0	-1.4	1.64	*
130	W_TS	*Hirundo smithii*	Wire-tailed Swallow	4	0.11	4	0.72	0.2	1	0.02	0	0.1	-0.68	-3.7	2.58	*	-0.02	-1.3	1	*	-0.6	-2.6	1.38	*
131	WS	*Tringa glareola*	Wood Sandpiper	1	0.03	1	0.14	0	0.9	0.02	0	0.1	-1.16	-4.3	1.86	*	0.35	-0.6	1.6	**	-0.96	-3	0.85	**
132	Y_EB	*Chrysomma sinense*	Yellow-eyed Babbler	6	0.17	7	0.4	0.1	1	0.04	0	0.1	-2.23	-5.1	0.5	**	0.4	-0.5	1.6	**	0.17	-1.5	1.86	*
133	Y_FGP	*Treron phoenicopterus chlorigaster*	Yellow-footed Green-pigeon	4	0.11	4	0.44	0.1	0.9	0.03	0	0.1	-1.7	-4.6	1.77	*	0.19	-0.7	1.2	**	-1.36	-3.3	0.5	**
134	Y_FPW	*Dendrocopos mahrattensis*	Yellow-fronted Pied Woodpecker	2	0.06	2	0.38	0	1	0.02	0	0.1	-1.04	-4.1	2.5	*	0.2	-0.8	1.4	**	-1.1	-3.2	0.98	**
135	Y_TS	*Gymnoris xanthocollis*	Yellow-throated Sparrow	19	0.54	30	0.87	0.6	1	0.13	0.1	0.2	-1.39	-3.3	1.36	*	0.1	-1	1.1	*	-1.03	-2.6	0.58	**

Abbr – Abbreviation; Pre – Presence; Det – Detections; CI – Credible interval; *- Weak effect; ** - Moderate effect; *** - Strong effect; UI- Unidentified

III. AMPHIBIANS

							Occupancy			Detection			Slope parameter Elevation (α_1)				Slope parameter Forest (α_2)				Slope parameter Anthropogenic habitat cover (α_3)			
Sr. No.	Abbr	Scientific Name	Common Name	Pre	Naïve occupancy	Det	Mean	95% CI		Mean	95% CI		Mean	95% CI			Mean	95% CI			Mean	95% CI		
1	AR_bomb	*Raorchestes cf bombeyensis*	Bombay Bush Frog	5	0.142	22	0.013	0.001	0.12	0.063	0.018	0.182	2.431	0.83	4.743	***	1.427	-0.191	3.328	**	-0.681	-2.29	0.824	**
2	AR_gha	*Raorchestes ghatei*	Ghate's Bush Frog	2	0.057	8	0.009	0	0.105	0.064	0.014	0.283	1.691	-0.051	4.096	**	1.297	-0.476	3.517	**	-0.69	-2.364	0.885	**
3	AP_mac	*Polypedates maculatus*	Common Tree Frog	12	0.342	36	0.501	0.16	0.876	0.028	0.013	0.058	0.581	-1.331	2.738	*	2.323	0.561	4.784	***	-0.988	-2.67	0.08	**
4	AI_lei	*Indirana leithii*	Leith's leaping Frog	3	0.085	11	0.055	0.001	0.63	0.004	0	0.027	1.685	-0.673	4.685	**	1.488	-0.735	4.288	**	-0.796	-2.538	0.653	**
5	AS_bre	*Sphaerotheca breviceps*	Indian Burrowing Frog	5	0.142	18	0.21	0.031	0.749	0.005	0.001	0.024	-0.526	-3.256	3.573	*	2.416	0.594	5.251	***	-0.946	-2.663	0.293	**
6	AD_mel	*Duttaphrynus melanostictus*	Asian Common Toad	13	0.371	27	0.826	0.41	0.994	0.018	0.007	0.038	1.298	-1.145	3.911	*	1.625	-0.178	3.853	**	-0.576	-1.787	0.708	**
7	AF_sp1	*Fejervarya sp 1*	Cricket Frog	19	0.542	41	0.948	0.64	0.999	0.042	0.025	0.069	-0.005	-2.741	3.182	*	0.814	-1.356	3.295	**	-0.988	-2.596	0.205	**
8	AF_sp2	*Fejervarya sp 2*	Cricket Frog	16	0.457	49	0.538	0.315	0.805	0.094	0.06	0.136	1.062	-0.159	2.689	**	0.239	-0.761	1.511	**	-0.337	-1.165	0.613	**
9	AH_bah	*Hydrophlylax bahuvistara*	Fungoid Frog	6	0.171	18	0.191	0.044	0.527	0.01	0.002	0.034	-1.248	-3.182	0.67	**	0.932	-0.327	2.639	**	-1.094	-3.065	-0.006	***
10	AU_mor	*Uperodon mormorata*	--	4	0.114	10	0.054	0.003	0.402	0.035	0.011	0.107	-0.532	-2.262	1.901	*	2.161	0.481	4.55	***	-0.86	-2.721	0.391	**
11	AU_glo	*Uperodon globulosus*	Balloon Frog	1	0.028	1	0.052	0.001	0.836	0.005	0	0.053	-0.117	-3.079	3.287	*	1.739	-0.193	4.128	**	-0.788	-2.365	0.594	**
12	AE_cya	*Euphlyctis cyanophlyctis*	Skittering Frog	14	0.4	40	0.786	0.412	0.98	0.035	0.019	0.062	-0.936	-3.233	1.408	*	1.289	-0.742	4.013	**	-0.587	-1.729	0.799	**
13	AH_tig	*Hoplobatrachus tigerenus*	Indian Bull Frog	10	0.285	16	0.705	0.254	0.978	0.014	0.006	0.035	0.316	-2.013	2.976	*	1.253	-0.692	4.199	**	-0.845	-2.221	0.175	**
14	AN_hum	*Nyctibatrachus humayuni*	Bombay Night Frog	4	0.114	5	0.115	0.004	0.785	0.012	0.003	0.047	1.362	-0.99	3.893	**	1.751	-0.266	4.624	**	-0.811	-2.696	0.508	**
15	AI_mah	*Indotyphlus battersbyi*	Battersby's Caecilian	1	0.028	1	0.062	0.001	0.963	0.004	0	0.047	1.030	-1.395	3.851	*	1.448	-0.85	4.276	**	-0.703	-2.307	0.89	**
16	AM_orn	*Microhyla ornata*	Ornate Narrow Mouthed Frog	4	0.114	7	0.123	0.023	0.54	0.016	0.003	0.063	-0.164	-2.213	1.601	*	-0.985	-3.224	0.855	**	-0.678	-1.93	0.374	**

Abbr – Abbreviation; Pre – Presence; Det – Detections; CI – Credible interval; *- Weak effect; ** - Moderate effect; *** - Strong effect

IV. REPTILES

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr	Scientific Name	Common Name	Pre	Naïve occupancy	Det	Mean	95% CI		Mean	95% CI		Mean	95% CI			Mean	95% CI			Mean	95% CI		
1	RH_bro	*Hemidactylus cf brookii*	Brook's Gecko	28	0.8	253	0.973	0.851	0.998	0.31	0.272	0.35	1.706	-0.121	4.684	**	-2.214	-4.407	-0.232	***	-2.821	-5.034	-1.058	***
2	RH_mac	*Hemidactylus maculatus*	Rock Gecko	13	0.371	25	0.801	0.179	0.996	0.03	0.018	0.05	1.245	-1.411	4.469	*	0.046	-2.805	3.497	*	-3.479	-6.622	-0.863	***
3	RH_les	*Hemidactylus leshnaultii*	Leshnault’s Bark Gecko	8	0.229	11	0.882	0.148	1	0.011	0.005	0.024	1.085	-1.777	4.313	*	-0.38	-3.497	3.066	*	-3.161	-6.501	-0.203	***
4	RH_fre	*Hemidactylus frenautus*	House Gecko	3	0.086	4	0.216	0.004	1	0.023	0.002	0.138	-0.089	-3.066	2.564	*	-1.388	-4.949	1.336	*	0.746	-3.344	3.437	*
5	RG_dec	*Cyrtodactylus deccanensis*	Deccan ground Gecko	14	0.4	31	0.912	0.298	0.999	0.026	0.015	0.042	1.12	-1.525	4.438	*	0.204	-2.726	3.256	*	-3.531	-6.944	-0.783	***
6	RO_jer	*Ophisops jerdonii*	Jerdon's Snake Eye	10	0.286	19	0.726	0.196	0.995	0.023	0.012	0.045	1.798	-0.484	4.597	**	-2.101	-4.806	0.956	**	-2.086	-4.896	0.593	**
7	RL_lin	*Lygosoma lineata*	Lined Writhing Skink	16	0.457	26	0.895	0.271	0.998	0.027	0.016	0.044	1.327	-1.367	4.72	*	0.132	-2.638	3.162	*	-3.713	-6.981	-1.051	***
8	RE_car	*Eutrophis carinata*	Many Keeled Grass Skink	23	0.657	57	0.994	0.877	1	0.056	0.041	0.076	1.021	-1.569	4.104	*	-0.913	-4.032	2.442	*	-1.979	-4.87	0.855	**
9	RE_all	*Eutrophis allapalensis*	-	17	0.486	33	0.993	0.807	1	0.03	0.019	0.046	0.706	-1.941	3.774	*	-0.422	-3.708	3.224	*	-1.902	-4.853	0.884	**
10	RE_mac	*Eutrophis macularia*	Bronze Skink	25	0.714	147	0.968	0.792	0.998	0.162	0.131	0.197	1.751	-0.525	4.883	**	-2.14	-4.725	0.959	**	-2.89	-5.393	-0.975	***
11	RC_ver	*Calotes versicolor*	Garden Calotes	26	0.743	72	0.994	0.875	1	0.078	0.06	0.1	0.596	-2.059	3.728	*	-1.154	-4.081	1.947	*	-1.672	-4.482	1.02	*
12	RC_rou	*Calotes rouxii*	Forest Calotes	14	0.4	49	0.527	0.074	0.969	0.065	0.039	0.102	0.949	-1.546	4.582	*	1.161	-1.698	4.21	*	-2.985	-6.061	-0.678	***
13	RC_zyl	*Chamaleon zylanicus*	Chamaleon	1	0.029	1	0.727	0.012	1	0.002	0	0.018	0.509	-2.753	4.136	*	-0.565	-4.199	2.927	*	-2.539	-6.048	0.92	**
14	RV_ben	*Varanus benghalensis*	Monitor Lizard	6	0.171	8	0.849	0.169	0.999	0.011	0.005	0.027	-0.291	-3.495	3.372	*	-1.741	-4.867	1.535	*	-2.433	-5.555	0.654	**
15	RS_spi	*Sitana spinaecephalus*	Fan-throated lizard	10	0.286	11	0.778	0.14	0.999	0.017	0.007	0.037	0.094	-2.825	3.116	*	-3.087	-6.227	0.365	**	-1.34	-3.817	1.388	*
16	RT_gra	*Trimeresurus gramineus*	Bamboo Pit Viper	11	0.314	21	0.757	0.102	0.998	0.021	0.011	0.04	1.164	-1.383	4.338	*	0.599	-2.605	4.156	*	-3.172	-6.382	-0.523	***
17	RA_nas	*Ahetula nasuta*	Green Vine Snake	11	0.314	25	0.895	0.185	0.999	0.018	0.009	0.035	1.034	-1.696	4.383	*	0.344	-2.633	3.447	*	-3.237	-6.598	-0.308	***
18	RB_cae	*Bungarus caeruleus*	Common Krait	7	0.2	8	0.988	0.513	1	0.008	0.003	0.017	0.643	-2.099	3.835	*	-0.434	-3.577	2.99	*	-2.001	-5.266	1.239	*
19	RD_tri	*Dendrelaphis tristis*	Common Bronze Back Tree Snake	5	0.143	8	0.664	0.048	0.998	0.011	0.004	0.027	-0.782	-3.791	2.966	*	-0.813	-4.021	2.417	*	-2.905	-6.229	0.129	**
20	RP_muc	*Ptyas mucosus*	Indian Rat Snake	10	0.286	10	0.985	0.609	1	0.011	0.005	0.022	-0.505	-3.992	3.187	*	-1.546	-4.842	1.829	*	-1.55	-4.501	1.446	*
21	RA_sto	*Amphiesma stolatum*	Buff-striped Keelback	4	0.114	4	0.609	0.023	0.998	0.007	0.002	0.022	0.486	-2.718	4.019	*	-1.902	-4.97	1.666	*	-2.704	-5.874	0.403	**
22	RO_arn	*Oligodon arnensis*	Banded Kukri	3	0.086	3	0.967	0.179	1	0.004	0.001	0.014	0.807	-2.039	3.707	*	-1.193	-4.542	2.099	*	-1.561	-4.92	1.734	*
23	RO_tae	*Oligodon taeniolatus*	Russell's Kukri	1	0.029	1	0.575	0.003	1	0.003	0	0.018	1.203	-1.532	4.244	*	-0.387	-3.923	3.111	*	-2.262	-5.676	1.073	*
24	RL_aul	*Lycodon aulicus*	Wolf Snake	8	0.229	9	0.921	0.178	1	0.009	0.004	0.019	0.816	-2.074	4.258	*	0.035	-3.083	3.386	*	-2.262	-5.676	1.073	*
25	RX_pis	*Xenochrophis piscator*	Checkered Keelback	4	0.114	9	0.282	0.007	0.997	0.016	0.005	0.061	0.833	-1.168	3.797	*	0.071	-2.755	2.629	*	-3.137	-6.46	-0.037	***
26	RN_naj	*Naja naja*	Indian Cobra	1	0.029	2	0.417	0.002	0.999	0.005	0.001	0.046	0.231	-2.922	3.938	*	-0.026	-3.511	3.111	*	-2.489	-5.72	0.371	**
27	REc_car	*Echis carinatus*	Saw scaled Viper	4	0.114	5	0.861	0.088	1	0.006	0.002	0.017	0.204	-3.299	4.322	*	-0.447	-3.67	2.907	*	-2.431	-5.822	0.728	**
28	RD_rus	*Daboia russelii*	Russel's Viper	5	0.143	7	0.862	0.072	1	0.008	0.003	0.021	0.963	-1.726	4.067	*	-0.465	-3.551	2.912	*	-2.882	-6.32	0.255	**

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr	Scientific Name	Common Name	Pre	Naïve occupancy	Det	Mean	95% CI		Mean	95% CI		Mean	95% CI			Mean	95% CI			Mean	95% CI		
29	RB_bed	*Boiga beddomei*	Beddome's Cat Snake	4	0.114	7	0.305	0.004	0.998	0.011	0.003	0.049	1.236	-1.079	4.162	*	0.602	-2.927	3.858	*	-2.972	-6.424	0.196	**
30	RE_joh	*Eryx johnii*	John's Sand Boa	1	0.029	1	0.603	0.006	0.999	0.003	0	0.026	0.442	-2.735	3.897	*	-1.242	-4.68	2.282	*	-2.339	-5.779	0.755	**
31	RE_con	*Eryx conicus*	Common Sand Boa	2	0.057	2	0.833	0.026	1	0.003	0.001	0.016	0.262	-3.298	4.095	*	-0.476	-3.6	2.682	*	-2.332	-5.773	0.95	**
32	RU_mac	*Uropeltis macrolepis*	Large-scaled Shieldtail	1	0.029	4	0.008	0	0.207	0.07	0.008	0.278	1.15	-0.574	3.429	**	-0.41	-2.643	1.906	*	-2.704	-6.147	0.415	**
33	RC_hel	*Coelognathus helena monticollaris*	Montane Trinket	2	0.057	2	0.858	0.036	1	0.003	0.001	0.012	1.018	-1.872	4.202	*	-0.492	-3.87	3.142	*	-1.676	-4.701	1.059	*
34	RR_bra	*Indotyphlops braminus*	Blind snake	1	0.029	1	0.86	0.012	1	0.003	0	0.03	0.242	-3.034	3.675	*	-1.38	-5.029	2.162	*	-2.625	-6.077	0.654	**
35	RP_mol	*Python molurus*	Indian Rock Python	2	0.057	2	0.97	0.112	1	0.003	0.001	0.013	0.066	-3.455	3.423	*	-0.653	-3.815	2.535	*	-1.006	-4.535	2.546	*
36	RC_rhy	*Cerberus rynchops*	Dog-faced Water Snake	2	0.057	2	0.949	0.057	1	0.003	0.001	0.024	-0.045	-3.454	3.449	*	-0.573	-3.583	2.474	*	-1.58	-4.866	1.758	*

Abbr – Abbreviation; Pre – Presence; Det – Detections; CI – Credible interval; *- Weak effect; ** - Moderate effect; *** - Strong effect

V. BUTTERFLIES

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr.	Scientific Name	Common Name	Pre	Naïve occupancy	Det	Mean	95% CI		Mean	95% CI		Mean	95% CI			Mean	95% CI			Mean	95% CI		
1	AC	*Ariadne ariadne*	Angled Castor	1	0.029	1	0.05	0	0.8	0.013	0.001	0.189	-0.343	-3.593	2.853	*	0.536	-1.53	2.593	*	0.295	-2.136	2.818	*
2	AP	*Caleta decidia*	Angled Pierrot	7	0.2	14	0.26	0.01	0.96	0.019	0.002	0.147	-0.883	-4.136	2.173	*	0.174	-1.949	1.944	*	-0.09	-2.598	2.435	*
3	BB	*Azanus* sp.	Babul Blue	1	0.029	2	0.057	0	0.87	0.013	0.001	0.175	-0.274	-3.481	3.055	*	0.535	-1.52	2.578	*	0.305	-2.19	2.838	*
4	Bar	*Symphaedra nais*	Baronet	10	0.286	18	0.51	0.07	0.98	0.044	0.012	0.149	-1.803	-4.916	1.12	*	0.63	-1.006	2.474	*	-0.626	-3.345	1.786	*
5	BR	*Charaxes solon*	Black Rajah	1	0.029	1	0.167	0.01	0.92	0.019	0.002	0.131	-0.677	-3.837	2.712	*	1.049	-0.532	3.147	**	-0.065	-2.627	2.236	*
6	BM	*Papilio polymnestor*	Blue Mormon	7	0.2	14	0.1	0	0.9	0.031	0.004	0.196	1.477	-0.85	3.932	**	0.911	-0.708	3.009	**	0.123	-2.348	2.392	*
7	BO	*Kallima horsefieldii*	Blue Oakleaf	4	0.114	4	0.1	0	0.88	0.041	0.005	0.28	1.482	-0.713	4.121	**	0.819	-0.855	2.899	**	0.037	-2.443	2.268	*
8	BP	*Junonia orithya*	Blue Pansy	3	0.086	3	0.06	0	0.85	0.012	0.001	0.155	-0.283	-3.446	2.995	*	0.539	-1.513	2.46	*	0.313	-2.076	2.786	*
9	BT	*Tirumala limniace*	Blue Tiger	12	0.343	17	0.18	0.01	0.93	0.017	0.002	0.117	-0.76	-3.73	2.501	*	0.926	-0.816	2.877	**	-0.107	-2.649	2.26	*
10	BA	*Badamia exclamationis*	Brown Awl	3	0.086	4	0.06	0	0.82	0.013	0.001	0.157	-0.359	-3.663	2.819	*	0.571	-1.458	2.629	*	0.304	-2.179	2.91	*
11	Ch_Bob	*Imbrix salsala*	Chestnut Bob	6	0.171	8	0.1	0	0.88	0.031	0.004	0.215	1.441	-0.834	3.826	**	0.916	-0.665	2.987	**	0.108	-2.442	2.393	*
12	ChSS	*Neptis jumbah*	Chestnut-streaked Sailer	1	0.029	1	0.06	0	0.85	0.013	0.001	0.192	-0.44	-3.59	2.822	*	0.483	-1.563	2.505	*	0.269	-2.228	2.768	*
13	CP	*Junonia iphita*	Chocolate Pansy	21	0.6	70	0.46	0.08	0.95	0.11	0.035	0.294	1.081	-1.057	3.694	**	1.343	-0.165	3.74	**	-0.869	-3.464	1.019	*
14	CBA	*Hasora chromus*	Common Banded Awl	1	0.029	2	0.05	0	0.75	0.066	0.007	0.472	0.943	-1.197	3.675	**	0.652	-1.062	2.586	*	0.118	-2.232	2.227	*
15	CBr	*Euthalia aconthea*	Common Baron	8	0.229	11	0.06	0	0.84	0.013	0.001	0.174	-0.417	-3.514	2.846	*	0.541	-1.364	2.522	*	0.245	-2.251	2.696	*
16	Com_Bush	*Mycalensis perseus*	Common Bushbrown	17	0.486	48	0.53	0.08	0.98	0.057	0.015	0.197	0.51	-1.645	3.172	*	0.772	-0.851	2.842	**	-0.545	-3.216	1.618	*
17	Com_Cas	*Ariadne merione*	Common Castor	6	0.171	10	0.15	0.01	0.92	0.024	0.003	0.208	-0.838	-4.013	2.051	*	0.353	-1.649	2.231	*	1.149	-0.632	3.578	**
18	Com_Cer	*Jamides celeno*	Common Cerulean	26	0.743	86	0.75	0.24	0.99	0.038	0.012	0.111	-0.325	-2.41	2.089	*	1.151	-0.465	3.126	**	0.549	-1.605	2.891	*
19	Com_Cr	*Euploea core*	Common Crow	32	0.914	78	0.92	0.57	1	0.086	0.041	0.165	0.224	-1.818	2.531	*	0.775	-0.98	2.786	**	0.223	-1.683	2.209	*
20	CE	*Catopsilia pomona*	Common Emigrant	22	0.629	62	0.86	0.48	0.99	0.167	0.093	0.284	-0.934	-3.053	1.573	*	0.37	-1.372	2.168	*	0.424	-1.093	2.249	*
21	CEB	*Melanitis leda*	Common Evening Brown	15	0.429	24	0.05	0	0.83	0.014	0.001	0.183	-0.341	-3.453	2.874	*	0.519	-1.462	2.5	*	0.259	-2.252	2.645	*
22	CF	*Ypthima baldus*	Common Fivering	1	0.029	1	0.1	0	0.9	0.025	0.002	0.208	1.067	-1.128	3.746	*	0.835	-0.906	2.956	**	0.157	-2.25	2.579	*
23	CGY	*Eurema hecabe*	Common Grass Yellow	30	0.857	134	0.59	0.21	0.95	0.123	0.051	0.264	-0.297	-2.144	1.601	*	0.283	-1.179	1.795	*	1.072	-0.493	3.095	**
24	CG	*Cepora nerissa*	Common Gull	16	0.457	50	0.69	0.22	0.98	0.126	0.055	0.254	-2.605	-5.571	0.167	**	0.499	-0.955	2.073	**	0.387	-1.411	2.473	*
25	CHB	*Acytolepis puspa*	Common Hedge Blue	5	0.143	9	0.12	0	0.91	0.019	0.002	0.147	1.159	-1.183	3.744	*	0.847	-0.934	3.031	**	0.094	-2.624	2.43	*
26	Com_Jay	*Graphium doson*	Common Jay	4	0.114	4	0.52	0.05	0.98	0.021	0.004	0.088	0.536	-1.757	3.402	*	0.932	-0.647	3.119	**	-0.468	-3.132	1.722	*
27	Com_Jez	*Delias eucharis*	Common Jezebel	15	0.429	20	0.25	0.02	0.94	0.036	0.005	0.229	-1.414	-4.536	1.56	*	0.803	-0.728	2.58	**	0.623	-1.39	3.111	*
28	Com_Leo	*Phalanta phalantha*	Common Leopard	18	0.514	39	0.46	0.08	0.94	0.079	0.027	0.212	0.146	-1.653	2.469	*	0.913	-0.49	2.712	**	-0.601	-3.101	1.388	*
29	Com_Lin	*Prosotas nora*	Common Lineblue	8	0.229	14	0.3	0.01	0.96	0.014	0.002	0.092	-0.724	-3.927	2.497	*	0.501	-1.545	2.598	*	-0.159	-2.627	2.163	*
30	CM	*Papilio polytes*	Common Mormon	16	0.457	35	0.78	0.21	0.99	0.038	0.011	0.126	-0.126	-2.462	2.437	*	0.644	-1.171	2.696	*	0.266	-1.584	2.241	*

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr.	Scientific Name	Common Name	Pre	Naïve occupancy	Det	Mean	95% CI		Mean	95% CI		Mean	95% CI			Mean	95% CI			Mean	95% CI		
31	CN	*Charaxes bharata*	Common Nawab	1	0.029	1	0.05	0	0.84	0.014	0.001	0.155	-0.361	-3.568	2.833	*	0.528	-1.536	2.406	*	0.292	-2.296	3.04	*
32	Com_Pie	*Castalius rosimon*	Common Pierrot	9	0.257	17	0.37	0.02	0.97	0.023	0.004	0.117	-1.251	-4.443	1.868	*	0.571	-1.119	2.375	*	-0.27	-2.79	2.084	*
33	Com_Red	*Rapala iarbus*	Common Redflash	1	0.029	1	0.12	0	0.87	0.024	0.003	0.197	1.212	-1.054	3.956	*	0.757	-0.964	2.839	**	0.053	-2.476	2.367	*
34	Com_Ros	*Pachliopta aristolochiae*	Common Rose	10	0.286	13	0.48	0.06	0.97	0.032	0.007	0.137	-1.475	-4.562	1.511	*	0.487	-1.225	2.225	*	0.348	-1.689	2.62	*
35	Com_Sai	*Neptis hylas*	Common Sailer	14	0.4	42	0.22	0.02	0.9	0.058	0.013	0.213	0.403	-1.542	3.015	*	1.417	-0.075	3.589	**	-0.353	-2.951	1.67	*
36	Com_Sil	*Spindasis vulcanus*	Common Silverline	7	0.2	12	0.36	0.03	0.97	0.051	0.011	0.231	-1.124	-4.143	1.888	*	-0.051	-2.069	1.807	*	-0.561	-3.129	1.703	*
37	C_Sm_F	*Sarangesa dasahara*	Common Small Flat	1	0.029	1	0.06	0	0.9	0.013	0.001	0.179	-0.335	-3.568	2.848	*	0.54	-1.52	2.491	*	0.299	-2.035	2.82	*
38	CSF	*Celaenorrhinus leucocera*	Common Spotted Flat	3	0.086	4	0.11	0	0.88	0.031	0.004	0.2	1.547	-0.947	4.171	**	0.86	-0.81	3.047	**	0.064	-2.471	2.281	*
39	CT	*Ypthima asterope*	Common Threering	3	0.086	3	0.12	0	0.89	0.02	0.002	0.159	1.156	-1.233	3.909	*	0.816	-0.955	2.973	**	0.124	-2.383	2.567	*
40	CW	*Pareronia hippia*	Common Wanderer	17	0.486	41	0.06	0	0.86	0.014	0.001	0.165	-0.386	-3.419	2.741	*	0.541	-1.331	2.446	*	0.335	-2.028	3.034	*
41	Cri_Ros	*Pachliopta hector*	Crimson Rose	1	0.029	2	0.06	0	0.89	0.014	0.001	0.19	-0.303	-3.581	2.872	*	0.543	-1.364	2.473	*	0.254	-2.201	2.822	*
42	DE	*Hypolimnas misippus*	Danaid Eggfly	14	0.4	17	0.12	0	0.9	0.019	0.002	0.146	1.16	-1.145	3.804	*	0.85	-0.857	2.913	**	0.129	-2.464	2.557	*
43	DGB	*Zizeeria karsandra*	Dark Grass Blue	21	0.6	69	0.25	0.04	0.72	0.119	0.04	0.285	-1.619	-4.614	1.017	*	0.355	-1.089	1.749	*	1.586	-0.118	4.089	**
44	FMN	*Catochrysops strabo*	Forget Me Not	10	0.286	16	0.85	0.39	0.99	0.054	0.02	0.128	-0.234	-2.495	2.265	*	0.512	-1.192	2.383	*	0.612	-1.167	2.734	*
45	GT	*Parantica aglea*	Glassy Tiger	3	0.086	4	0.06	0	0.85	0.013	0.001	0.156	-0.361	-3.487	2.776	*	0.521	-1.384	2.478	*	0.288	-2.175	2.913	*
46	GA	*Caprona ransonnettii*	Golden Angle	4	0.114	4	0.37	0.02	0.97	0.022	0.004	0.116	-1.249	-4.384	1.778	*	0.537	-1.149	2.257	*	-0.221	-2.797	2.089	*
47	GB	*Euchrysops cnejus*	Gram Blue	25	0.714	81	0.87	0.3	1	0.039	0.014	0.109	-0.544	-3.335	2.266	*	0.047	-2.033	1.888	*	-0.234	-2.659	2.167	*
48	GD	*Udaspes folus*	Grass Demon	2	0.057	3	0.04	0	0.62	0.074	0.008	0.505	0.838	-1.13	3.282	*	0.751	-1.003	2.751	*	0.151	-2.269	2.387	*
49	GJ	*Freyeria trochylus*	Grass Jewel	6	0.171	6	0.22	0.02	0.91	0.033	0.005	0.157	-1.072	-4.097	1.955	*	0.147	-1.842	1.945	*	1.41	-0.557	4.281	**
50	GE	*Hypolimnas bolina*	Great Eggfly	17	0.486	25	0.06	0	0.85	0.012	0.001	0.151	-0.319	-3.534	2.978	*	0.525	-1.42	2.455	*	0.251	-2.287	2.683	*
51	GP	*Junonia atlites*	Grey Pansy	21	0.6	42	0.05	0	0.83	0.013	0.001	0.166	-0.356	-3.451	2.839	*	0.535	-1.388	2.535	*	0.29	-2.19	2.847	*
52	IC	*Everes lacturnus*	Indian Cupid	2	0.057	2	0.23	0.02	0.94	0.031	0.005	0.154	-1.176	-4.416	1.732	*	0.182	-1.919	1.983	*	1.393	-0.647	4.199	**
53	IPB	*Suastus gremius*	Indian Palm Bob	1	0.029	1	0.06	0	0.92	0.013	0.001	0.178	-0.363	-3.632	2.86	*	0.534	-1.579	2.651	*	0.32	-2.051	2.933	*
54	In_Sk	*Spialia galba*	Indian Skipper	1	0.029	1	0.06	0	0.87	0.013	0.001	0.163	-0.235	-3.463	3.046	*	0.563	-1.279	2.557	*	0.275	-2.222	2.754	*
55	In_Sun	*Curetis thetis*	Indian Sunbeam	4	0.114	6	0.06	0	0.91	0.013	0.001	0.158	-0.327	-3.591	2.922	*	0.532	-1.425	2.541	*	0.329	-2.093	2.864	*
56	LSA	*Colotis fausta*	Large Salmon Arab	1	0.029	1	0.11	0	0.88	0.028	0.003	0.253	-0.946	-4.004	2.166	*	1.065	-0.484	3.16	**	-0.086	-2.555	2.139	*
57	LP	*Junonia lemonias*	Lemon Pansy	23	0.657	81	0.61	0.19	0.97	0.098	0.037	0.23	-0.784	-3.264	2.289	*	0.562	-0.905	2.116	**	-0.346	-2.211	1.473	*
58	Lim_Blu	*Chilades lajus*	Lime Blue	1	0.029	2	0.15	0	0.94	0.025	0.003	0.202	-0.781	-4.06	2.228	*	0.323	-1.791	2.107	*	1.126	-0.836	3.604	**
59	Lim_But	*Papilio demoleus*	Lime Butterfly	8	0.229	8	0.36	0.03	0.97	0.041	0.008	0.181	-1.384	-4.57	1.456	*	0.044	-2.113	1.761	*	0.856	-0.892	3.283	**
60	MSF	*Celaenorrhinus ambareesa*	Malabar Spotted Flat	3	0.086	4	0.13	0	0.95	0.022	0.002	0.189	1.099	-1.268	3.823	*	0.761	-1.042	2.924	*	0.082	-2.396	2.461	*
61	Mal	*Megisba malaya*	Malayan	1	0.029	1	0.3	0.01	0.97	0.014	0.002	0.1	-0.803	-3.93	2.245	*	0.527	-1.438	2.563	*	-0.173	-2.827	2.161	*
62	MP	*Rathinda amor*	Monkey Puzzle	5	0.143	6	0.06	0	0.84	0.013	0.001	0.176	-0.371	-3.49	2.849	*	0.544	-1.473	2.484	*	0.321	-2.121	2.805	*
63	ME	*Catopsilia pyranthe*	Mottled Emigrant	2	0.057	2	0.23	0.01	0.96	0.019	0.002	0.171	-0.87	-4.141	2.49	*	0.257	-1.919	2.051	*	-0.067	-2.624	2.259	*
64	PL	*Vanessa cardui*	Painted Lady	2	0.057	3	0.06	0	0.87	0.013	0.001	0.173	-0.382	-3.687	2.939	*	0.564	-1.426	2.689	*	0.292	-2.199	2.687	*
65	PGB	*Pseudozizeeria maha*	Pale Grass Blue	1	0.029	1	0.06	0	0.86	0.013	0.001	0.161	-0.349	-3.702	2.904	*	0.509	-1.597	2.399	*	0.322	-2.131	3.012	*

							Occupancy			Detection			Slope parameter				Slope parameter				Slope parameter			
													Elevation (α1)				Forest (α2)				Anthropogenic habitat cover (α3)			
Sr. No.	Abbr.	Scientific Name	Common Name	Pre	Naïve occupancy	Det	Mean	95% CI		Mean	95% CI		Mean	95% CI			Mean	95% CI			Mean	95% CI		
66	PD	*Telicota* sp.	Palm dart	2	0.057	3	0.07	0	0.91	0.012	0.001	0.15	-0.325	-3.499	2.943	*	0.551	-1.456	2.576	*	0.284	-2.221	2.864	*
67	PB	*Lampides boeticus*	Pea Blue	17	0.486	37	0.1	0.01	0.84	0.055	0.006	0.356	-0.932	-3.862	1.946	*	0.21	-1.726	1.881	*	-0.103	-2.414	2.062	*
68	PP	*Junonia almana*	Peacock Pansy	19	0.543	56	0.75	0.19	0.99	0.029	0.009	0.09	-1.375	-4.483	1.958	*	0.472	-1.531	2.454	*	-0.181	-2.493	2.01	*
69	PT	*Danaus chrysippus*	Plain Tiger	17	0.486	29	0.63	0.13	0.99	0.104	0.035	0.297	-0.647	-3.519	2.183	*	-0.642	-3.137	1.332	*	0.167	-1.828	2.792	*
70	PC	*Chilades pandava*	Plains Cupid	4	0.114	4	0.23	0.01	0.95	0.021	0.002	0.164	-0.971	-4.191	2.092	*	0.261	-1.783	2.144	*	0.728	-1.573	3.462	*
71	PJ	*Abisara echerius*	Plum Judy	8	0.229	16	0.35	0.03	0.96	0.03	0.006	0.119	0.713	-1.363	3.426	*	1.446	-0.087	3.786	**	-0.282	-2.875	2.003	*
72	Psy	*Leptosis nina*	Psyche	11	0.314	34	0.36	0.03	0.97	0.019	0.003	0.098	-0.87	-4.049	2.443	*	0.868	-0.755	2.914	**	-0.339	-2.971	1.877	*
73	PLB	*Amblypodia anita*	Purple Leaf Blue	2	0.057	2	0.21	0.01	0.93	0.02	0.002	0.149	0.9	-2.042	4.24	*	0.198	-2.046	2.058	*	-0.188	-2.787	2.033	*
74	RH	*Papilio helenus*	Red Helen	1	0.029	1	0.05	0	0.82	0.014	0.001	0.189	-0.335	-3.544	2.812	*	0.536	-1.445	2.571	*	0.331	-2.049	2.838	*
75	RS	*Borbo cinnara*	Rice Swift	13	0.371	20	0.06	0	0.84	0.013	0.001	0.171	-0.433	-3.571	2.874	*	0.537	-1.44	2.615	*	0.328	-2.142	2.866	*
76	RP	*Tarucus nara*	Rounded Pierrot	7	0.2	9	0.55	0.11	0.98	0.095	0.025	0.316	-0.389	-3.253	2.626	*	0.246	-1.331	1.763	*	0.776	-0.773	2.691	**
77	Rus	*Cupha erymanthis*	Rustic	2	0.057	2	0.06	0	0.87	0.014	0.001	0.183	-0.417	-3.603	2.793	*	0.507	-1.468	2.422	*	0.331	-2.273	3.069	*
78	SC	*Chilades parrhasius*	Small Cupid	4	0.114	5	0.3	0.02	0.96	0.031	0.005	0.168	-1.132	-4.325	1.993	*	0.569	-1.089	2.416	*	-0.232	-2.69	2.133	*
79	Sm_Gr_Y	*Eurema brigitta*	Small Grass Yellow	11	0.314	18	0.41	0.03	0.98	0.025	0.004	0.143	-1.203	-4.393	1.954	*	0.041	-2.198	1.852	*	0.459	-1.869	2.935	*
80	SSA	*Colotis amata*	Small Salmon Arab	6	0.171	50	0.06	0.01	0.22	0.82	0.424	0.958	-2.388	-5.234	-0.35	**	1.06	-0.031	2.409	**	-0.05	-1.337	1.12	*
81	SS	*Graphium nomius*	Spot Swordtail	4	0.114	9	0.19	0.02	0.7	0.115	0.032	0.341	0.473	-1.593	3.27	*	1.324	0.021	3.315	**	-0.57	-2.947	1.289	*
82	Spo_Gr_Y	*Eurema laeta*	Spotless Grass Yellow	11	0.314	14	0.64	0.1	0.98	0.031	0.007	0.113	-1.449	-4.692	1.627	*	0.388	-1.564	2.233	*	-0.023	-2.266	2.277	*
83	SSF	*Sarangesa purendra*	Spotted Small Flat	8	0.229	15	0.08	0	0.83	0.045	0.006	0.26	1.465	-0.765	3.932	**	0.838	-0.749	2.889	**	0.126	-2.266	2.408	*
84	ST	*Danaus genutia*	Striped Tiger	14	0.4	21	0.31	0.03	0.94	0.034	0.006	0.188	-1.054	-4.19	1.903	*	-0.063	-2.214	1.627	*	0.427	-1.703	2.942	*
85	TJ	*Graphium agamemnon*	Tailed Jay	11	0.314	18	0.05	0	0.83	0.014	0.001	0.189	-0.303	-3.712	2.902	*	0.514	-1.473	2.361	*	0.304	-2.148	2.956	*
86	Tail_Lin	*Prosotas dubiosa*	Tailless Lineblue	3	0.086	3	0.06	0	0.85	0.013	0.001	0.176	-0.329	-3.537	2.949	*	0.544	-1.384	2.542	*	0.294	-2.28	2.871	*
87	TC	*Acraea terpsicore*	Tawny Coster	3	0.086	3	0.17	0.01	0.91	0.04	0.006	0.206	-1.012	-4.223	1.964	*	0.207	-1.991	1.95	*	1.43	-0.402	4.053	**
88	TGB	*Zizula hylax*	Tiny Grass Blue	17	0.486	47	0.16	0.03	0.51	0.269	0.107	0.535	-1.281	-3.946	0.992	**	0.416	-1.019	1.793	*	1.624	0.087	3.82	**
89	Un_Hes1	*Borbo* sp.	Unid Hesperiid sp.1	1	0.029	1	0.06	0	0.84	0.013	0.001	0.154	-0.393	-3.637	2.761	*	0.55	-1.421	2.569	*	0.298	-2.338	2.895	*
90	Un_Hes2	*Borbo* sp.	Unid Hesperiid sp.2	1	0.029	1	0.06	0	0.86	0.013	0.001	0.151	-0.342	-3.538	2.949	*	0.535	-1.504	2.564	*	0.306	-2.198	2.904	*
91	Un_Lyc1	*Prosotas* sp.	Unid Lineblue	2	0.057	2	0.12	0	0.91	0.023	0.002	0.198	1.113	-1.202	3.771	*	0.767	-1.07	2.849	*	0.112	-2.416	2.532	*
92	Un_Lyc2	*Chilades* sp.	Unid Cupid	1	0.029	1	0.21	0.01	0.96	0.016	0.002	0.121	-0.814	-3.89	2.362	*	0.897	-0.812	3.074	**	-0.064	-2.515	2.264	*
93	VB	*Arnetta vindhiana*	Vindhyan Bob	1	0.029	1	0.13	0	0.94	0.019	0.002	0.146	1.157	-1.397	4.05	*	0.838	-1.014	3.046	*	0.108	-2.413	2.572	*
94	WSF	*Tagiades litigiosa*	Water Snow Flat	1	0.029	1	0.19	0.01	0.93	0.018	0.002	0.126	-0.836	-4.047	2.458	*	0.906	-0.778	2.997	**	-0.089	-2.633	2.33	*
95	WOT	*Ixias marianne*	White Orange Tip	6	0.171	10	0.13	0	0.89	0.028	0.003	0.216	-0.632	-3.796	2.455	*	0.319	-1.742	2.107	*	1.209	-0.599	3.677	**
96	Yam	*Loxura atymnus*	Yamfly	2	0.057	2	0.05	0	0.8	0.013	0.001	0.175	-0.355	-3.567	2.83	*	0.569	-1.353	2.614	*	0.327	-2.14	2.905	*
97	YOT	*Ixias pyrene*	Yellow Orange Tip	8	0.229	20	0.16	0.02	0.8	0.074	0.017	0.268	-1.427	-4.269	1.454	*	1.098	-0.256	2.942	**	-0.347	-2.577	1.627	*
98	YP	*Junonia hierta*	Yellow Pansy	6	0.171	7	0.06	0	0.87	0.013	0.001	0.177	-0.449	-3.609	2.665	*	0.486	-1.47	2.394	*	0.342	-2.127	2.97	*
99	ZB	*Leptotes plinius*	Zebra Blue	4	0.114	5	0.31	0.02	0.95	0.039	0.008	0.205	-0.828	-3.765	2.47	*	0.526	-1.13	2.232	*	-0.202	-2.621	2.119	*

Abbr – Abbreviation; Pre – Presence; Det – Detections; CI – Credible interval; *- Weak effect; ** - Moderate effect

7. Photo-plates

I. HABITATS

Semi-evergreen forest at Prabalgad

Moist-deciduous forest of Karnala Bird Sanctuary

Scrub Forest

Grassland

Mangrove

Agriculture

II. MAMMALS

Wild Boar *Sus scrofa*

Bonnet Macaque *Macaca radiata* and
Barking Deer *Muntiacus muntjak*

Common Palm Civet
Paradoxurus hermaphroditus

Ruddy Mongoose *Herpestes smithii*

Indian Mouse Deer *Moschiola indica*

Southern Plains Gray Langur
Semnopithecus dussumieri

III. BIRDS

Ashy Drongo *Dicrurus leucophaeus*

Blue-capped Rock Thrush
Monticola cinclorhyncha

Tickell's Blue Flycatcher
Cyornis tickelliae

Rose-ringed Parakeet *Psittacula krameri*

Red-breasted Flycatcher
Ficedula parva

Sirkeer Malkoha
Phaenicophaeus leschenaultii

IV. WATER BIRDS

Ruddy Shelduck *Tadornaferruginea*

Common Redshank *Tringa tetanus*

Painted Stork *Mycteria leucocephala*

Common Sandpiper *Tringa hypoleucos*

Common Teal *Anas crecca*

Lesser Flamingo *Phoeniconaias minor*

V. AMPHIBIANS

Common Indian Tree Frog *Polypedates maculatus*

Fungoid Frog *Hydrophylax bahuvistara*

Indian Bull Frog *Hoplobatrachus tigerinus*

Bombay Night Frog *Nyctibatrachus humayuni*

Asian Common Toad *Duttaphrynus melanostictus*

Ornate Narrow Mouth Frog *Microhyla ornata*

VI. REPTILES

Forest Calotes *Calotes rouxii*

Indian Chameleon *Chamaeleo zeylanicus*

Deccan Ground Gecko *Cyrtodactylus deccanensis*

Rock Gecko *Hemidactylus maculatus*

Banded Kukri *Oligodo narnensis*

Saw-scaled Viper *Echis carinatus*

VII. INSECTS

BUTTERFLIES

Common Bluebottle *Graphium sarpedon*

Common Nawab *Charaxes bharata*

Small Salmon Arab *Colotis amata*

Monkey Puzzle *Rathinda amor*

Orange-tail Awl *Bibasis sena*

Plum Judy *Abisara echerius*

ODONATES


Blue Darner *Anaximmaculifrons*Darner*Gynacantha* sp.

Spreadwing *Lestes* sp.

Bush Dart *Copera* sp.

Coromandel Marsh Dart *Ceriagrion coromandelianum*

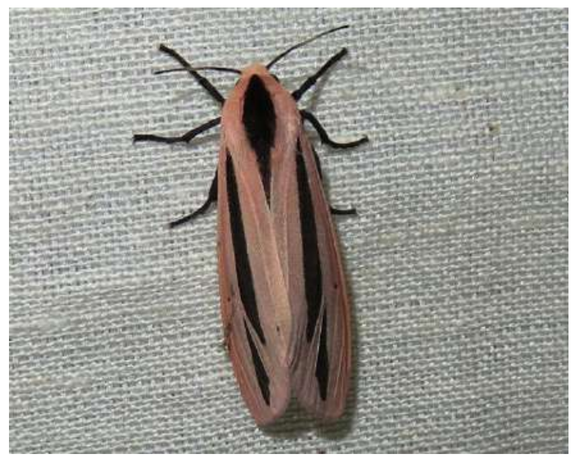
Green Marsh Hawk *Orthetrum sabina*

INSECTS AT LIGHT TRAP

Click Beetle *Lanelater* sp.

Long-horned Beetle *Celosterna spinator*

Olepa ricini



Creatonotos gangis

Parotis sp.

Maruca vitrata

VIII. FISHES

Khandalla minnow *Parapsilorhynchus tentaculatus*

Schistura denisoni

Giant Danio *Devario aequipinnatus*

Striped panchax killifish *Aplocheilus lineatus*

Systomus sarana subnasutus on top left, African cichlid *Oreochromis mossambicus* and deformed specimen of Silver carp *Hypophthalmichthys molitrix*.

IX. PLANTS

Ghela *Catunaregam spinosa* (Thunb.)

Anjani *Memecylon umbellatum* Burm. F.

Tivar *Avicennia marina* (Forssk.)Vierh

Kumkum *Mallotus philippensis* (Lam.)Müll. Arg.

Jambhul *Syzygium cumini* (L.) Skeels

Ain *Terminalia elliptica* Willd.

ANNEXURE-XIV (A)

PART – II: CONSERVATION AND PRESERVATION PLAN

BASELINE DOCUMENTATION OF FLORA AND FAUNA OF KARNALA BIRD SANCTUARY (KBS) AND NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT AREA FOR PREPARATION OF CONSERVATION AND PRESERVATION PLAN)

BASELINE DOCUMENTATION OF FLORA AND FAUNA OF KARNALA BIRD SANCTUARY (KBS) AND NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT AREA FOR PREPARATION OF CONSERVATION AND PRESERVATION PLAN - PART II

BASELINE DOCUMENTATION OF FLORA AND FAUNA OF KARNALA BIRD SANCTUARY (KBS) AND NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT AREA FOR PREPARATION OF CONSERVATION AND PRESERVATION PLAN

PART - II

CONSERVATION AND PRESERVATION PLAN

Dr. Deepak Apte

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Sameer Bajaru

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The land use and land cover table (Table 1) clearly shows that a very small proportion of the study site is covered with primary and less disturbed forest (semi-evergreen forest, moist deciduous forest and mangrove, 9%) while 24 % is occupied with degraded forest (scrub and grassland) and the remaining 67 % constitute settlement and agriculture (Map 1). Similarly, the landscape is also covered with a small amount of primary and less disturbed forest (9%), followed by degraded forest (40 %) and settlement and agriculture (51%). In contrast to percentage cover, if we look at the actual area under

Table 1. Land use and land cover types in the study area and the landscape.

	Study Site Area*		Landscape Area*	
	Ha	**%**	**Ha**	**%**
Settlement	10423	31	21028	11
Agriculture	11083	33	76281	39
Grassland	1584	5	20160	10
Scrub	6555	19	58212	30
Moist Deciduous Forest	1542	5	10788	5
Semi-evergreen Forest	0.1	0.1	1367	1
Mangrove	1571	5	5353	3
Water	1247	4	4000	2
	34,007		**1,97,189**	

** Please refer section 2.1 in part I report for more details of study site and landscape.*

primary and less disturbed forest between the study site and landscape, the increase is about seven fold for moist-deciduous forest, from 1542 ha to 10778 ha, and more than thousand fold for semi-evergreen forest, from 0.1 ha to 1367 ha. Therefore, priority should be given for the conservation of these last remaining primary and less disturbed forests at the study site as well as the landscape.

Unlike the primary and less disturbed forests, degraded forests occupy considerably large areas – for example 8140 ha in the study site and 78,372 ha in the landscape (Table 1). This degraded forest is a direct consequence of the clearing of the original moist-deciduous and semi-evergreen forests. Though these disturbed forests are in various stages of degradation and have lost their original diversity, we must consider their restoration in order to increase total forest cover and maintain integrity and connectivity among currently isolated patches of primary forests in the landscape. Based on the distribution of the primary forest cover, degraded forest cover, human habitation and terrain, we identified four key links and associated corridors which connect key species richness areas in this landscape (Map – 2).

The key links are the areas that have lost their primary forest and are generally covered with scrub, agriculture and human settlement. Their restoration will be crucial to maintain the functionality of the corridors. The corridors, on the other hand, are larger than the key links; they are mainly covered with a mosaic of primary and degraded forests, and they are generally small hill ranges or offshoots of a large hill range. In addition to the preservation of key links, the functionality of corridors will depend on the restoration of degraded forests and conservation of primary forests in the corridors.

1. Key Link 1: It would connects Karnala Bird Sanctuary (KBS) and Manikgad hill range (Map – 3). It is a narrow strip of about 1.5 km length and 0.5 km width, located on the west of Apta and north of Sarsai and Kaliwali villages. It is covered with scrub, almost no settlement and a small part is occupied by agricultural fields, mostly on the banks of the Patalganga River which passes through this link. In addition to this, the Savroli-Karpada road and a train track cross this link.

2. Key Link 2: It would connects Manikgad hills with a hill range which is has branched off from main ranges of the northern Western Ghats at Khandala and Lonavala (Map – 4). It is narrow strip of about 800 m length and 350 m width, situated on the south of Karambeli Chattishi, north of Gagode Budruk and northwest of Shedashi villages. It is a highly disturbed area, devoid of forest cover, occupied with agriculture (mostly seasonal) and grassy patches, and flanked by settlements. Pen-Khopoli road and distributary of the Patalganga River pass through this link.

3. Key Link 3: It would connects KBS with Prabalgad–Matheran–Malanggad Hill Range (Map – 5). It is approximately spread across 2.35 km in length and 0.7 km in width, located between Bhinganwadi and Bhingar villages. This link is also disturbed and Shedung village situated in the link is covered largely with agricultural fields, followed by scrub and settlements. This link is traversed by two main highways – Mumbai–Pune expressway and NH 48 highway.

4. Key Link 4: It would connects Prabalgad–Matheran–Malanggad Hill Range with the main mountain ranges of the northern Western Ghats at Khandala and Lonavala

(Map – 6). It is about 2.40 km in length and 0.7 km in width, situated on the west of Karjat and east of Pali Budruk. It is mainly covered with scrub and grasslands, and partly by agriculture. The Karjat–Murbad road passes through this link.

In addition to the key links and corridors, we also identified three key species-rich areas based on the predictions of the multi-species occupancy model using percentage of forest (primary and less disturbed) cover and elevation as predictors in 1 sq. km grid across the landscape (Report Part I – Chapter 1 to 6, Map - 7). Though we used mammals, birds, amphibians, reptiles and butterflies as representative taxa for determining these species-rich areas, other taxa such as plants, fishes and invertebrates are likely to show similar pattern of species richness distribution (Map – 8 to 12). In addition to this, a forth key area comprising marine fauna was determined based on qualitative and quantitative data collected in this study.

1. Prabalgad–Matheran–Malanggad Hill Range: This is the most species-rich area in this landscape. It is covered with semi-evergreen forest, hence endemic and evergreen forest specialist plants and animals of the Western Ghats are restricted to this area in the landscape. Among all, it is the highest priority area for conservation.

2. Karnala Bird Sanctuary: It is already a protected area and one of the very few remaining undisturbed forests in the Konkan region. Mainly it is covered with moist-deciduous forest but evergreen woody plants are found in the riparian zone. It is comparatively less species rich than Prabalgad–Matheran–Malanggad Hill Range.

3. Manikgad: It is a well-known fort, located on the south of KBS. Along with historical importance, it is also a species rich area of the landscape. The habitat and species richness of Manikgad is comparable with KBS.

4. Karanja–Boripakhadi–Panvel Creeks –These areas are degraded and have lost contiguity, especially of the mangroves, and are under tremendous pressure of urbanisation, even though scattered marine species-rich patches with low disturbances are recorded.

Apart from species richness, this landscape harbours many threatened and schedule species. In this study, about 32 Schedule I species were recorded, among which 23 were birds followed by 4 species of mammals, 4 species of insects and a species of reptile (Table 2). However among 14 species belonged to Schedule II, of which 11 were mammals. In addition to this, two Schedule III species were observed. A critically endangered plant and an endangered bird, amphibian and freshwater fish were also recorded. Apart from this, 14 vulnerable species were noted, among which 5 were birds and 4 were plants. Similarly, 13 species belonged to near threatened category, of which 9 were birds.

Table 2. Number of species (TNS), Wildlife (Protection) Act, 1972 (WPA) status, IUCN (International Union for Conservation of Nature) red list status of the species recorded in this study.

	TNS	**WPA Status**			**IUCN Status**			
		I	II	III	CR	EN	VU	NT
Mammals	26	4	11	2	-	-	2	1
Birds	280	23	-	-	-	1	5	9
Amphibians	16	-	-	-	-	1	2	-
Reptiles	36	1	1	-	-	-	-	-
Insects	176	4	2	-	-	-	-	-
Plants	241	-	-	-	1	-	4	-
Freshwater Fishes	36	-	-	-	-	1	1	3
Marine Invertebrates	238	-	-	-	-	-	-	-
Total		32	14	2	1	3	14	13

I - Schedule I; II - Schedule II; III - Schedule III; CR - Critically Endangered; EN - Endangered; VU - Vulnerable; NT - Near Threatened

Please refer annexures in part I of the report for more details

Though species rich and part of the Western Ghats, Mumbai Metropolitan Region (MMR) is one the highly developing regions in the World. Mumbai Metropolitan Region Development Authority (MMRDA), the planning authority for MMR, has predicted in their 40-year concept plan that the city would have 44 million (current population - 20.7 million) inhabitants by 2052, spread over 1050 sq. km, which is almost double the present area of 603 sq. km. This indicates that anthropogenic pressure on the natural habitats in the landscape, which are already under huge stress, would increase by manifolds in the near future and adversely affect many species.

The findings of our study clearly suggested that a large number of species will be negatively impacted by the conversion of forest or degraded forest into anthropogenic habitat cover (settlement and agriculture). All species of mammals (25 species) and amphibians (16 species) showed negative impact of the anthropogenic habitat cover on their occupancies. Among them 52 % of the mammal species (13 of 25 species) and an amphibian species showed significant negative impact. They were followed by reptiles (35 of 36 species) and birds (115 of 135 species), which depicted negative impact of the anthropogenic habitat cover; 27.77% of the reptiles (10 of 36 species) and 7 % of the birds (9 of 135 species) showed significant negative impact. Among all these groups, butterflies appeared to be less impacted, with only 31 % (31 of 99 species) showing non-significant negative impact of the anthropogenic habitat cover. While looking at the current pace of urbanisation in this landscape and the future development plan of MMR, we suspect that a large number of species would become locally extinct from this landscape, unless we take immediate strict conservation actions.

We recommend the following actions to conserve the biodiversity of Navi Mumbai International Airport (NMIA) area, and minimise damages to the wildlife found in the NMIA area in particular and the landscape in general.

1. The immediate concern related particularly to the NMIA project is the populations of waterbirds close to the airport site. These are six major sites – NRI (Non-residential Indian) complex, Delhi Public School (DPS), Training Ship Chanakya (TSC), Panje, NSPS (Nava Sheva Police Station) and Jasai where large aggregations of birds are observed. NRI, TSC and DPS are very close to the airport site (6 km aerial distance) and though the birds inhabit these sites throughout the year, a large number of the individuals are seen in December and January; on the other hand, birds of Panje, NSPS and Jasai showed decline and these sites are comparatively at a longer distance from airport site (15 km), hence are of little concern.

Our study indicates that there is a high probability of bird movement between the study sites and it appears that tidal height and water depth in temporary water pools created by local fishermen govern this movement. The movement of tidal birds is very high during high tide and they congregate at these sites to feed and rest. During our study, apart from tidal birds, there were large populations of non-tidal birds, which moved less between the sites as they did not depend on the tide, at NRI and Panje.

In a single day, the average maximum numbers of birds counted (including all the sites) were about 10,861; therefore looking at this large numbers of birds and their local movement, we advise NMIA authority that they should be cautious during high tide and in December to February so as to avoid bird hit calamities (Please refer chapter 3 in part I of the report).

We recommend encouraging the local people to maintain existing and potential waterbird habitats close to the mudflats to the extent possible at a safe distance from the airport activity zone, preferably towards Uran and Nerul. Mangrove Foundation can also help local people in developing these habitats. Creation of such artificial habitats at multiple and evenly-distributed sites may reduce the large congregations and mass movements of the birds at particular sites, especially those close to the airport area. These sites can also be developed as bird tourism centres in cooperation with local villages for the long-term sustainability of this initiative. BNHS could play an important role in the development of habitats and in capacity-building among local people to act as guides. CIDCO could provide the financial support for this initiative for a long-term to promote sustainable conservation of waterbirds in the coastal region of this landscape.

2. We strictly suggest that CIDCO should protect and conserve following biologically important habitats,

A. Wetland - NRI (Non residential Indian) complex, Delhi Public School (DPS), Training Ship Chanakya (TSC), Panje, NSPS (Nava Sheva Police Station) and Jasai where large aggregations of birds are observed.

B. Key links and corridors in the landscape identified in this study.

C. Karnala Bird Sanctuary and notified Ecological Sensitive Zones.

Maintaining the current state of this landscape especially wetlands and Protected Areas is absolutely essential for the air safety of upcoming Navi Mumbai International Airport (NMIA). Any changes in the current state of these areas will result into more erratic movement of the birds in the landscape between feeding and roosting sites and will jeopardise the air safety of NMIA.

3. CIDCO should provide the financial support for building infrastructure in existing protected sites such as KBS and Matheran. Actions that can be taken up under this initiative are:

i) Provide patrolling vehicle, advanced communication equipment, GPS, camera traps, binoculars, cameras, field guides, mobiles with wildlife monitoring apps and field accessory to guards.

ii) Build capacity of the forest staff, local NGOs and wildlife enthusiasts for monitoring wildlife in this landscape.

iii) Develop interactive and creative nature interpretation centres at KBS and Matheran.

4. CIDCO should support the Forest Department of Maharashtra and BNHS financially to restore degraded habitats in the identified corridors, key links and species rich areas. Actions that can be taken up under this initiative are:

i) Create awareness among people and policy makers about the importance of the natural habitats in this landscape and the need to conserve them.

ii) Reduce anthropogenic pressure on the existing habitats by providing alternatives for fuel wood and fodder.

iii) Build capacity among the forest staff and local people to develop nurseries of native moist-deciduous or semi-evergreen trees for restoring the degraded habitats.

iv) Encourage private land owners in areas of conservation importance to take up conservation, especially those with agricultural lands and wastelands and plant native trees grown in local nurseries (developed as part of this initiative); in addition, they could get incentives and conduct ecotourism activities.

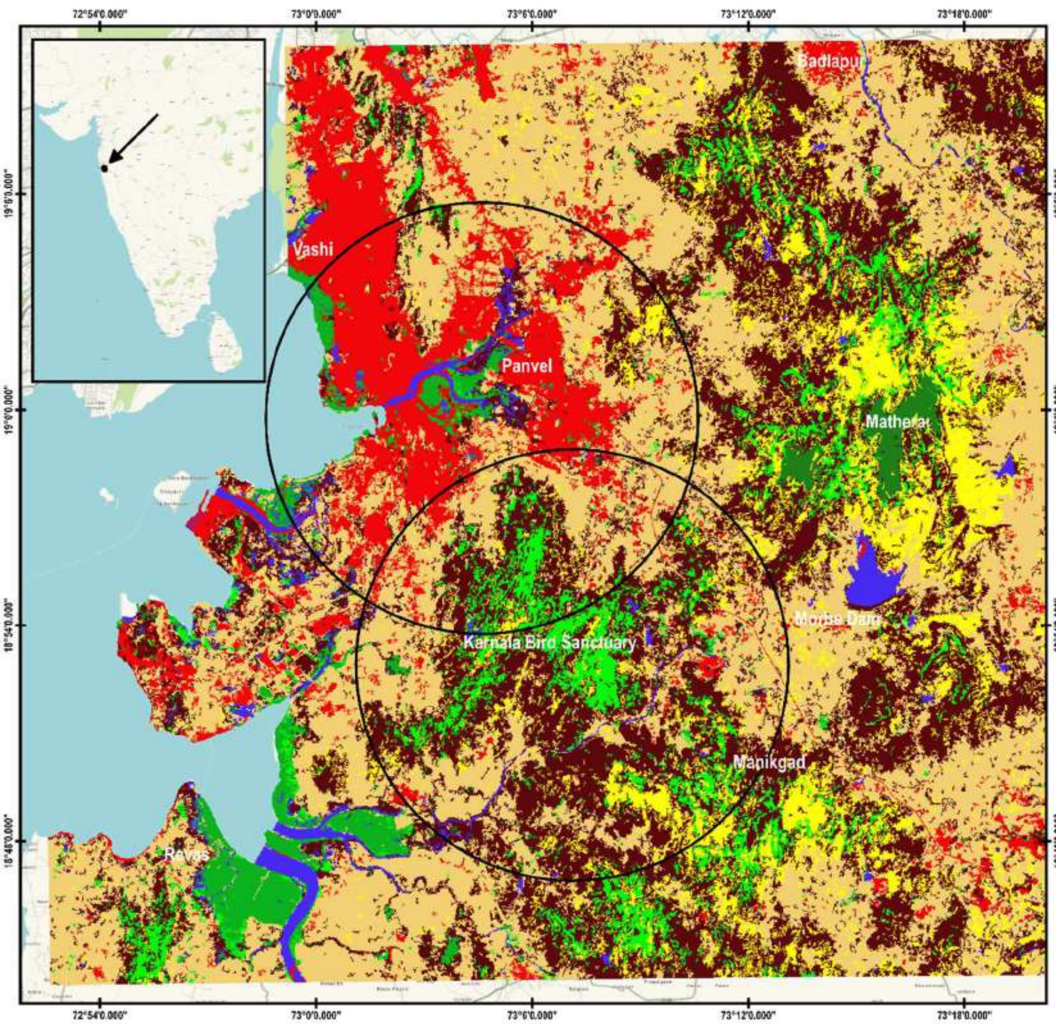
5. While looking at the proposed plan of CIDCO and the pace of development in this region, we recommend that CIDCO should provide financial support to for continuation of the present research work, which would involve

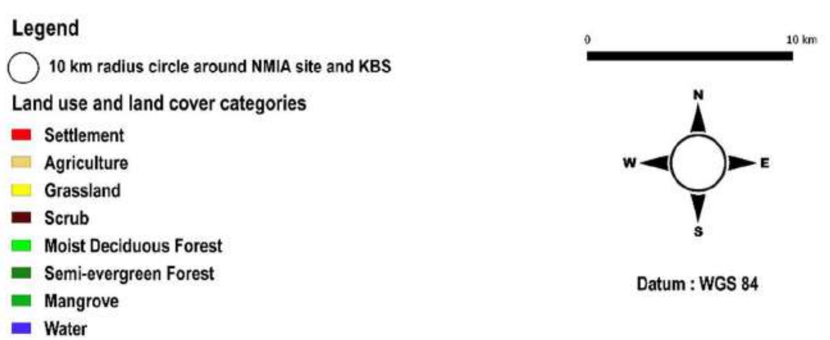
i) Rigorous assessment of the functionality of the proposed key links and corridors through advanced techniques such as camera trapping, DNA sequencing and GPS tracking.

ii) Development of high resolution GIS maps and their integration with the data collected from advanced techniques, which can be used to construct robust and realistic biodiversity conservation models in this landscape.

MAP - 1

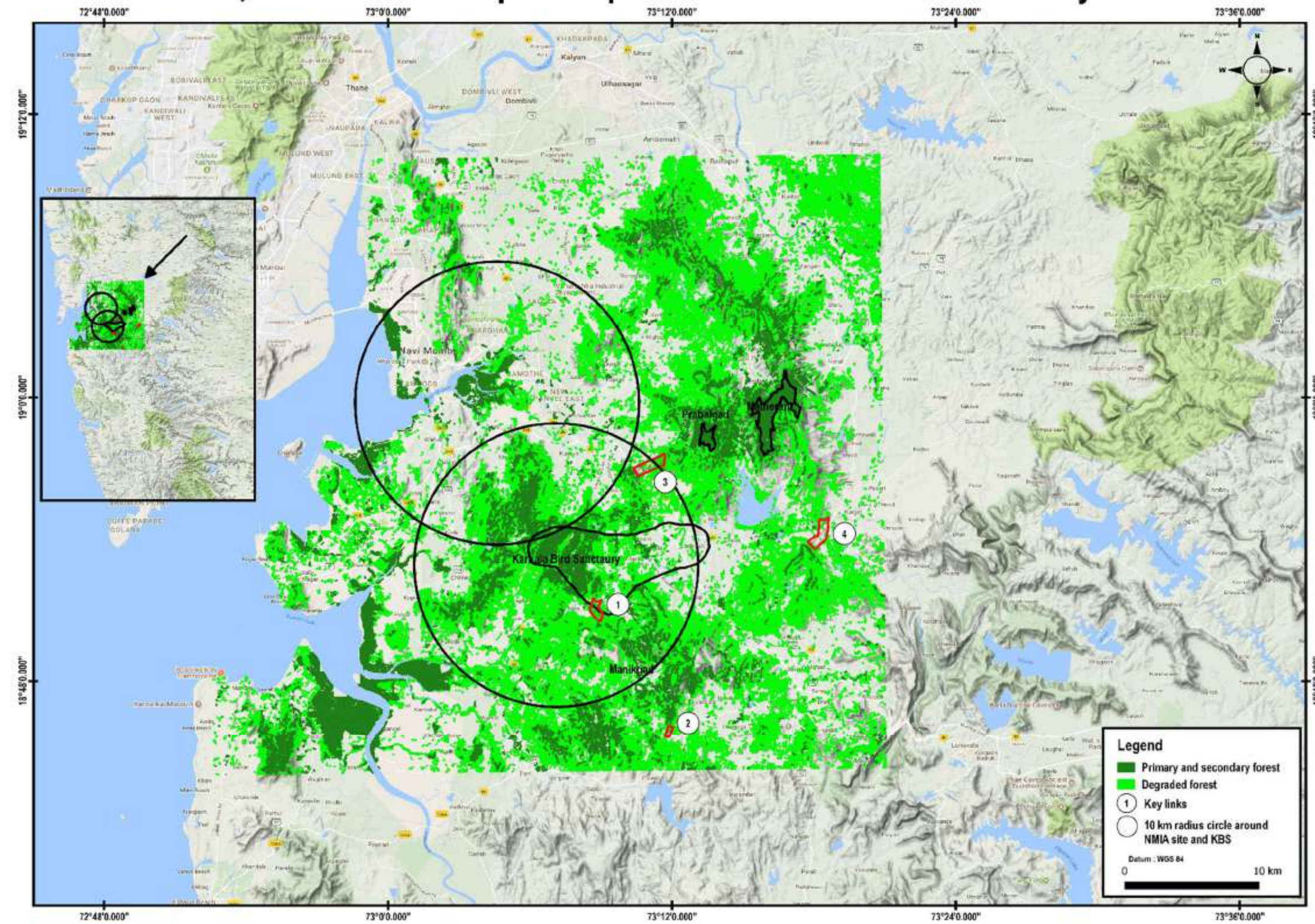
Land use and land cover map of NMIA site, KBS and landscape





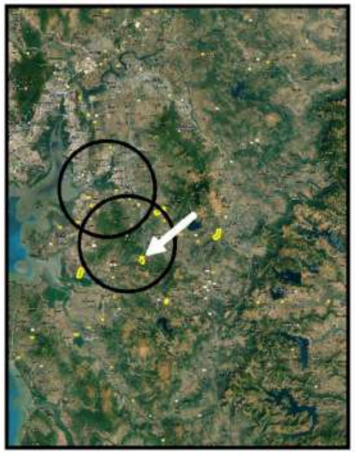
MAP - 2

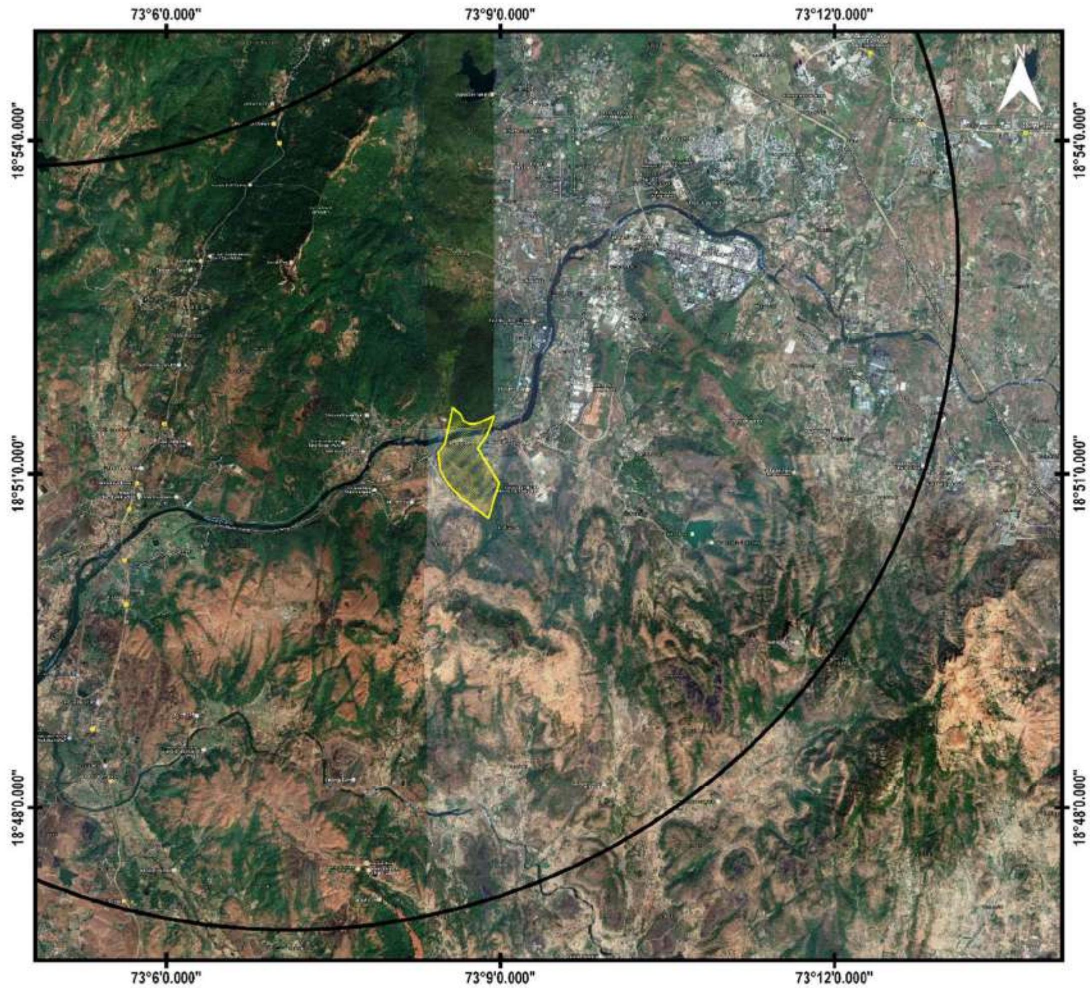
NMIA site, KBS and landscape with potential wildlife corridors and key links



MAP - 3

Key Link - 1





Legends

10 km radius around NMIA site and KBS

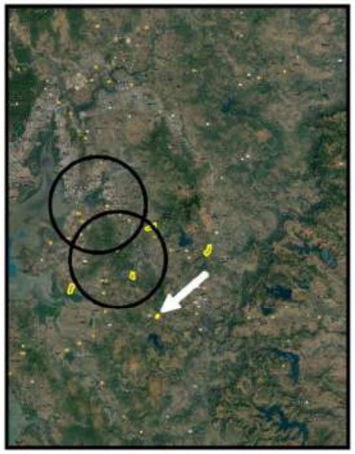
Potential wildlife corridor

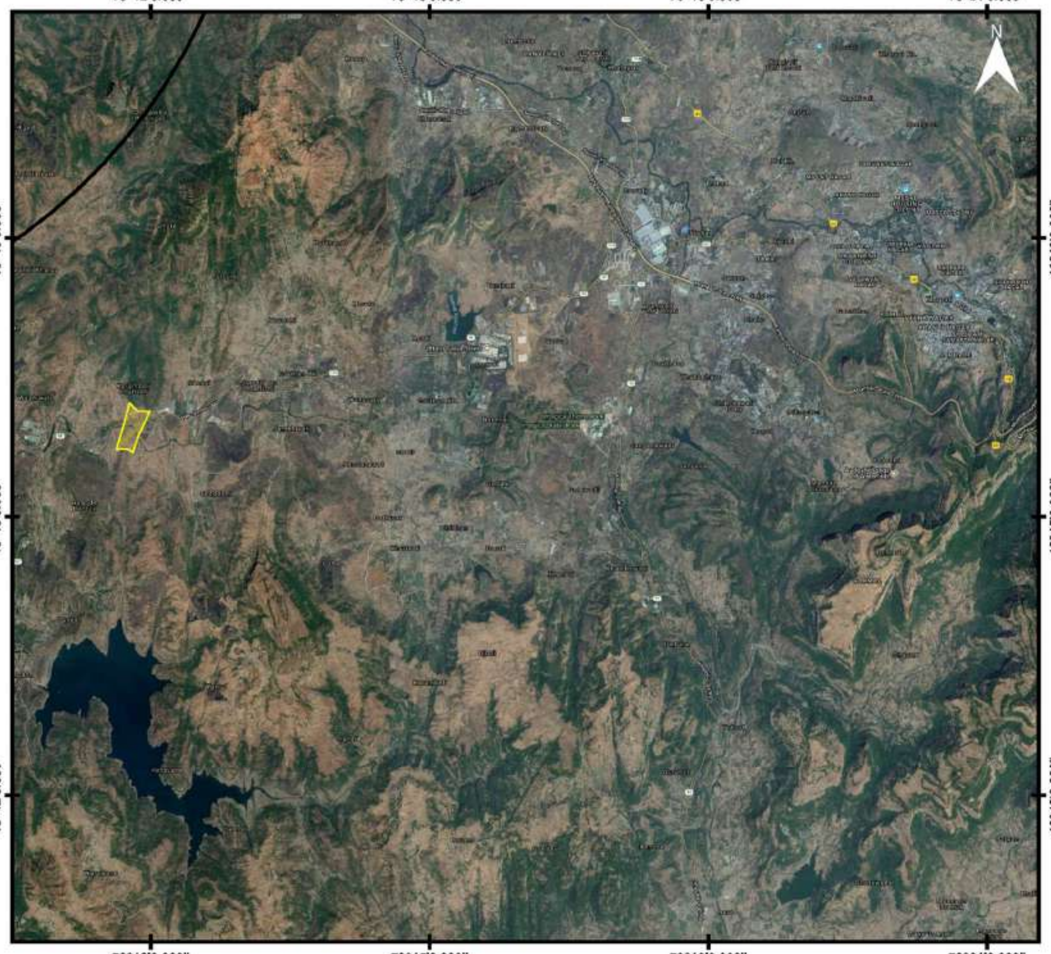
Datum : WGS84

0 4 km

MAP - 4

Key Link - 2





Legends

10 km radius around NMIA site and KBS

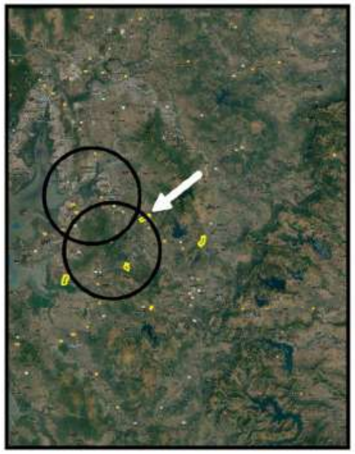
Potential wildlife corridor

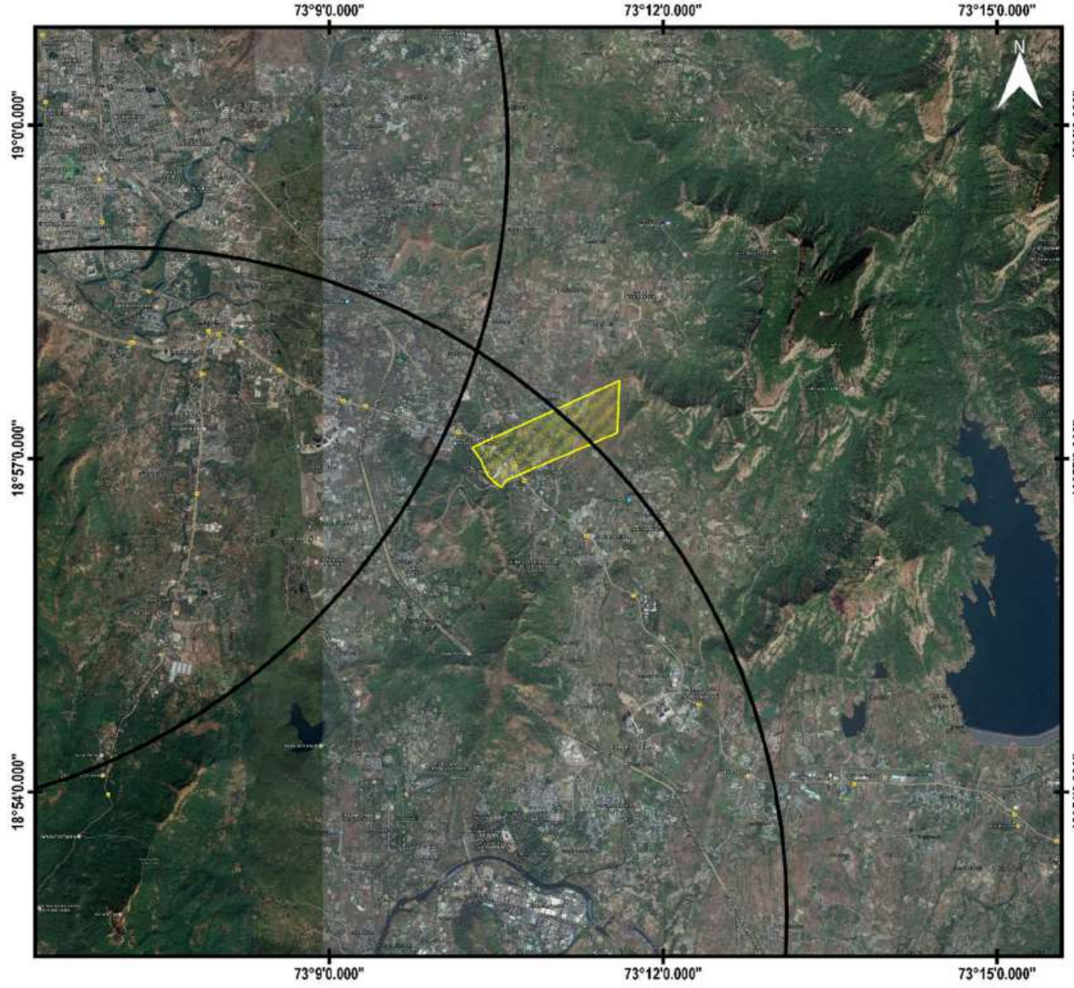
Datum : WGS84

0 5 km

MAP - 5

Key Link - 3





Legends

10 km radius around NMIA site and KBS

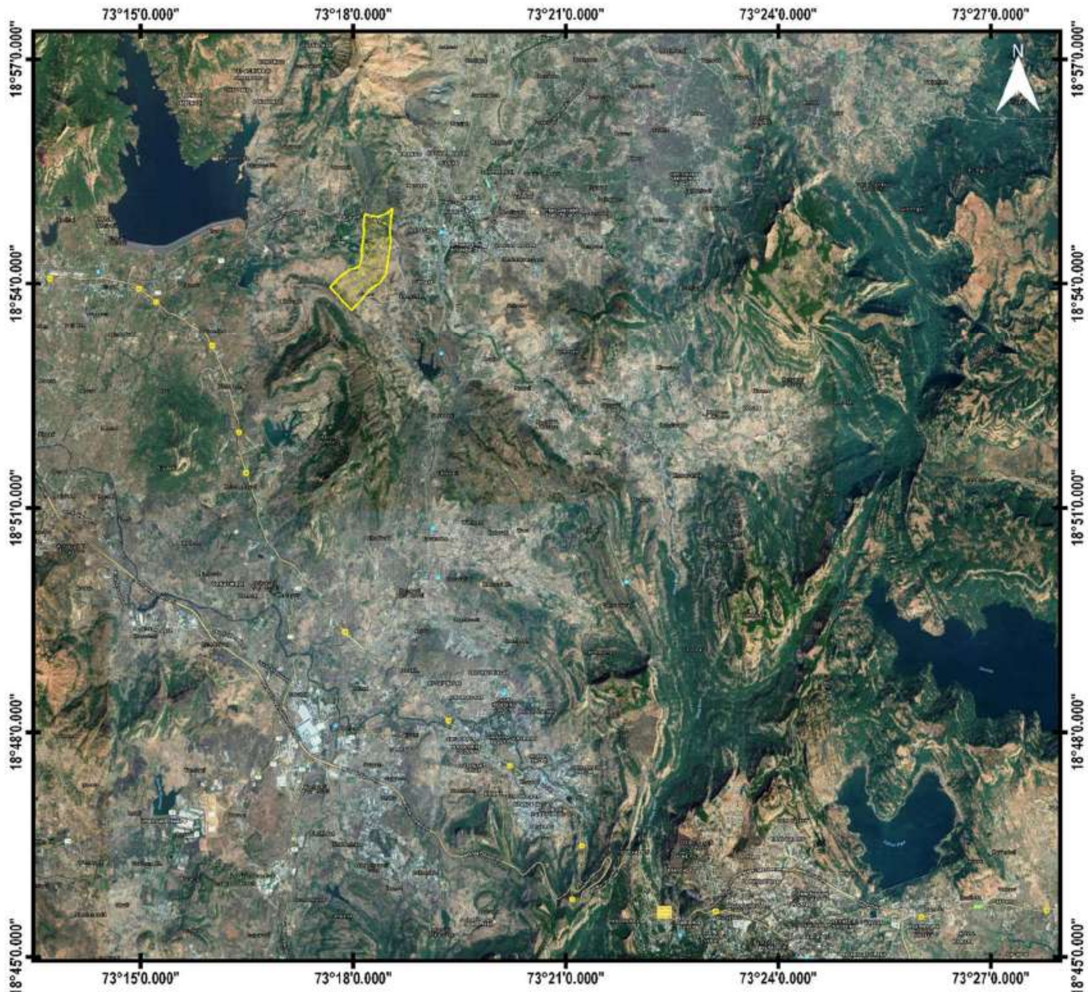
Potential wildlife corridor

Datum : WGS84

0 4 km

MAP - 6

Key Link - 4



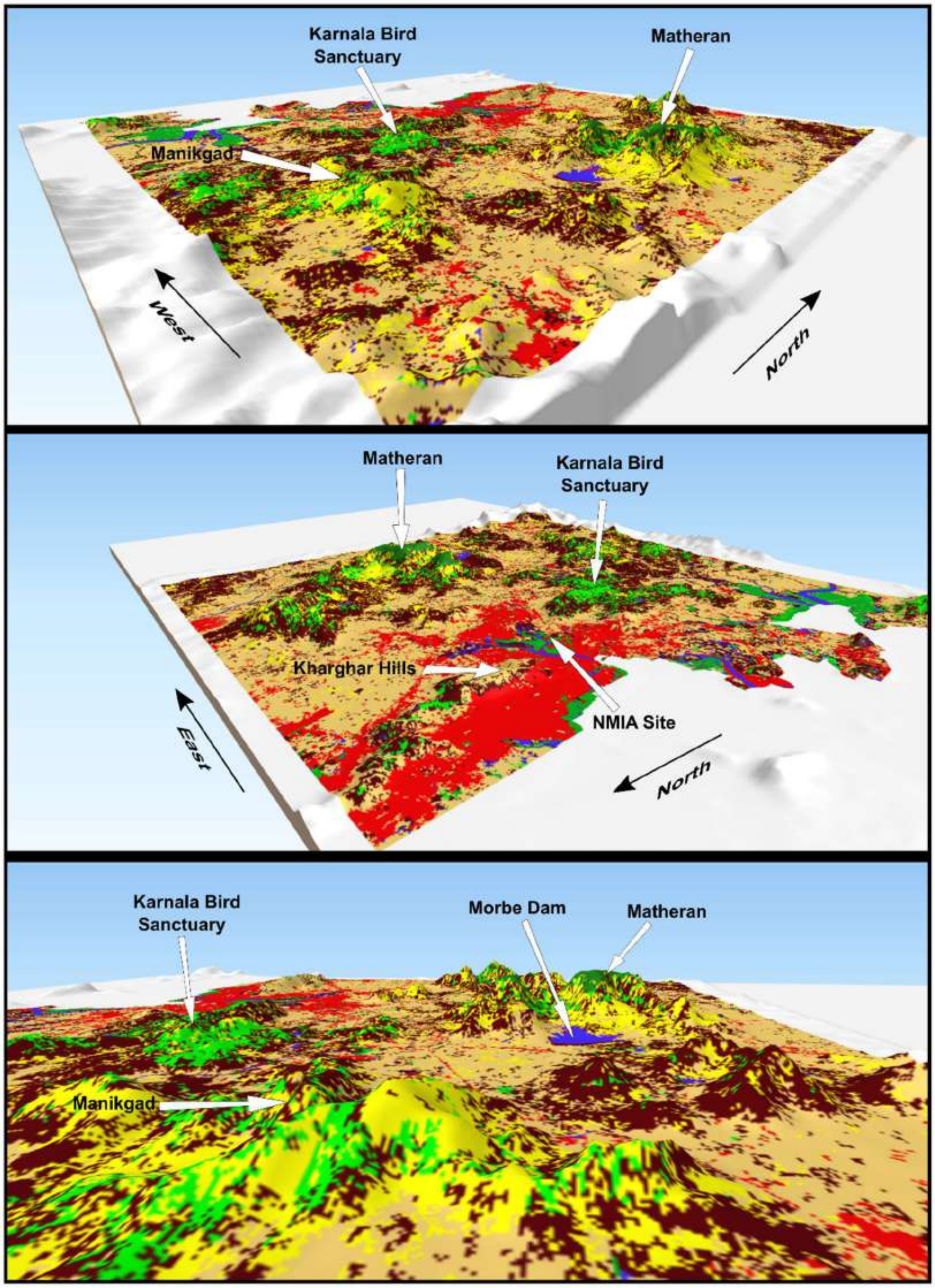
Legend

Potential wildlife corridor

Datum : WGS84 / UTM Zone 43N
Scale : 1,00,000

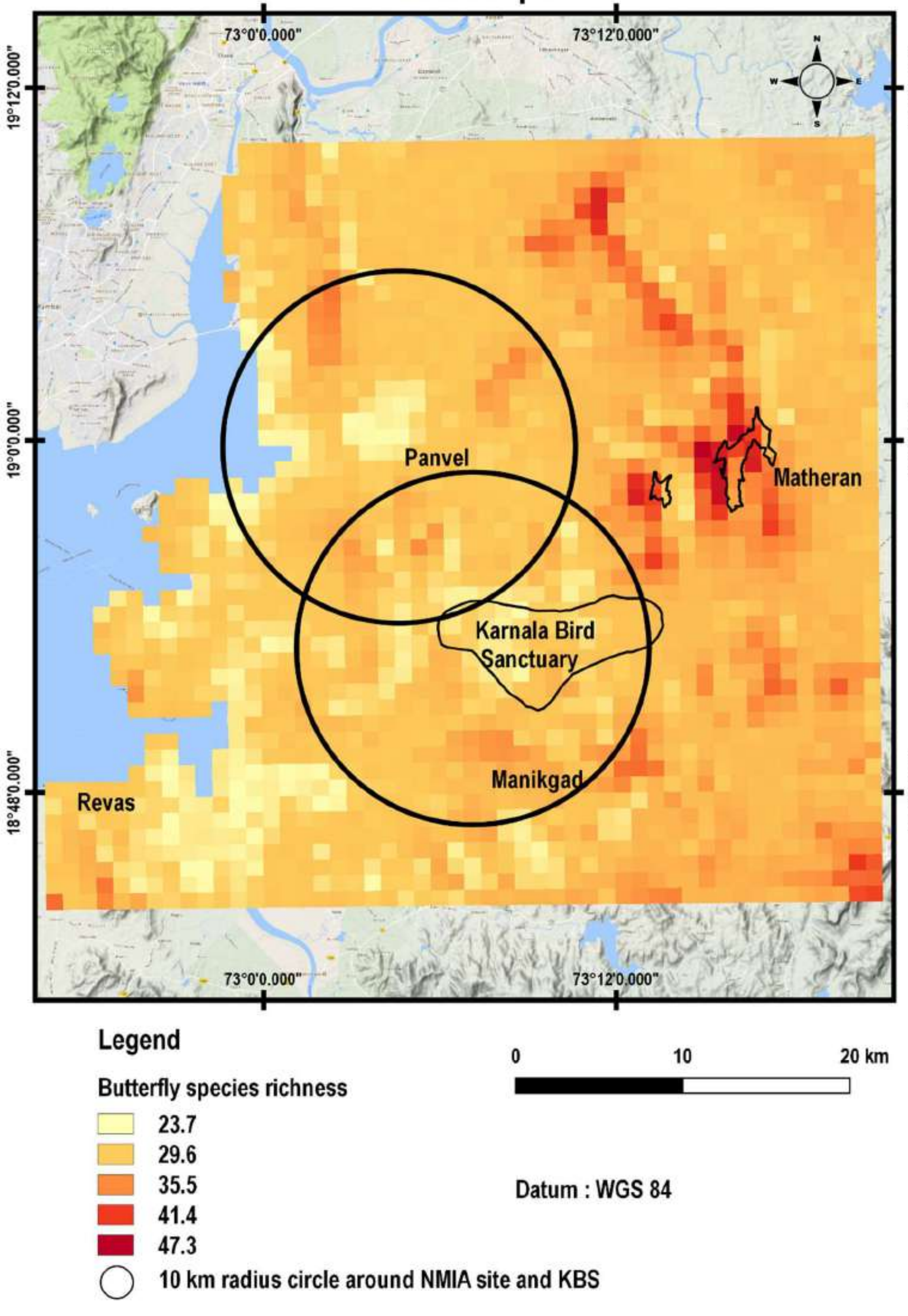
0 6 km

MAP - 7
3D visualisation of the landscape



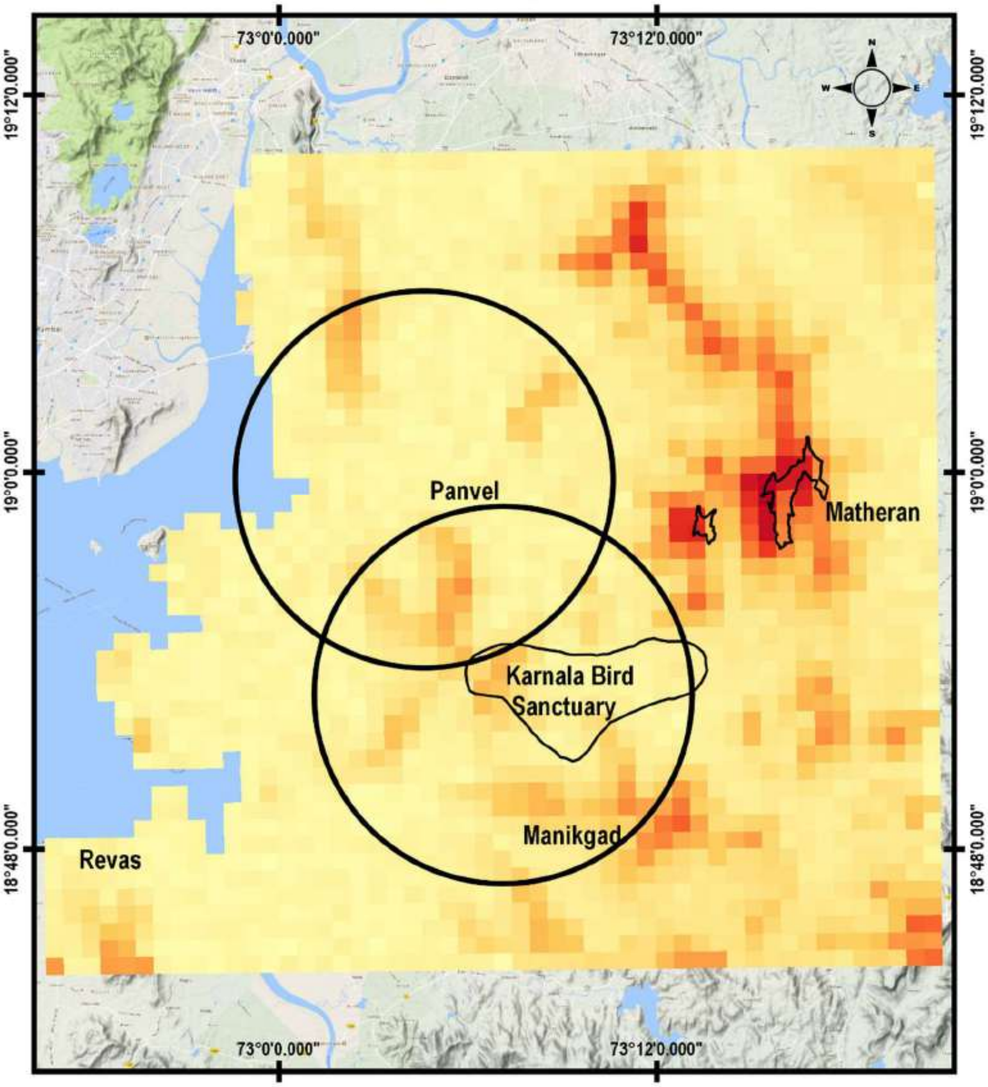
MAP - 8

Butterfly species richness map of NMIA site, KBS and landscape



MAP - 9

Amphibian species richness map of NMIA site, KBS and landscape



Legend

Amphibian species richness

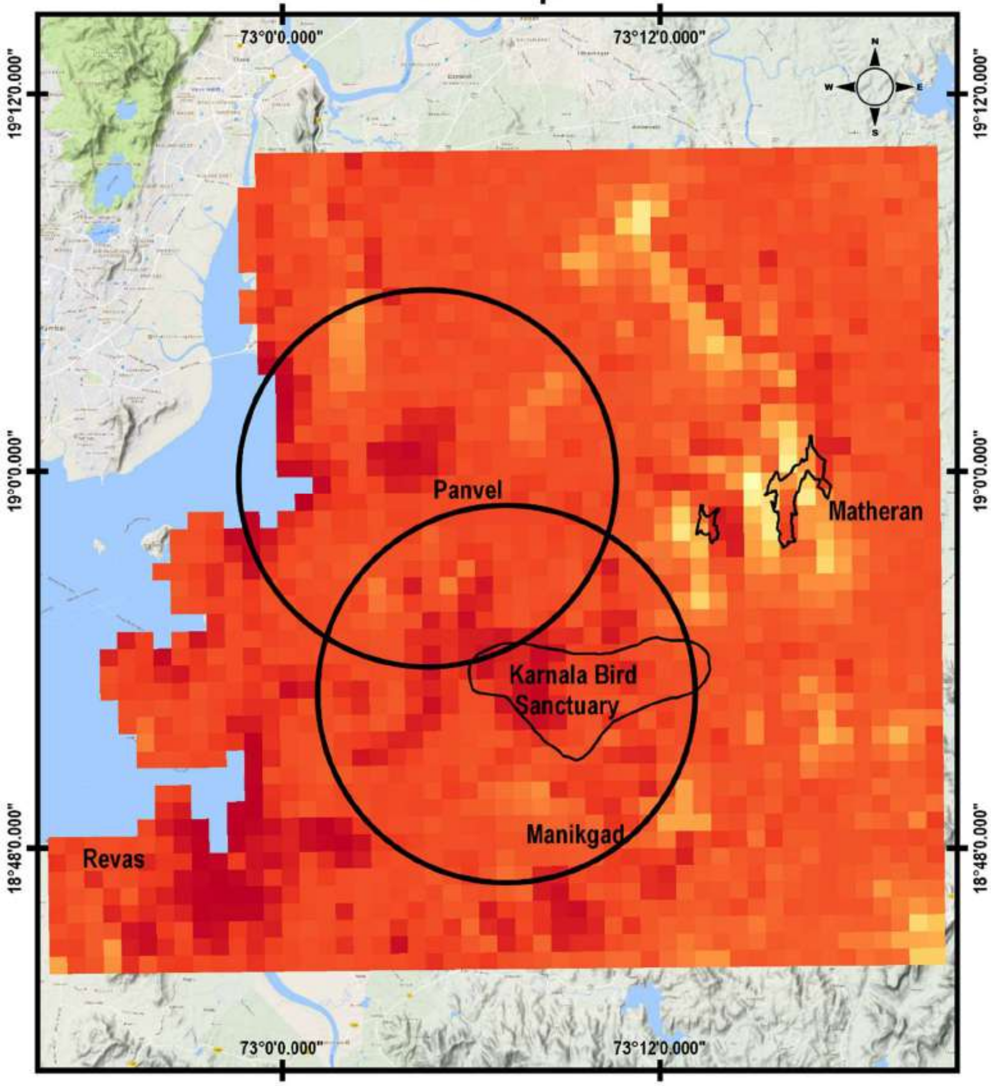
- 3.55
- 5.16
- 6.78
- 8.39
- 10
- 10 km radius circle around NMIA site and KBS

0 10 20 km

Datum : WGS 84

MAP - 10

Reptile species richness map of NMIA site, KBS and landscape



Legend

0 10 20 km

Reptile species richness

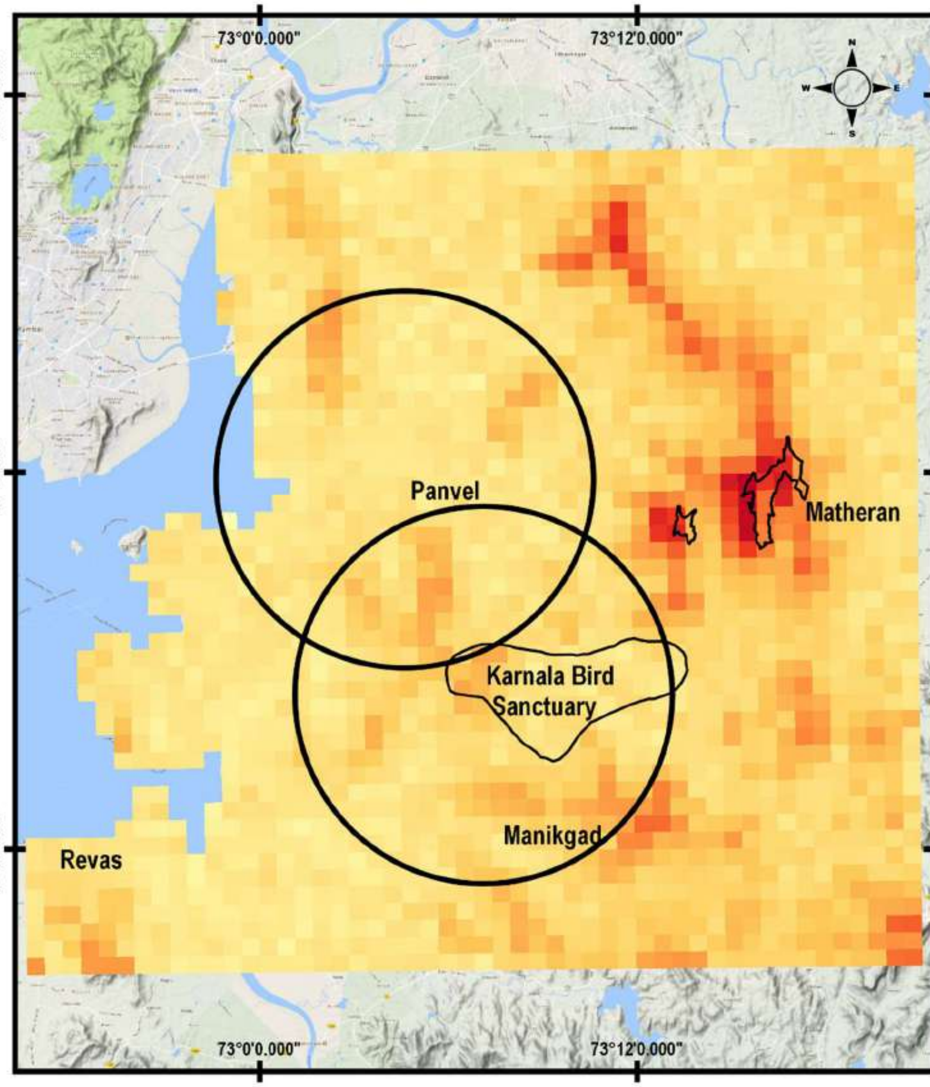
- 17.5
- 19.9
- 22.2
- 24.6
- 27

10 km radius circle around NMIA site and KBS

Datum : WGS 84

MAP - 11

Bird species richness map of NMIA site, KBS and landscape



Legend

Bird species ricnhess

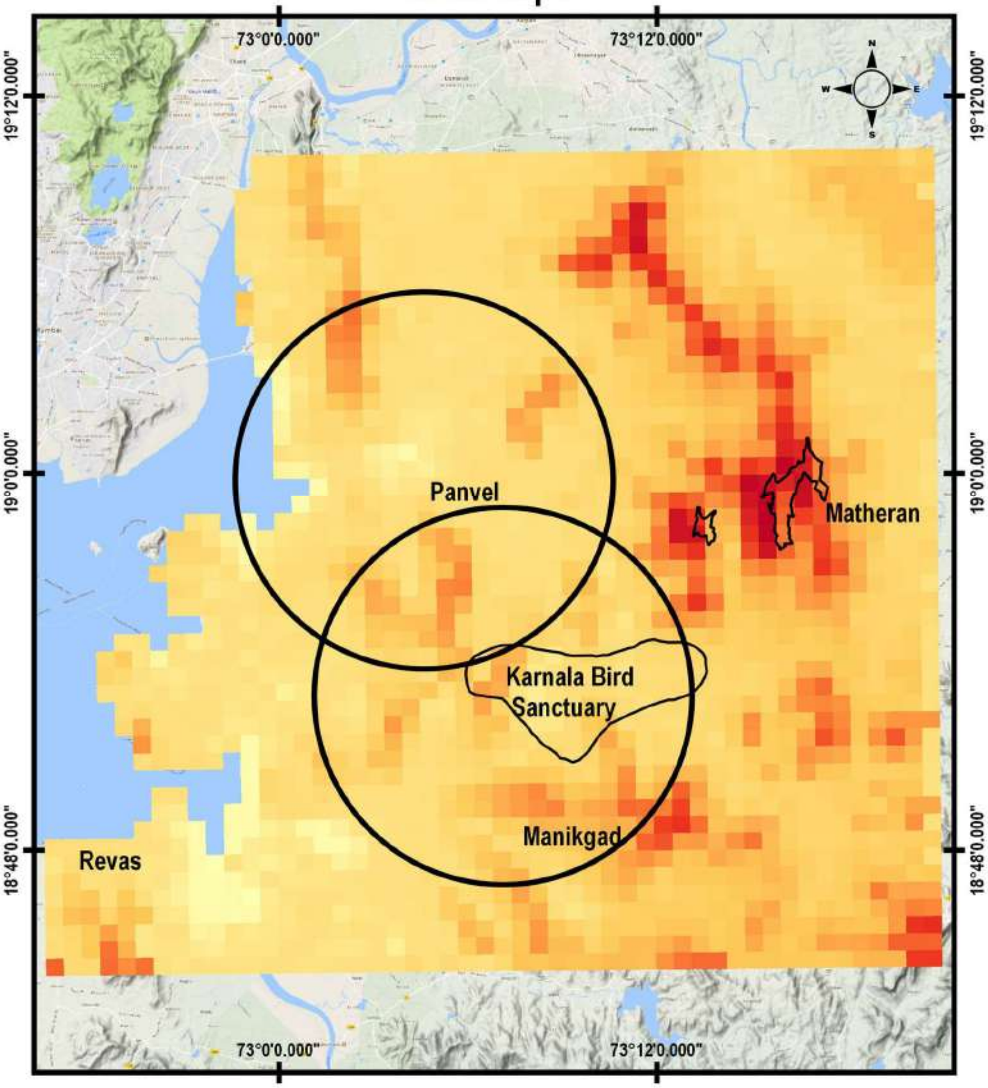
- 62.84
- 65.56
- 68.27
- 70.98
- 73.7
- 10 km radius circle around NMIA site and KBS

0 10 20 km

Datum : WGS 84

MAP - 12

Mammal species richness map of NMIA site, KBS and landscape



Legend

Mammal species richness

- 7.32
- 10.8
- 14.3
- 17.8
- 21.3
- 10 km radius circle around NMIA site and KBS

0 10 20 km

Datum : WGS 84

ANNEXURE-XV
PREPARATION OF LOCAL LEVEL COASTAL REGULATION ZONE MAP FOR THE PROPOSED NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) IN NAVI MUMBAI, RAIGAD DISTRICT, MAHARASHTRA

(Project Ref No. F.No. AU/IRS/KSR/222-2021
Dated 19th January, 2021)

RESTRICTED DOCUMENT

NO.IRS/AU/IRS/KSR/ 222-2021 DT 19.01.2021

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Navi Mumbai International Airport(NMIA) in Navi Mumbai, Raigad District, Maharashtra

SPONSORED BY

M/s Navi Mumbai International Airport Private Limited (NMIAL)
Director- Urban Planning, Terminal 1B,
Chhatrapati Shivaji Maharaj International Airport,
1st Floor, Santacruz(E) - Mumbai 400 099

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY, CHENNAI-25

JANUARY 2021

Project Data Sheet

Title	Preparation of Local Level Coastal Regulation Zone Map for the Proposed Navi Mumbai International Airport(NMIA) in Navi Mumbai, Raigad District, Maharashtra
Project Ref No.	AU/IRS/KSR/222-2021 DT. 19.01.2021
Funded by	M/s Navi Mumbai International Airport Private Limited (NMIAL), Director- Urban Planning, Terminal 1B, Chhatrapati Shivaji Maharaj International Airport, 1st Floor, Santacruz(E) - Mumbai 400 099
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Report Preparation	Dr. K.Srinivasa Raju, Associate Professor
Quality Assessment Team	Dr. R.Vidhya, Professor Dr. K.Srinivasan, Assistant Professor Mrs.M.Navamuniyammal, Asst. Professor

The Quality Assessment Committee for consultancy projects has scrutinized the local level CRZ map and corresponding text report of the above project on 21.01.2021. The principal consultant of the project has presented the approach adopted, findings of the study to the committee. The committee has evaluated the CRZ Map and the report for different parameters against the standards prescribed for the mapping. The positional accuracy, attribute accuracy, completeness, semantic accuracy of the output were assessed and found satisfactory. The committee recommends the approval of the map and associated report

Dr. K.Srinivasa Raju
(Principal Consultant)

Dr.R.Vidhya
(QAC Member)

Dr.K.Srinivasan
(QAC Member)

Mrs.M.Navamuniyammal
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29/1/21

DIRECTOR, IRS

Director
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Executive Summary

Institute of Remote Sensing, Anna University, Chennai has taken up the task of preparing local level Coastal Regulation Zone (CRZ) Map in the vicinity of proposed Navi Mumbai International Airport site on the request of the M/s Navi Mumbai International Airport Private Limited (NMIAL), Director-Urban Planning, Terminal 1B, Chhatrapati Shivaji Maharaj International Airport, 1st Floor, Santacruz (E) - Mumbai 400 099. Navi Mumbai International Airport limited (NMIAL) has been appointed as the Concessionaire for the development of Navi Mumbai International Airport (NMIA) with CIDCO, Navi Mumbai as a partner. The objective of the project is to superimpose the proposed development activities of NMIA in Navi Mumbai, Raigad District, Maharashtra on Approved CZMP (Sheet No. MH 74 & 77) published by MCZMA in 2018 for Raigad district. M/s NMIAL, Mumbai also requested IRS to prepare a map to present status of project site considering construction activities taken up by M/s NMIAL as per clearances obtained from MoEFCC. The satellite imagery of various dates available in open domain of the project area was interpreted for analysis of geomorphic characteristics in the vicinity of proposed project site. The proposed project site falls in villages Targhar, Ulwe, Owle, Pargaon, Pargoandungi, Kopar and Vadghar of Raigad district, Maharashtra and falls in the vicinity of Panvel Creek, Ulwe river, Gandi river, creeklets which are tidal influenced inland water bodies with mangroves and mudflats. Hence, the project site falls partly inside CRZ as per approved CZMP prepared by NCSCM, Chennai as per CRZ notification 2011 and published by MCZMA.

The NMIAL has informed that the environmental and CRZ Clearance was granted to NMIA project to CIDCO as project proponent, by Ministry of Environment, Forest and Climate Change (MoEF & CC) vide F. No. 10-53/20009 -I.A. III dated November 22, 2010 and also granted extension of validity for the Environmental clearance vide F. No. 10-53/2009-IA. III. The Ulwe River has been diverted outside southern boundary of NMIA Site by creating 120 - 200 Mtrs wide Ulwe Recourse Channel (URC). The Bombay High Court permitted CIDCO to clear Mangroves for the development of NMIA site vide order dated 29th October, 2013 in No M.419 of 2011. Accordingly, CIDCO has taken the development of project site by reclaiming low lying areas through cutting of Ulwe hill falling within project site as per the documents provided by per the documents provided by NMIAL

Based on request of NMIAL, the field team of IRS has conducted field verification survey during November 2020. It is observed that Ulwe River which was passing through NMIA site, has been diverted outside southern boundary of NMIA site by constructing a 120 –200m wide Ulwe Recourse Channel (URC). The Ulwe River within NMIA Site has been filled up as part of project construction activities. Due to filling and reclamation activities in project site, no mangroves or intertidal zone was observed within NMIA site during field verification survey.

The Navi Mumbai International Airport master plan was superimposed on approved CZMP prepared as per CRZ Notification 2011 is presented in Annexure III. The master plan superimposed on Draft CZMP prepared by NCSCM as per CRZ Notification 2019, Chennai is also presented as Annexure IV as per NMIAL's request. The current status of project site indicating the Navi Mumbai International Airport master plan along with reclaimed land, diverted Ulwe River is presented in Annexure V. The project site and proposed master plan of Navi Mumbai International Airport is superimposed on to Approved CZMP prepared by CRZ Notification 2011 is presented in Annexure VI.

1.0 INTRODUCTION

1.1 Coastal Regulation Zone

The coastal zone is the area of interaction between land and sea. The coastal Zone of Maharashtra has a very high concentration of population along with ecologically sensitive areas like mangroves. There is a spurt of developmental activities including development of an International Airport at Ulwe in Navi Mumbai along the coast of Maharashtra and in coastal zone. There is a need to protect the coastal environment while ensuring development judiciously striking a balance between ecological and developmental needs.

The Ministry of Environment and Forest in the CRZ Notification, 2011 declared the following areas as CRZ and imposed with effect from the date of the notification the restrictions on the setting up and expansion of industries, operations or processes and the like in the CRZ. The areas that are defined as CRZ as per CRZ Notification, 2011 are

(i) The land area from High Tide Line (HTL) to 500 mts on the landward side along the sea front.

(ii) CRZ shall apply to the land area between HTL to 100 meters or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea and the distance upto which development along such tidal influenced water bodies is to be regulated shall be governed by the distance up to which the tidal effects are experienced which shall be determined based on salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year and distance up to which tidal effects are experienced shall be clearly identified and demarcated accordingly in the Coastal Zone Management Plans.

(iii) The land area falling between the hazard line and 500 mts from HTL on the landward side, in case of seafront and between the hazard line and 100 mts line in case of tidal influenced water body the word 'hazard line' denotes the line demarcated by Ministry of Environment and through the Survey of India taking into account tides, waves, sea level rise and shoreline changes.

(iv) Land area between HTL and Low Tide Line (LTL) which will be termed as the intertidal zone.

(v) The water and the bed area between the LTL to the territorial water limit (12 Nm) in case of sea and the water and the bed area between LTL at the bank to the LTL on the opposite side of the bank, of tidal influenced water bodies.

The Classification of the CRZ is also modified for the purpose of conserving and protecting the coastal areas and marine waters as CRZ – I, CRZ – II, CRZ – III and CRZ – IV. The CRZ – I include the areas that are ecologically sensitive and the geomorphological features which play a role in the maintaining the integrity of the coast like (a) Mangroves (b) Corals and coral reefs and associated biodiversity (c) Sand Dunes (d) Mudflats which are biologically active (e) National parks, marine parks, sanctuaries, reserve forests, wildlife habitats and other protected areas (f) Salt Marshes (g) Turtle nesting grounds (h) Horse shoe crabs habitats (i) Sea grass beds (j) Nesting grounds of birds and (k) Areas or structures of archaeological importance and heritage sites and the area between Low Tide Line and High Tide Line. The

CRZ-II includes areas that have been developed up to or close to the shoreline. The CRZ-III includes areas that are relatively undisturbed and those do not belong to either CRZ-I or II, which include coastal zone in the rural areas (developed and undeveloped) and also areas within municipal limits or in other legally designated urban areas, which are not substantially built up. The CRZ-IV includes the water area from the Low Tide Line to twelve nautical miles on the seaward side and the water area of the tidal influenced water body from the mouth of the water body at the sea up to the influence of tide which is measured as five parts per thousand during the driest season of the year.

The Ministry of Environment and Forest has also provided guidelines for demarcation of High Tide Line in the CRZ Notification, 2011. As per the guidelines, Cadastral (village) maps in 1:3960 or the nearest scale shall be used as the base maps. HTL and LTL demarcated by NCSCM, Chennai is used for superimposition on the cadastral map based on physical verification using coastal geomorphological signatures or features in accordance with the CZMP Maps approved by the Central Government.

In order to facilitate classification of Coastal Regulation Zones, Government of India has approved few agencies/institutions across the Country vide Lr. No. J17011/8/92-1A III, dated 10.05.1999 of Ministry of Environment and Forests. Institute of Remote Sensing, Anna University being one of them, has been carrying out HTL and LTL mapping following the guidelines issued by Ministry of Environment & Forests, Government of India.

1.2 Background

M/s Navi Mumbai International Airport Private Limited (NMIAL), Mumbai has requested Institute of Remote Sensing, Anna University to prepare local level CRZ Map by superimposing master plan of proposed Navi Mumbai International Airport at Ulwe, Navi Mumbai in Raigad district of Maharashtra along with HTL, LTL for the Sea/Bay/tidal influenced water bodies and ecologically sensitive areas on 1:4,000 scale cadastral maps. NMIAL has also requested to prepare a map indicating the current status of Panvel Creek, Ulwe River, Gadhi River, creeklets, mangroves, mudflats and intertidal areas by field verification. Panvel creek, Gadhi River, mangroves, mudflats and intertidal areas falls in the vicinity of NMIA site. The Ulwe River was passing through NMIA project site. It is in this context, the project site and proposed construction activities of NMIAL need to be evaluated to assess whether they fall under regulations of CRZ Notification, 2011. Hence IRS has taken up the work of superimposing project site and activities on approved CZMP prepared by NCSCM and present status of tidal influenced water bodies by field verification.

1.3 Objectives

The objective of the present study is to examine the proposed airport construction site at Ulwe in Navi Mumbai, Raigad district, Maharashtra with reference to CRZ Notification, 2011 and 2019. Keeping in view of the requirements of notification, Institute of Remote Sensing, Anna University under took the project with following agreed scope of work:

- Transfer of HTL, LTL for Panvel Creek, Ulwe River and Gadhi River and creeklets as indicated in approved CZMP in the vicinity of the NMIA site by digitization from approved CZMP at 1:25,000 scale.
- Digitisation of ecologically sensitive entities such as Mangroves, Sand dunes, Turtle breeding grounds as indicated on approved CZMP in the vicinity of project site
- Superimposition of HTL, LTL, Ecologically Sensitive Areas along with the master plan of NMIA on to the georeferenced cadastral map
- Preparation of land use map depicting the present status of NMIA site indicating diverted Ulwe River and Reclamation activities.

1.4 Data Products

CZMP prepared as per CRZ Notification 2011 and approved by MOEF, New Delhi were collected from the authority and used as reference for transfer of HTL, LTL and Ecologically Sensitive Areas in the vicinity of project site on to local level CRZ Map. The data products used for the study and mapping include approved CZMP published by MCZMA (Map No.MH 74 and MH 77) in 2018 vide CRZ Notification 2011 and village maps of various villages obtained from MSRAC, Nagpur.

1.5 Methodology

The cadastral maps of various villages falling within NMIA site namely Village Targhar, Ulwe, Owle, Pargaon, Pargoandungi, Kopar and Vadghar of Raigad district, Maharashtra has been used for preparation of local level CRZ Map. The geomorphic characteristics of the coastal zone have been analyzed from the satellite data. Coastal geomorphologic features and existence of permanent vegetation identified from the satellite imagery were used to transfer the HTL demarcated by NCSCM on approved CZMP. The approved CZMP was georeferenced using graticules available on the maps.

The cadastral maps of the villages were digitized from approved CZMP to create a vector dataset of survey polygons in the vicinity of project locations. The same is superimposed on satellite imagery to identify the present status of project activities of NMIA. The HTL, LTL and ecologically sensitive areas in the vicinity of project location are digitized from georeferenced approved CZMP. 100 m setback line from HTL for Panvel creek and Ulwe River, Gadhi River, width of creek setback line from HTL for creeklets and 50 m setback line from mangroves was generated using GIS buffering tool. The zones between LTL, HTL and setback lines are delineated to corresponding CRZ as per CRZ Notification 2011 and CRZ Notification 2019.

2.0 STUDY AREA

2.1 Description of Study Area

The project site allocated for construction of Navi Mumbai International Airport is located in villages Targhar, Ulwe, Owle, Pargaon, Pargoandungi, Kopar and Vadghar of Raigad district, Maharashtra. Ulwe River was passing through the proposed project site where as Gadhi River flowing outside the NMIA boundary on the North-eastern side. Mangroves and mudflats were also present in the project area before development as indicated in approved CZMP prepared as per CRZ Notification 2011. The Navi Mumbai International Airport in Navi Mumbai is proposed to be constructed with an areal extent of 1160 ha and is connected by existing national highway in East and Major Arterial Road Amra Marg in West. NMIA site is also accessible from existing Mankhurd-Belapur-Panvel and Thane-Panvel commuter rail corridors from Khandeshwar Railway Station and from Targhar Railway Station on the Nerul – Uran Railway line.

Environmental and CRZ Clearance was granted to NMIA project to CIDCO as project proponent, by Ministry of Environment, Forest and Climate Change (MoEF & CC) vide F. No. 10-53/20009 -I.A. III dated November 22, 2010 and also granted extension of validity for the Environmental clearance vide F. No. 10-53/2009-IA. III. As a part of development of project site, the Ulwe River within NMIA site has been filled up and diverted outside southern boundary of NMIA site with 120 - 200 Mtrs wide Ulwe Recourse Channel (URC).

As per the documents provided by NMIAL, that Forest department had granted permission for Stage I clearance of 108 Ha. of Mangroves and diversion of 250 Ha of Forest land vide letter No. F. No. 8-95/2012-FC dated December 17, 2013 (stage I) and Stage II dated April 24, 2017. Honourable High Court of Mumbai had also approved clearance of mangroves vide its Order dated October 29, 2013 as per documents provided by NMIAL. Various pre-construction activities are taken up in the project site by reclamation and filling of intertidal areas, low lying lands and areas with mangroves. During field verification in November 2020, no mangroves or intertidal zones have been observed within NMIA Site. It is also observed during field verification that construction of North Road, South Road, East Road, rerouting of EHVT Lines, drainage outfalls at different locations is ongoing within project area.

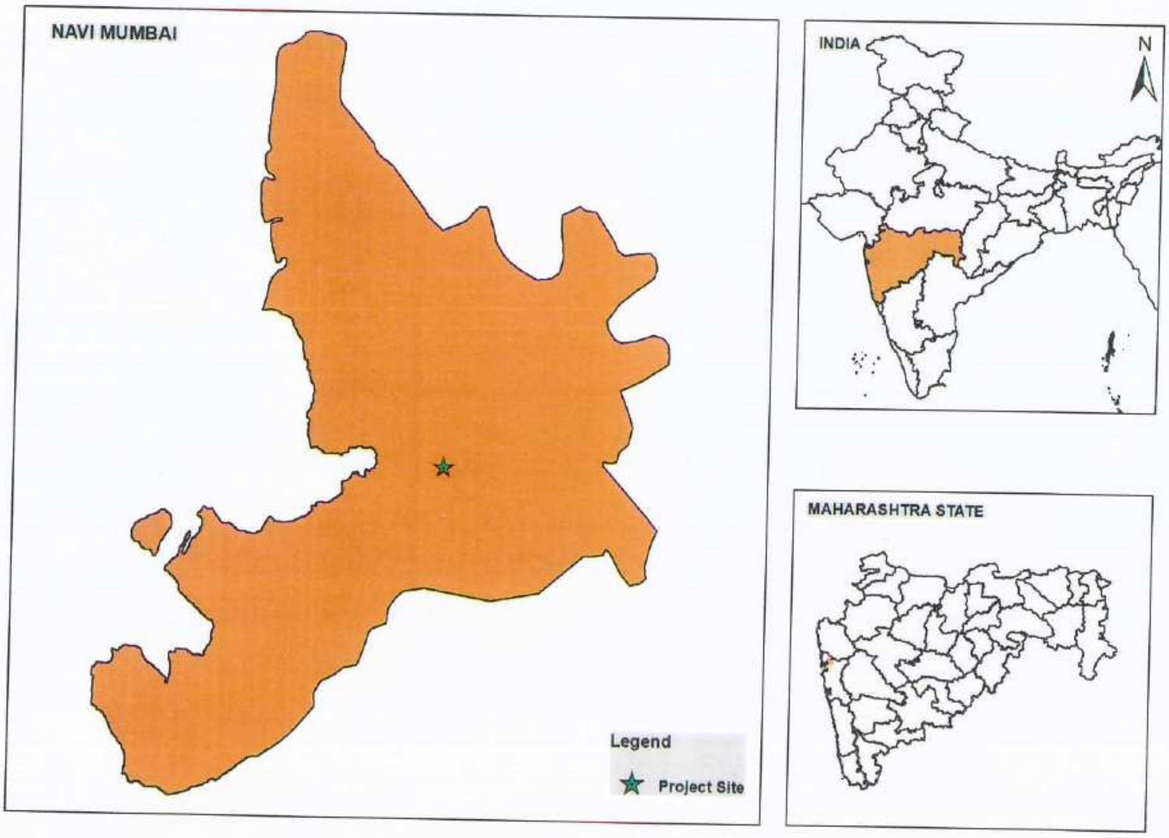

Fig. 1 Location of proposed project Site

The corner coordinates of the project site as per field observations using dual frequency GPS are presented in Table 1

Table 1 Coordinates of Site Corners as per GPS Survey

Label	Latitude	Longitude
A	18° 59' 58.515" N	73° 02' 09.877" E
B	19° 00' 12.199" N	73° 03' 41.008" E
C	19° 00' 02.511" N	73° 03' 50.896" E
D	19° 00' 11.133" N	73° 04' 58.721" E
E	18° 59' 30.168" N	73° 05' 38.699" E
F	18° 59' 09.394" N	73° 05' 24.035" E

2.2 Status as per Approved CZMP prepared by NCSCM vide CRZ Notification 2011, Chennai

The proposed project site in villages Targhar, Ulwe, Owle, Pargaon, Pargoandungi, Kopar and Vadghar of Raigad district, Maharashtra falls partly inside CRZ as per approved CZMP. Hence, the proposed project activity falls partly inside CRZ-IA, CRZ-IB, CRZ-IVB, NDZ, CRZ-II as per approved CZMP map prepared by NCSCM, Chennai vide CRZ Notification 2011.

3.0 RESULTS AND CONCLUSIONS

3.1 Results

The cadastral maps of villages Targhar, Ulwe, Owle, Pargaon, Pargoandungi, Kopar and Vadghar of Raigad district, Maharashtra were georeferenced using tic points available on approved CZMP of Raigad District, Maharashtra. The HTL and LTL for Panvel Creek, Ulwe River, Gadhi River and Mangroves, Mudflats as indicated in approved CZMP were superimposed on to georeferenced cadastral maps in the vicinity of project site. Setback lines for 100 m or width of creek from HTL for Panvel creek, Ulwe River, Gadhi River and other creeks/creeklets, 50m setback line from Mangroves as indicated in approved CZMP prepared vide CRZ Notification 2011 were superimposed on to georeferenced base map to prepare local level CRZ map at 1:4.000 scale **(Annexure III).** The satellite imagery of project site (November 2020) is presented for reference **(Annexure I).** The co-ordinates of points on HTL line derived from approved CZMP 2011 are presented in **Annexure II.** Proposed Master Plan of Navi Mumbai International Airport superimposed on to draft CZMP published vide CRZ Notification 2019 is presented in **Annexure IV**. The land use depicting present status of NMIA project site is presented in **Annexure V.** The project site and proposed master plan of Navi Mumbai International Airport is superimposed on to Approved CZMP prepared by CRZ Notification 2011 is presented in **Annexure VI.**

3.2 Conclusions

The status of project site as per approved CZMP of Raigad district is

- The project site of Navi Mumbai International Airport falls partly inside CRZ-IA, CRZ-IB, CRZ-II, CRZ-IVB with remaining part outside CRZ as per Approved CZMP of Raigad district vide CRZ Notification 2011 (Map Nos. MH 74 and MH 77). The statistics of area of project site falling within and outside CRZ zones is presented in Table 2.

Table 2 Area Statistics proposed project site of NMIA

Sl. No.	CRZ - Classification	CRZ Notification 2011	CRZ Notification 2019
		Area in Hectares	
1	50m Mangrove Buffer (CRZ - IA)	159.3	159.3
2	CRZ - IA	147.5	147.5
3	CRZ - IB	134.5	134.5
4	CRZ - II	91.1	41.9
5	CRZ - IVB	13.0	13.0
6	Outside CRZ	614.6	663.8
	Total	**1160.0**	**1160.0**

During field verification survey, the following observations were made

- No Mangroves are present within NMIA project site due to reclamation and filling activities.
- Ulwe Recourse Channel (URC) of 120-200 m width was constructed outside southern boundary of NMIA Site.
- No Intertidal areas are present within NMIA project site due to filling and reclamation activities.
- The Ulwe River, a tidal influenced inland water body passing through the NMIA site has been filled up.
- Formation of Roads along Northern, Western and Eastern boundary of NMIA site is under progress.

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Chennai - 600 025

ANNEXURE I

Satellite Imagery of project site

(courtesy: Google Earth)

ANNEXURE II

Coordinates of HTL Reference Points

Point No	Latitude	Longitude
1	18° 59' 11.127" N	73° 1' 55.362" E
2	18° 59' 00.253" N	73° 1' 56.582" E
3	18° 58' 48.983" N	73° 1' 56.289" E
4	18° 58' 34.476" N	73° 1' 53.414" E
5	18° 58' 40.028" N	73° 1' 57.214" E
6	18° 58' 57.232" N	73° 2' 03.264" E
7	18° 58' 51.165" N	73° 2' 07.517" E
8	18° 58' 42.719" N	73° 2' 08.472" E
9	18° 58' 35.779" N	73° 2' 11.087" E
10	18° 58' 42.345" N	73° 2' 13.661" E
11	18° 58' 34.336" N	73° 2' 11.971" E
12	18° 58' 40.157" N	73° 2' 20.173" E
13	18° 58' 40.434" N	73° 2' 27.559" E
14	18° 58' 34.521" N	73° 2' 34.786" E
15	18° 58' 44.209" N	73° 2' 29.724" E
16	18° 58' 50.517" N	73° 2' 18.003" E
17	18° 58' 53.751" N	73° 2' 16.159" E
18	18° 59' 03.229" N	73° 2' 16.983" E
19	18° 59' 12.476" N	73° 2' 17.054" E
20	18° 59' 20.400" N	73° 2' 12.513" E
21	18° 59' 15.138" N	73° 2' 12.517" E
22	18° 59' 25.423" N	73° 2' 11.418" E
23	18° 59' 13.569" N	73° 2' 11.457" E
24	18° 59' 05.520" N	73° 2' 15.039" E
25	18° 58' 48.502" N	73° 2' 14.694" E
26	18° 58' 47.940" N	73° 2' 09.554" E
27	18° 58' 58.253" N	73° 2' 15.517" E
28	18° 59' 10.104" N	73° 2' 12.355" E
29	18° 59' 12.905" N	73° 2' 06.771" E
30	18° 59' 19.315" N	73° 2' 06.338" E
31	18° 59' 26.672" N	73° 2' 04.484" E
32	18° 59' 31.573" N	73° 1' 56.173" E
33	18° 59' 23.376" N	73° 1' 57.617" E
34	18° 59' 15.690" N	73° 2' 00.278" E
35	18° 59' 25.734" N	73° 1' 49.081" E
36	18° 59' 36.707" N	73° 1' 55.472" E
37	18° 59' 38.258" N	73° 1' 57.985" E
38	18° 59' 34.328" N	73° 2' 02.704" E
39	18° 59' 41.691" N	73° 2' 07.375" E
40	18° 59' 48.549" N	73° 2' 01.256" E
41	18° 59' 43.107" N	73° 1' 54.170" E

42	18° 59' 52.213" N	73° 1' 55.304" E
43	19° 00' 00.906" N	73° 1' 56.436" E
44	19° 00' 07.716" N	73° 2' 07.149" E
45	19° 00' 02.793" N	73° 2' 13.607" E
46	18° 59' 52.783" N	73° 2' 14.372" E
47	19° 00' 03.444" N	73° 2' 21.579" E
48	19° 00' 12.266" N	73° 2' 20.421" E
49	19° 00' 16.017" N	73° 2' 27.257" E
50	19° 00' 11.665" N	73° 2' 32.498" E
51	18° 59' 53.628" N	73° 2' 36.643" E
52	19° 00' 05.483" N	73° 2' 35.683" E
53	19° 00' 12.620" N	73° 2' 39.362" E
54	19° 00' 08.462" N	73° 2' 45.968" E
55	19° 00' 00.002" N	73° 2' 47.647" E
56	18° 59' 57.909" N	73° 2' 57.130" E
57	18° 59' 54.990" N	73° 3' 01.649" E
58	18° 59' 46.688" N	73° 3' 04.620" E
59	18° 59' 36.505" N	73° 3' 13.838" E
60	18° 59' 32.555" N	73° 3' 22.381" E
61	18° 59' 36.792" N	73° 3' 19.449" E
62	18° 59' 33.108" N	73° 3' 28.116" E
63	18° 59' 27.347" N	73° 3' 24.769" E
64	18° 59' 27.985" N	73° 3' 30.453" E
65	18° 59' 24.835" N	73° 3' 35.287" E
66	18° 59' 29.266" N	73° 3' 36.001" E
67	18° 59' 29.601" N	73° 3' 31.927" E
68	18° 59' 32.120" N	73° 3' 30.926" E
69	18° 59' 33.588" N	73° 3' 37.015" E
70	18° 59' 30.387" N	73° 3' 38.795" E
71	18° 59' 27.508" N	73° 3' 42.474" E
72	18° 59' 25.140" N	73° 3' 37.889" E
73	18° 59' 24.669" N	73° 3' 42.878" E
74	18° 59' 21.172" N	73° 3' 40.994" E
75	18° 59' 17.015" N	73° 3' 41.051" E
76	18° 59' 13.140" N	73° 3' 37.832" E
77	18° 59' 05.517" N	73° 3' 38.181" E
78	18° 59' 05.399" N	73° 3' 48.001" E
79	18° 59' 01.821" N	73° 3' 45.210" E
80	18° 58' 53.670" N	73° 3' 44.369" E
81	18° 58' 45.045" N	73° 3' 45.061" E
82	18° 58' 42.116" N	73° 3' 52.314" E
83	18° 58' 43.811" N	73° 3' 59.637" E
84	18° 58' 45.512" N	73° 4' 01.733" E
85	18° 58' 45.959" N	73° 4' 05.283" E
86	18° 58' 47.480" N	73° 4' 03.620" E
87	18° 58' 46.821" N	73° 3' 59.585" E

88	18° 58' 50.159" N	73° 3' 56.637" E
89	18° 58' 57.089" N	73° 3' 56.314" E
90	18° 59' 06.702" N	73° 3' 56.090" E
91	18° 59' 12.218" N	73° 3' 52.033" E
92	18° 59' 10.574" N	73° 3' 56.502" E
93	18° 59' 12.018" N	73° 4' 09.686" E
94	18° 59' 16.186" N	73° 4' 00.320" E
95	18° 59' 21.858" N	73° 4' 01.732" E
96	18° 59' 22.466" N	73° 3' 55.772" E
97	18° 59' 28.504" N	73° 3' 51.590" E
98	18° 59' 38.544" N	73° 3' 53.475" E
99	18° 59' 29.019" N	73° 3' 49.706" E
100	18° 59' 41.181" N	73° 3' 48.643" E
101	18° 59' 36.291" N	73° 3' 57.958" E
102	18° 59' 32.024" N	73° 4' 05.704" E
103	18° 59' 29.635" N	73° 4' 18.125" E
104	18° 59' 39.894" N	73° 4' 18.741" E
105	18° 59' 47.732" N	73° 4' 10.222" E
106	18° 59' 41.577" N	73° 4' 03.613" E
107	18° 59' 44.588" N	73° 3' 55.669" E
108	18° 59' 55.174" N	73° 3' 53.506" E
109	19° 00' 01.897" N	73° 3' 51.321" E
110	19° 00' 00.843" N	73° 3' 43.061" E
111	18° 59' 54.493" N	73° 3' 42.284" E
112	19° 00' 06.327" N	73° 3' 46.670" E
113	19° 00' 11.032" N	73° 3' 40.767" E
114	19° 00' 01.760" N	73° 3' 38.613" E
115	18° 59' 57.684" N	73° 3' 36.033" E
116	18° 59' 51.642" N	73° 3' 34.990" E
117	18° 59' 54.997" N	73° 3' 30.871" E
118	19° 00' 00.775" N	73° 3' 34.518" E
119	19° 00' 05.056" N	73° 3' 27.397" E
120	19° 00' 07.817" N	73° 3' 39.457" E
121	19° 00' 17.790" N	73° 3' 39.628" E
122	19° 00' 15.421" N	73° 3' 28.492" E
123	19° 00' 08.891" N	73° 3' 23.221" E
124	19° 00' 01.620" N	73° 3' 20.728" E
125	19° 00' 02.347" N	73° 3' 14.152" E
126	19° 00' 03.904" N	73° 3' 08.023" E
127	19° 00' 03.574" N	73° 3' 15.865" E
128	19° 00' 06.061" N	73° 3' 20.803" E
129	19° 00' 13.121" N	73° 3' 20.793" E
130	19° 00' 07.418" N	73° 4' 21.087" E
131	18° 59' 52.662" N	73° 4' 20.642" E
132	18° 59' 49.304" N	73° 4' 24.543" E
133	18° 59' 42.470" N	73° 4' 43.496" E

134	18° 59' 46.901" N	73° 4' 31.828" E
135	18° 59' 42.186" N	73° 4' 53.625" E
136	18° 59' 50.069" N	73° 4' 58.709" E
137	18° 59' 55.247" N	73° 5' 10.873" E
138	19° 00' 04.238" N	73° 5' 07.854" E
139	18° 59' 57.360" N	73° 5' 13.507" E
140	18° 59' 45.391" N	73° 5' 12.536" E
141	18° 59' 39.042" N	73° 5' 17.997" E
142	18° 59' 33.078" N	73° 5' 15.471" E
143	18° 59' 30.999" N	73° 5' 26.582" E
144	18° 59' 25.924" N	73° 5' 37.569" E
145	18° 59' 36.083" N	73° 5' 38.122" E
146	18° 59' 19.508" N	73° 5' 38.141" E
147	18° 59' 06.140" N	73° 5' 44.324" E

(Source: Approved CZMP – Map No. MH 74 and MH 77)

PRINCIPAL CONSULTANT

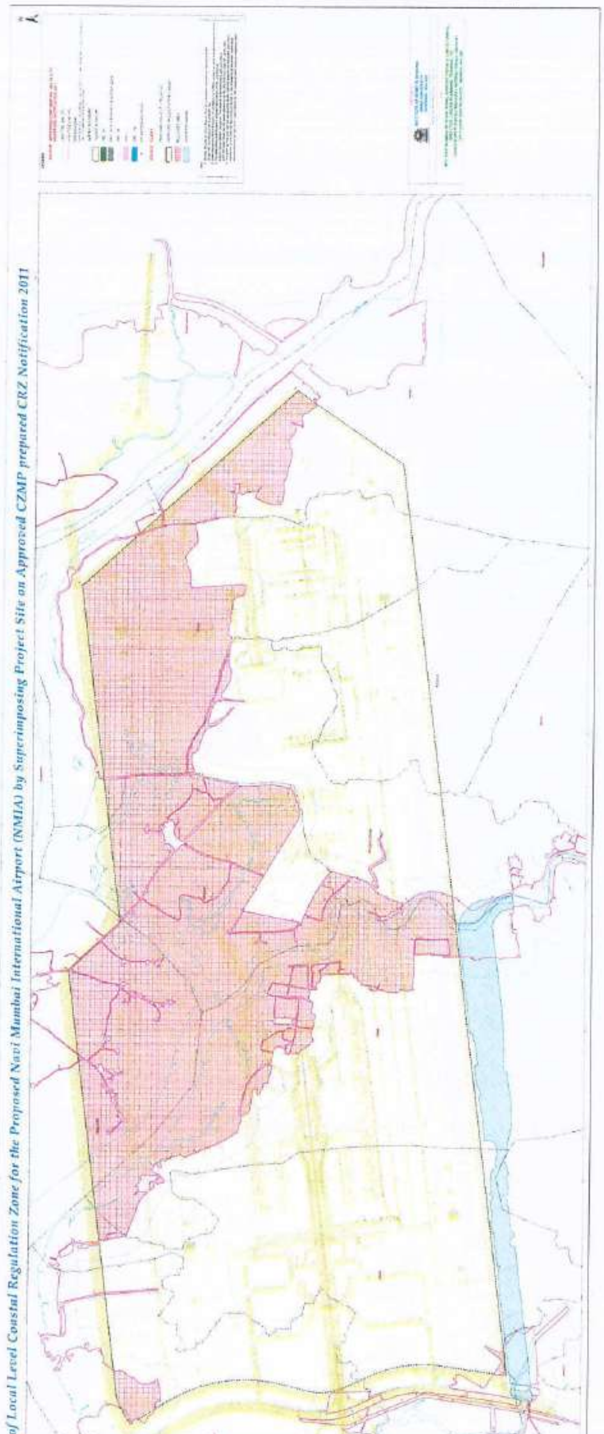
29/1/21

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025

ANNEXURE III

Local Level CRZ Map for the NMIA Site (CRZ Notification 2011)

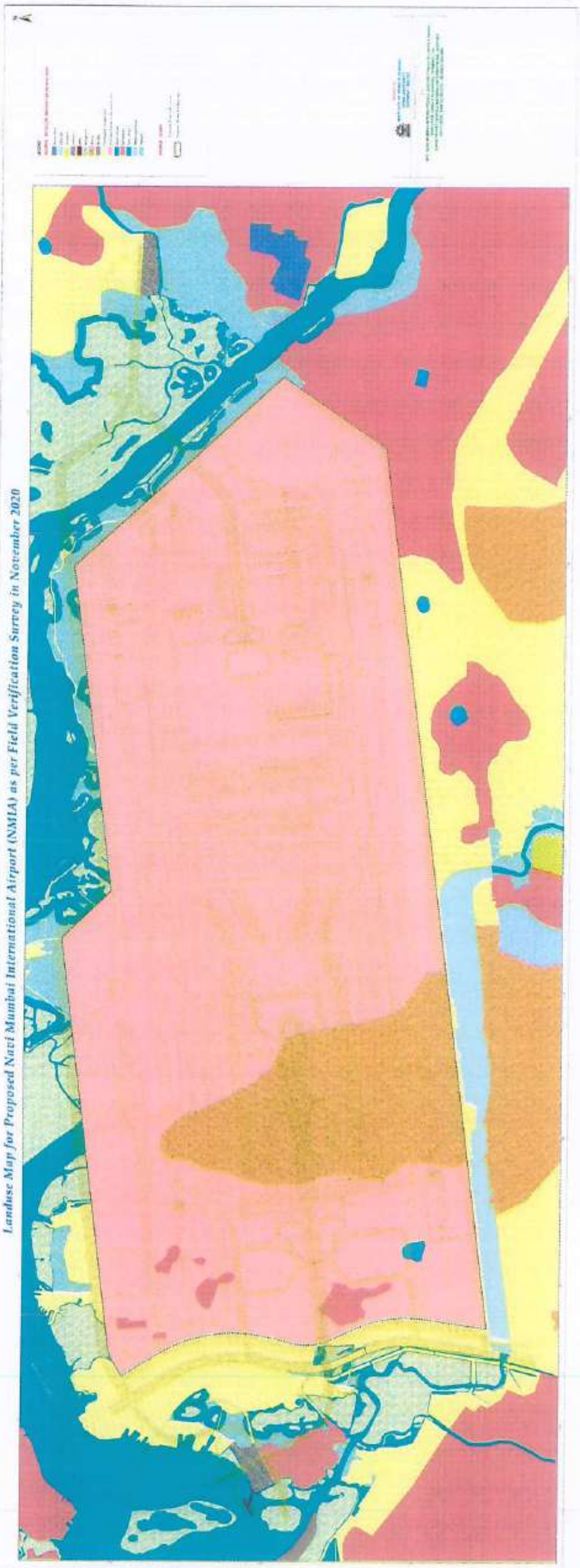


ANNEXURE IV

Local Level CRZ Map for the NMIA Site
(CRZ Notification 2019)

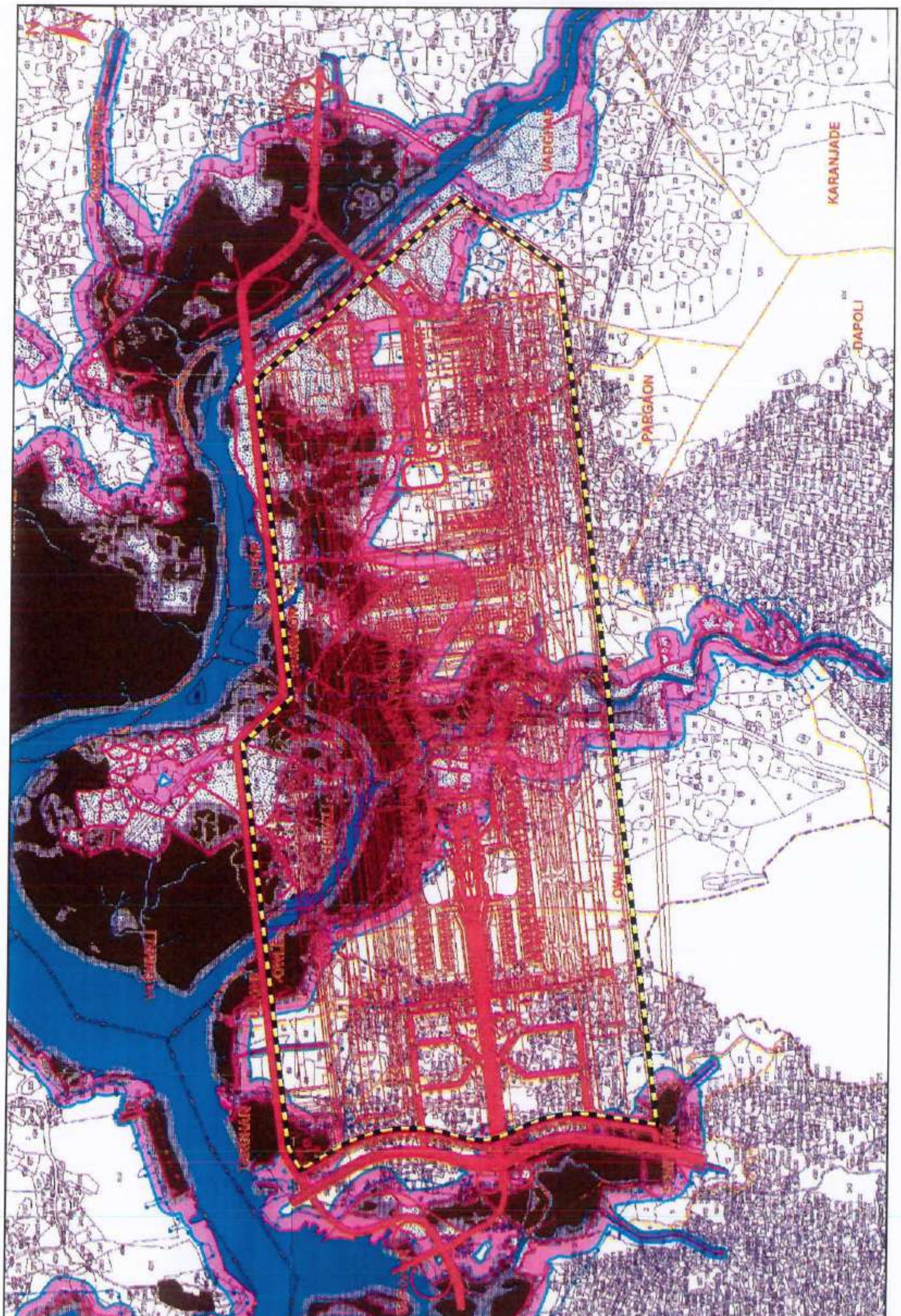
ANNEXURE V

Landuse Map for NMIA Site
(As per Field Verification Survey)



ANNEXURE VI

Project Site and Master Plan superimposed on Approved CZMP prepared vide CRZ Notification 2011



ANNEXURE-XV (A)
PREPARATION OF LOCAL LEVEL COASTAL REGULATION ZONE MAP FOR THE PROPOSED NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) IN NAVI MUMBAI, RAIGAD DISTRICT, MAHARASHTRA

(NMIAL letter No. NMIAL/02/2020/08 dated 14th February, 2020; Suggestion/Objection/Clarification Regarding Draft CZMP Plan of Panvel Taluka with respect to NMIA Project site)

O/C

URGENT

No. NMIAL/02/2020/08

February 14, 2020

The Member Secretary,
Maharashtra Coastal Zone Management Authority,
Environmental Department, 15th Floor,
New Administrative Building,
Mantralaya, Mumbai -400 032

Subject: **Suggestion/Objection/Clarification regarding draft CZMP for Panvel Taluka (sheet No. E43 H1/NW- Map No. MH-74 & sheet No. E43 B4/SW- Map No. MH-77) with respect to NMIA project site**

Ref:

1) **EC and CRZ clearance F. No. 10-53/20009 -I.A. III dated November 22, 2010 and extension of validity vide F. No. 10-53/2009-IA. III valid up-to November 21, 2020.**

Sir,

Navi Mumbai International Airport limited (NMIAL) has been appointed as the Concessionaire for the development of Navi Mumbai International Airport (NMIA). CIDCO is a partner in NMIAL in developing this prestigious project. It is a project of national importance, and particularly for Mumbai Metropolitan Region (MMR).

As you are aware, Navi Mumbai International Airport (NMIA) is being developed on 1160 Hectare of Land including Village Targhar, Ulwe, Owale, Waghiwali, Pargoan, Pargoan Dungi, Kopar and Vadghar including Ulwe River. NMIA Project has received Environment & CRZ Clearance from

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पर्यावरण विभाग
मंत्रालय, मुंबई

MoEFCC vide F. No. 10-53/20009 -I.A. III dated November 22, 2010 (**Annexure – I**) and also granted extension of validity for the Environmental clearance vide F. No. 10-53/2009-IA. III valid up-to November 21, 2020 (**Annexure – II**).

As you are aware, the CRZ Notification of 6th Jan 2011 has been amended to permit the development of Navi Mumbai International Airport (NMIA) in CRZ area as under:

- Exempted from the list of prohibited activities under clause 3 (i) (d)
- Permitted for development in CRZ-I under clause 8 (I) (f)
- Permitted for development even in NDZ area of CRZ III and CRZ – III area under clause 8 (III) (A) (iii) (m) and 8 (III) (B) (x).

For construction of NMIA, MoEFCC had permitted diversion of Ulwe River which earlier passed through NMIA site. Also, MoEFCC had permitted clearance of Mangroves located on project site and vicinity (admeasuring approximately 108 Ha) and acquisition of Forest land admeasuring 250 Ha. The Forest Department had also granted Stage I clearance for clearance of Mangroves and diversion of Forest land vide letter No. F. No. 8-95/2012-FC dated December 17, 2013 (stage I) and Stage II dated April 24, 2017. (**Annexure – III & IV**). Honourable High Court of Mumbai had also approved clearance of mangroves vide its Order dated (vide Order dated October 29, 2013) (**Annexure – V**). Urban Development Department, Government of Maharashtra has also approved and amended Navi Mumbai Development Plan (NMDP) incorporating NMIA in NMDP (enclosed as **Annexure – VI**).

After obtaining all clearances & approvals from respective Government organizations, CIDCO commenced Land development works in May 2016 including construction of Ulwe Recourse Channel.

As per approvals, CIDCO has diverted the Ulwe River outside southern boundary of NMIA Site and created 120 - 200 Mtrs wide Ulwe Recourse Channel (URC) outside southern boundary of NMIA Site. The Ulwe River within NMIA Site has been filled up and URC is operational from June 2019.

There are no mangroves or intertidal zone present within NMIA Site now. The NMIA Site is filled upto 5.5. Mtrs AMSL.

CIDCO has also started construction of North Road, South Road, East Road, rerouting of EHVT Lines, drainage outfalls at 6 different locations, etc.

With reference to draft Coastal Zone Management Plan (CZMP) uploaded on Maharashtra Coastal Zone Management Authority (MCZMA) portal dated January 22, 2019 (sheet No. E43 H1/NW- Map No. MH-74 and sheet No. E43 B4/SW- Map No. MH-77) (copies enclosed at **Annexure VII & VIII**) is outdated. It is observed that these Draft CZMP Plans do not reflect the present physical condition of NMIA Site.

Google Image of October 16, 2018 showing NMIA Site Boundary with then existing Ulwe River (**Annexure IX**), Google Image of February 12, 2019 during filling work of Ulwe River (**Annexure X**), recent Photographs of Ulwe River Recourse Channel (**Annexure XI**), and recent Photographs showing the site condition after filling-up of Ulwe River (**Annexure XII**) is enclosed for your reference. You are also requested to visit NMIA Site and verify the same.

In view of the above facts, you are requested to kindly consider above mentioned points and update the draft CZMP to indicate correct existing site conditions at this location within NMIA Site.

Thanking You,

Yours faithfully,

For Navi Mumbai International Airport Private Limited

(Charudatta Deshmukh)
Director – Urban Planning

GVK

Enclosure:

Annexure I -	*Environment & CRZ Clearance from MoEFCC;*
Annexure II -	*Extension of EC;*
Annexure III -	*Stage I Forest clearance;*
Annexure IV -	*Stage II Forest clearance;*
Annexure V -	*Honourable High Court approval for clearance of mangroves;*
Annexure VI -	*UDD, GoM sanctioned modification to NMDP incorporating provision of NMIA;*
Annexure VII -	*CZMP sheet No. E43 H1/NW- Map No. MH-74 of NMIA Area;*
Annexure VIII -	*CZMP sheet No. E43 B4/SW- Map No. MH-77 of NMIA Area;*
Annexure IX -	*Google Image of October 16, 2018 showing NMIA Site Boundary with Ulwe River;*
Annexure X -	*Google Image of February 12, 2019 during filling work of Ulwe River;*
Annexure XI -	*Photographs showing Ulwe River Recourse Channel (URC);*
Annexure XII -	*Photographs showing the site condition after filling-up of Ulwe River;*

Annexure I

Environment & CRZ Clearance from MoEFCC

F.No.10-53/2009-IA.III
Government of India
Ministry of Environment & Forests
(IA-III Division)

MD's @ Belapur Office
INW. No.: 1941
Date: 26/11/10

Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi - 110 003,

Dated: 22nd November, 2010

To
Vice Chairman & Managing Director,
City & Industrial Dev. Corpn. of Maharashtra Ltd.,
CIDCO Bhawan, CBD-Belapur,
Navi Mumbai-400 614.

Subject: **Environmental and CRZ Clearance for establishment of Navi Mumbai International Airport by M/s. City & Industrial Development Corporation of Maharashtra Ltd. - Reg.**

This has reference to your letter no. CIDCO/T&C/ACTE/MD/2009/567 dated 16.06.2009 and subsequent letters dated 06.07.2010, 07.08.2010, 10.10.2010 and 12.11.2010 seeking Environmental and CRZ Clearance under the Environment Impact Assessment Notification, 2006 and Coastal Regulation Zone (CRZ) Notification, 1991. The proposal has been appraised as per prescribed procedure in the light of provisions under the Environment Impact Assessment Notification, 2006 as amended in 2009 and CRZ Notification, 1991 on the basis of the mandatory documents enclosed with the application viz., Questionnaire, EIA/EMP and recommendations of Coastal Zone Management Authority, the additional clarifications furnished in response to the observations of the Expert Appraisal Committee constituted by the competent authority in its meetings held on 20th - 22nd July 2009, 21st - 23rd July 2010, 18th - 20th August 2010, 21st - 23rd September 2010, 20th - 22nd October 2010 and 09th - 10th November, 2010.

ACTE
23/11

2. It is interalia, noted that the proposed site of Airport is situated on National Highway No. 4B at a distance of approx. 35 kms. from the existing airport near Panvel in the geographical centre of Navi Mumbai having longitude of 73⁰.4'.18" and latitude 18⁰.59'.33". The main access to the proposed airport from the east is existing 4 lane National Highway 4B abutting the eastern boundary of the airport and 4 lane concrete road called Aamra Marg touches the western boundary of the airport. The proposed airport is also accessible by present commuter railway line called Mankhurd-Belapur-Panvel commuter railway line from the Khandeshwar Railway Station.

3. The proposal of Navi Mumbai International Airport is proposed to be established on an area of 1160 ha. The airfield of Navi Mumbai International Airport is designed to accommodate the new large aircraft (A-380 and equivalent) compatible to ICAO Standard of aerodrome 4-F. The ultimate capacity of airport will be 60 MPPA which will reach in four stages

CIDCO LTD.
T & C / ACTE
Inward No. 701
Date: 24/11/10

commencing from 10 MPPA in 2014. The Airport accommodates two parallel independent runways with the spacing of 1.55 kms. for simultaneous and independent operation with the provision of full length parallel taxi way along runways. The length of runway is of 3700 mts. X 60 mts. with runway safety area of 150 mts. X 60 mts., approach lighting of 900 mts., terminal building of domestic and international including Cargo admeasuring about 5,00,000 sq.mt. with other facilities such as; parking stands, GSE storage area, ATC Tower, airport ground lighting, airport lighting, cargo apron, maintenance and hanger along with other allied facilities etc. The other project activities involved are land development by cutting of hill and filling, development of airport in phases, re-coursing of the tidally influenced water body outlets from Ulwe, shifting of EHVT line, development of non-aeronautical activities, off-site physical infrastructure in terms of roads, interchange, water supply, power, etc., re-settlement & re-habilitation, and development of utility lines required for airport zone. The estimated basic cost (2008-09) of the project is Rs. 8722 Cr. spread over 4 phases i.e. in the first phase Rs 4424 Cr. in 2015 for 10 MPPA and Rs.1934 Cr. in 2020 for 25 MPPA in second phase; and Rs.1728 Cr. in 2025 for 45 MPPA in 3rd phase and finally Rs.636 Cr. in 4th phase for 2030 for 60 MPPA.

4. The non-aeronautical activities related to airport have been planned in the south of airport on an area of 276 ha. Further an area of 60 ha. will be required for diversion of tidally influenced water body of Ulwe River and 279 ha for off site infrastructure for roads, and crossings/intersection improvements.

5. A ToR for the project was issued on 04.08.2009. The Expert Committee also visited the site on 23rd December, 2009 and an additional TOR was issued on 8th February 2010. The public hearing was conducted on 5th May 2010 at Panvel Taluka, Dist. Raigad by Maharashtra Pollution Control Board (MPCB), Maharashtra and final EIA/EMP was submitted by CIDCO on 6th July 2010 for the issue of Environmental and CRZ Clearance. The recommendations of MCZMA were also submitted on 6th July 2010.

6. The Expert Appraisal Committee, after due consideration of the relevant documents submitted by the project proponent, additional clarifications furnished in response to its observations and various representations received on the project, have recommended for the grant of Environmental and CRZ Clearance for the project. Accordingly, the Ministry hereby accords necessary Environment and CRZ Clearance for the above project as per the provisions of Environment Impact Assessment Notification, 2006 and CRZ Notification 1991 and their subsequent amendments, subject to strict compliance of the terms and conditions as follows:

7. Specific Conditions:

I. Construction Phase

(i) "Consent for Establishment" shall be obtained from State Pollution Control Board under Air and Water Act and a copy shall be submitted to the Ministry before start of any construction work at the site.

(ii) CIDCO shall rehabilitate about 3000 families of 10 settlements from 7 villages falling within the airport zone as per the R & R policy of the Government of India or the Government of Maharashtra, which ever is more beneficial to the project affected persons.

(iii) CIDCO shall obtain necessary permission from Hon'ble High Court of Bombay for cutting or damaging of mangroves and clearance under Forest Conservation Act 1980 as per the orders in respect of notice of Motion no. 417 of 2006 in PIL no. 87/2006, as required.

(iv) The plantation and protection of mangroves over an area of 615 ha (245 hectares of good quality Mangroves Park shall be developed at Vaghivli on the north of the airport area + 60 hectare area located on the west side of the airport site around Moha creek and Panvel Creek + 310 hectares area on the northeast of the airport site between Gadhi River, Mankhurd Panvel Rail corridor and National Highway 4B shall be declared as No-development zone and CIDCO shall under take the development as Mangroves park/green area) would be developed and maintained in the shape of Biodiversity Mangrove Parks well before the airport project is initiated and its progress reported to the high level committee mentioned below at (xxxiii). CIDCO shall formally amend the land use in the sectioned development plan of Navi Mumbai following the due procedure under MRTP Act to achieve this objective.

(v) The proposed re-coursing of tidally influenced water body outlets from Ulwe river has a large cross sectional area at the middle with the river/creek on either end remaining unchanged with its natural course. The whole system should function as was functioning earlier without airport project. Surface runoff should not be let into the channel just because the area of cross section is large. The whole airport area will be reclaimed and the level raised to 7m whereas the existing level all around the airport will continue to be low in its natural state. There will be flow all around due to surface runoff. This additional quantity must be collected by appropriate drainage system and let into Gadhi River and not into the re-coursing channel. The recourse channel may be able to take it but not the river or creek on either side of the channel. This aspect shall be examined by CIDCO in details to avoid the flooding of the low-lying areas besides inducting other hydrological and environmental studies.

(vi) The entire system shall be studied as one composite system with appropriate boundary conditions to reflect the worst conditions – minimum 100 years to be specified and compliance ensured such as -flooding, surface runoff not only from the airport but also from surrounding areas as well, normal flow, tidal flow due to tidal surge having a long return period, possible obstructions to flow, tributaries joining the main river etc so as to take appropriate protection and remedial measures. Due to construction of recourse Channels and also due to tail end of the Gadhi & Ulwe Rivers into Panvel Creek, there is a need to prepare a Comprehensive Master Plan for Surface drainage and Flood protection, keeping in view the proposed developments. CIDCO shall submit the above Master Plan to the Ministry.

(vii) Systemic and periodic monitoring mechanism need to be put in place by CIDCO to assess the impact on sub-surface flow/ impact on aquifers as well as surface water bodies in different seasons. Necessary additional environmental protection measures to be adopted to address the impact of proposed development in coastal sub-subsurface flow as well as impact on aquifers.

(viii) CIDCO shall prepare a Management Plan to handle the runoff from the airport and to ensure that runoff associated risks/ impacts such as siltation in receiving water body are avoided and are taken care within airport area during monsoons.

(ix) On the northern part of the airport there is a secondary channel of the Gadhi River which will be filled up for the airport runway construction. This will be replaced by a shorter channel along the northern boundary of the airport. The channel shall be designed appropriately through overall modeling study so that the channel provides tidal water to the mangrove park and moderate tidal flows under worst environmental conditions. Need for widening and deepening of Gadhi River may also be studied simultaneously, if required. The revised widths and depths of recourse channels shall be determined with modified drainage and worst rainfall/tide conditions including appropriate factor of safety.

(x) The flow channels and the low lying mangrove area which will receive water from diverted recourse/ Channels should remain undisturbed. No road, embankment or any other construction shall be permitted. Any island formed due to deposition of sediment in front of Panvel creek shall be periodically removed.

(xi) A detailed map shall be submitted by CIDCO to the Ministry with quantification of affected mangrove area with density i.e. initial proposal & modified proposal and proposed mangrove forestation with species. The work on the proposed compensatory mangrove park should commence well before the construction of the airport is undertaken. The mangrove irrigation systems and diverse species selections for all the four areas may be scientifically made. The river front development in all the areas not protected by adequate mangrove buffer along the Panvel creek and Gadhi river may be considered through studies.

(xii) Whatever EIA data was submitted and presented was related to a situation for "no airport condition". The project proposal has under gone many changes in terms of converting the lagoon as Mangrove Park, shifting of non-aeronautical activities to the south etc. Updated EIA report with all the modifications and commitments given by CIDCO shall be submitted to the MoEF, MPCB and to MCZMA. This updated EIA report will serve as the preliminary baseline data. CIDCO shall submit the second report (EIA Report II) after finalization of all the facilities followed by Comprehensive EIA report prepared with approved layout of the airport, new hydrological scenario, altered topography and land use. The Comprehensive EIA report should also include ecological aspects answering quires raised by BNHS and several other points raised during the meeting. After completion of Phase I of the project, the CIDCO shall conduct the "Environmental Audit" with a reputed organization and the audit shall also include the "Validation of the conclusions drawn in the EIA Report" and to submit to MoEF, MPCB and to MCZMA and shall be uploaded on the website.

(xiii) The water quality of the River Gadhi, Ulwe, the Panvel Creek and the ground water is to be monitored on quarterly basis for TOC, Pb, Cd and Hg at all the locations identified in the EIA study for a period of at least 2 years from the commencement for the construction work and the quarterly reports to be submitted to Ministry of Environment and Forests Govt. of India and Maharashtra State Pollution Control Board.

(xiv) The waste water generated from the aircraft maintenance hangers may contain hazardous materials like lead, chromium, Sulphates, Phenolic compounds, V.O.C's etc. The surface runoff from the airport area shall also contain oils, grease, Sulphates etc, which cannot be sent directly to sewage treatment plant for the treatment. A separate treatment plant for managing the waste water shall be specified and adopted.

(xv) Based on the geological profile underneath the proposed airport, suitable consolidation factor shall be arrived to assess the additional noise/ vibration levels that would be produced during impact of landing & take off the air crafts simultaneously on both the runways. Further, the partially quarried hills in the vicinity will become a rebound shell for noise. CIDCO shall examine the details of noise/ vibration levels those are likely to be increased both during day and night time and the mitigative measures shall be installed to reduce the (noise/ vibration levels) impacts.

(xvi) Standard instrument arrival and departure procedure shall be designed to minimise the noise levels within the permissible limits for the area falling in the funnel near the airport on either side.

(xvii) Energy conservation to the extent of 20% shall be incorporated in the bidding documents including water conservation (reuse/recycle, rain water harvesting and water efficient fixtures) and other green building practices for various buildings proposed within the airport complex. CIDCO shall consider ECBC Guidelines 2009 to achieve the energy – efficient design.

(xviii) CIDCO shall prepare a detailed traffic management plan to take care of increased vehicular traffic which should also cover/ clearly delineate widening/ increasing the existing roads and associated road infrastructure approving/ installation of road safety features/ pedestrian facility/FOB/under passes etc (that can be done by carrying out road safety audits). Measures shall be taken to prevent encroachment along/within the ROWs on connecting/ main arterial roads.

(xix) Necessary road (National and State Highways) and rail connectivity shall also be upgraded to handle the increased passenger and cargo traffic, in addition to metro for transition of passengers. The proposal of Havorport shall not be taken up on the north part of the airport area as this shall damage the mangroves.

(xx) The measures should be taken to improve public transportation including dedicated road / MRTS corridors to access to Airport, may also be considered for the same. Energy Efficient dedicated rail based public transport facility; suburban/ metro train in particular, may be created between the Santa Cruz and the Navi Mumbai Airport in addition to all other links connecting various parts of Mumbai city.

(xxi) Traffic Management during construction phase should be clearly planned so that the traffic situation is not further worsened on the existing connecting roads. Installations of Noise barrier/ Green Belts should be clearly indicated in the plan (After identifying critical locations).

(xxii) To avoid accidental damage (fire, hazardous material waste handling, oil spills, wastewater disposal) in the adjacent ecologically fragile surroundings and mangrove area – a risk assessment plan and disaster management plan should be prepared and with periodic compliance of safety measures in place to avoid loss due accidental damage that could have been otherwise avoided. Further CIDCO shall appoint a dedicated professional team/cell to handle disaster and associated risks.

(xxiii) In addition to the above –CIDCO shall ensure that all the risks (such as fire, hazardous material waste handling, oil spills, waste – both liquid/solid wastes) associated/ resultant risk during various stages of development (like planning, construction, operation) are managed within the airport area. In case of any unforeseen event as stated above the liability – environmental and social will rest with the developer/CIDCO, the decision of the high level Committee, stipulated below will be full and final for liability fixations.

(xxiv) The compliance report of the monitoring committee shall be made 'public' (put online and/or also displayed for wider dissemination of compliance) at all stages (planning, construction, operation) to ensure effective monitoring and compliance of conditions.

(xxv) Environment Management Plan or associated monitoring plan shall ensure that mitigation measures detailed out in terms of role, responsibility, budgetary provisions, timeline for completion, frequency of monitoring and compliance etc.

(xxvi) In order to meet all the essential aeronautical requirements and the further airport expansions, no property development shall be undertaken within the proposed aeronautical Airport Zone area (1160ha).

(xxvii) The Master plan/Development plan of Navi Mumbai shall be revised and recasted in view of the airport development to avoid and unplanned haphazard growth around the airport. The landuse should take care of bird menace including that from the Mangrove Parks.

(xxviii) All other nearby villages, if not required to be relocated should be provided with best possible infrastructure so that they compare well with the adjoining ultra modern airport infrastructure.

(xxix) CRZ provisions shall be applicable on the tidally influenced diverted channels of Ulwe and Gadhi Rivers and CIDCO shall finalise the Airport plans accordingly.

(xxx) Any cutting or filling up the airport site will create significant turbidity problem. CIDCO shall examine the impact on the marine life. The details will be put up on the website every 3 months.

(xxxi) CIDCO shall conduct the baseline survey of avian fauna before the start of construction and the details shall be put up every 3 months on the website in association with BNHS.

(xxxii) The Environmental Clearance/ CRZ Clearance is recommended below is only for the Navi Mumbai Airport project. CIDCO shall obtain the Environmental and CRZ clearance separately for off airport facilities and other off infrastructure projects after finalising the locations and details as may be required under the EIA Notification 2006 and the CRZ Notification.

(xxxiii) Taking a cue from the man-made 26/11 incident arising out of external threat to our country, a strategic airport safety and security plan covering also surrounding inhabited areas of the airport shall be prepared and put in place in consultation with appropriate government departments

(xxxiv) A high level advisory and monitoring committee which should include International experts of repute, reporting directly to the highest Airport Management Authority shall be constituted by CIDCO to plan, execute and maintain the environmental issues/ recommendations mentioned above. The monitoring shall be done at various stages (planning, construction, operation) of project for compliance of conditions. Budgetory provisions shall be made to the satisfaction of this Committee. The committee shall meet at least once in three months and the decisions taken in the meetings shall be put up on the web site for public information.

(xxxv) Regular modeling study of air, noise shall be carried out due to the increase in traffic

(xxxvi) The solid waste shall be properly collected, segregated and disposed as per the provision of Solid Waste (Management and Handling) Rules, 2000.

(xxxvii) Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche etc. The housing may be in the form of temporary structures to be removed after the completion of the project.

(xxxviii) A First Aid Room will be provided in the project both during construction and operation of the project.

(xxxix) Disposal of muck during construction phase should not create any adverse effect on the neighboring communities and be disposed taking the necessary precautions for general safety and health aspects of people, only in approved sites with the approval of competent authority.

(xl) Soil and ground water samples will be tested to ascertain that there is no threat to ground water quality by leaching of heavy metals and other toxic contaminants.

(xli) Construction spoils, including bituminous material and other hazardous materials, must not be allowed to contaminate watercourses and the dump sites for such material must be secured so that they should not leach into the ground water.

(xlii) Installation and operation of DG set shall comply with the guidelines of CPCB.

(xliii) The diesel generator sets to be used during construction phase should be low sulphur diesel type and should conform to

Environment (Protection) Rules prescribed for air and noise emission standards.

(xliv) The diesel required for operating DG sets shall be stored in underground tanks and if required, clearance from Chief Controller of Explosives shall be taken.

(xlv) Vehicles hired for bringing construction material to the site should be in good condition and should have a pollution check certificate and should conform to applicable air and noise emission standards and should be operated only during non-peak hours.

(xlvi) Ambient noise levels should conform to residential standards both during day and night. Incremental pollution loads on the ambient air and noise quality should be closely monitored during construction phase. Adequate measures should be made to reduce ambient air and noise level during construction phase, so as to conform to the stipulated standards by CPCB/ MPCB.

(xlvii) Fly ash should be used as building material in the construction as per the provisions of Fly Ash Notification of September, 1999 and amended as on 27th August, 2003.

(xlviii) Ready mixed concrete must be used in building construction.

(xlix) Storm water control and its re-use as per CGWB and BIS standards for various applications.

(l) Water demand during construction should be reduced by use of pre-mixed concrete, curing agents and other best practices referred.

(li) Use of glass may be reduced by upto 40% to reduce the electricity consumption and load on airconditioning. If necessary, use high quality double glass with special reflective coating in windows.

(lii) The approval of the competent authority shall be obtained for structural safety of the buildings due to earthquake, adequacy of fire fighting equipments, etc. as per National Building Code including protection measures from lightening etc.

(liii) Regular supervision of the above and other measures for monitoring should be in place all through the construction phase, so as to avoid disturbance to the surroundings.

II. <u>Operation Phase</u>

i) Diesel power generating sets proposed as source of back up power for elevators and common area illumination during operation phase should be of enclosed type and conform to rules made under the

Environment (Protection) Act, 1986. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. Use of low sulphur diesel. The location of the DG sets may be decided with in consultation with Maharashtra Pollution Control Board.

ii) Noise should be controlled to ensure that it does not exceed the prescribed standards. During night time the noise levels measured at the boundary of the building shall be restricted to the permissible levels to comply with the prevalent regulations.

iii) The green belt of the adequate width and density preferably with local species along the periphery of the plot shall be raised so as to provide protection against particulates and noise.

iv) Weep holes in the compound walls shall be provided to ensure natural drainage of rain water in the catchment area during the monsoon period.

v) Rain water harvesting for roof run- off and surface run- off, should be implemented. Before recharging the surface run off, pre-treatment must be done to remove suspended matter, oil and grease. The borewell for rainwater recharging should be kept at least 5 mts. above the highest ground water table.

vi) The ground water level and its quality should be monitored regularly in consultation with Central Ground Water Authority.

vii) Traffic congestion near the entry and exit points from the roads adjoining the proposed project site must be avoided. Parking should be fully internalized and no public space should be utilized.

viii) Energy conservation measures like installation of CFLs/TFLs for the lighting the areas outside the building should be integral part of the project design and should be in place before project commissioning. Use CFLs and TFLs should be properly collected and disposed off/sent for recycling as per the prevailing guidelines/ rules of the regulatory authority to avoid mercury contamination. Use of solar panels may be done to the extent possible.

ix) Efforts should be made to use solar energy to the maximum extent possible.

III. <u>General Conditions</u>:

(i) In the event of any change in the project profile a fresh reference shall be made to the Ministry of Environment and Forests.

(ii) This Ministry reserves the right to revoke this clearance, if any, of the conditions stipulated are not complied with to the satisfaction of this Ministry.

(iii) This Ministry or any other competent authority may stipulate any additional conditions subsequently, if deemed necessary, for environmental protection, which shall be complied with.

(iv) Full support should be extended to the officers of this Ministry's Regional Office at Bhopal and the offices of the Central and State Pollution Control Board by the project proponents during their inspection for monitoring purposes, by furnishing full details and action plans including the action taken reports in respect of mitigative measures and other environmental protection activities.

8. These stipulations would be enforced among others under the provisions of water (Prevention and Control of Pollution) Act, 1974 the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and Municipal Solid Wastes (Management and Handling) Rules, 2000 including the amendments and rules made thereafter.

9. All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department and Civil Aviation Department from height point of view, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.

10. The project proponent should advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment and Forests at http://www.envfor.nic.in. The advertisement should be made within 10 days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bhopal.

11. Environmental clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004, if applicable to this project.

12. A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad / Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/ representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.

13. The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall

update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB. The criteria pollutant levels namely; SPM, RSPM, SO_2, NOx (ambient levels as well as stack emissions) or critical sectoral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.

14. The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.

15. The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEF by e-mail.

(Bharat Bhushan)
Director (IA-III)
22.11.2010

Copy to:

1. The Secretary, Department of Environment, Govt. of Maharashtra, Mantralaya, Mumbai – 400 032.
2. The Joint Secretary (AS), Ministry of Civil Aviation, Rajiv Gandhi Bhawan, Safdarjung Airport, New Delhi 110003.
3. The Chairman, CPCB, Parivesh Bhawan, CBD-cum-Office Complex, East Arjun Nagar, Delhi – 32.
4. The Chairman, Maharashtra Coastal Zone Management Authority, Room No.217 (Annexe), Mantralaya, Mumbai – 400 032.
5. The Chairman, Maharashtra Pollution Control Board, Kalpataru Points, 3rd & 4th floor, Opp. Cine Planet, Sion Circle, Sion (E) Mumbai-400 022.
6. The Chief Conservator of Forests, Ministry of Environment and Forests, Regional Office, Western Region, Kendriya Paryavaran Bhavan, Link Road No. 3, Ravishankar Nagar, Bhopal – 462016 (M.P.)
7. Guard File.
8. Monitoring Cell.

(Bharat Bhushan)
Director (IA)

Annexure II

Extension of EC

F.No.10-53/2009-IA.III
Government of India
Ministry of Environment, Forest and Climate Change
(IA-III Section)

Indira Paryavaran Bhawan,
Jor Bagh Road, New Delhi - 3

Date: 20th December, 2017

To,

The General Manager (Environment),
City and Industrial Development Corporation of Maharashtra Ltd (CIDCO),
Navi Mumbai International Airport Office,
3rd Floor, Tower No.10,
Belapur Railway Station Complex, C.B.D. Belapur,
Navi Mumbai-400614 (Maharashtra) Fax: 022-22022509/66500933
Email: consultant.env@cidcoindia.com

Subject: Environmental and CRZ Clearance for establishment of Navi Mumbai International Airport at Mumbai by M/s City and Industrial Development Corporation of Maharashtra Ltd – Extension of validity of Environmental and CRZ Clearance - reg.

Sir,

This has reference to your online proposal No. IA/MH/MIS/235/2009 dated 6th September, 2017 submitted to this Ministry for extension of validity of Environmental and CRZ Clearance granted vide letter No. 10-53/2009 dated 22nd November, 2010 for 'Establishment of Navi Mumbai International Airport at Mumbai' in favour of M/s City and Industrial Development Corporation of Maharashtra Ltd, in terms of the provisions of the Environment Impact Assessment (EIA) Notification, 2006 under the Environment (Protection) Act, 1986 and CRZ Notification, 2011.

2. The proposal for grant of extension of validity of Environmental and CRZ Clearance to the above referred project was considered by the Expert Appraisal Committee (Infra-2) in its 24th meeting held in 30-31 October, 2017.

3. The EAC in its 24th meeting held in 30-31 October, 2017 has recommended the project for grant of extension of the validity of EC&CRZ clearance issued vide letter dated 22nd November, 2010 for a period of three years. As per recommendations of the EAC, the Ministry of Environment, Forest and Climate Change hereby extend the validity of Environmental and CRZ Clearance up to 21st November, 2020. The following additional conditions were also recommended.

(i) A certified report on the sources and availability of water from the local body supplying water along with the permission received by them for the same shall be submitted. This report shall specify the total annual water availability with the organization (local body), the quantity of water already committed to other development projects, the quantity of water committed for this project and the balance water available for distribution. This should be specified separately for ground water and surface water sources and ensure that there is no impact on other users.

(ii) A detailed traffic management and a traffic decongestion plan, to ensure that the current level of service of the roads within a 05 kms radius of the project site is maintained and improved upon, shall be drawn up through an organization of repute and specializing in Transport Planning within the next 6 months. This should be based on the cumulative impact of all development and increased inhabitation being carried out or proposed to be carried out by the project or other agencies in this 05 kms radius from the site under different scenarios of space and time and shall be implemented to the satisfaction of the State Urban Development and Transport Departments with the consent of all the concerned implementing agencies.

(iii) Treated effluents shall also be used for irrigation and in Road side plantation after taking due permission from the concerned authorities/ Forest department

(iv) The project proponents shall satisfactorily address to all the complaints that have been received against the project and submit a compliance report to the Ministry

(v) The extension of validity is being granted for the original proposals for which Environmental and CRZ Clearance was granted earlier. The project proponents will not make any changes in the project nature, structure or configuration and limit themselves to activities for which the Environmental and CRZ Clearance has been given earlier.

4. All other conditions stipulated in the Environmental and CRZ Clearance granted vide letter No. 10-53/2009 dated 22nd November, 2010, shall remain unchanged.

5. This issues with the approval of the Competent Authority.

(Kushal Vashist)
Director

Copy to:

1) The Principal Secretary, Environment Department, Government of Maharashtra, 15th Floor, New Administrative Building, Mantralaya, Mumbai - 400 032.
2) The Joint Secretary (AS), Ministry of Civil Aviation, Rajiv Gandhi Bhawan, Safdarjung Airport, New Delhi – 110 003.
3) The APCCF (C), MoEF&CC, Regional Office (WCZ), Ground Floor, East Wing, New Secretariat Building, Civil Lines, Nagpur - 440001.
4) The Chairman, Maharashtra Coastal Zone Management Authority, Room No. 217 (Annexe), Mantralya, Mumbai – 400 032.
5) The Chairman, Central Pollution Control Board Parivesh Bhavan, CBD-cum-Office Complex, East Arjun Nagar, New Delhi - 110 032.
6) The Chairman, Maharashtra Pollution Control Board, Kalpataru Point, 3rd and 4th floor, Opp. Cine Planet, Sion Circle, Mumbai - 400 022.
7) Monitoring Cell, MoEF&CC, Indira Paryavaran Bhavan, New Delhi.
8) Guard File/ Record File/ Notice Board.

(Kushal Vashist)
Director

Annexure III

Stage I Forest clearance

Forest clearance

I

F. No. 8-95/2012-FC
Government of India
Ministry of Environment & Forests
(FC Division)
***

Paryavaran Bhawan,
C.G.O Complex, Lodhi Road,
New Delhi - 110510.
Dated: 17th December. 2013.

To

The Principal Secretary (Forests),
Government of Maharashtra,
Mantralaya, Mumbai.

Sub: Diversion of 250.0635 ha of forest land in favour of General Manager (Airport) CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra- regarding.

Sir,

I am directed to refer to the State Government's letter no. FP/MH/Others/663/2012 dated 20.11.2012 on the above subject seeking prior approval of the Central Government under the Forest (Conservation) Act, 1980 and to say that the proposal has been examined by the Forest Advisory Committee constituted by the Central Government under section-3 of the said Act.

After careful examination of the proposal of the State Government and on the basis of the recommendation of the Forest Advisory Committee, the Central Government hereby conveys the 'in-principle' approval for diversion of 250.0635 ha of forest land in favour of General Manager (Airport) CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra subject to fulfilment of the following conditions:

i. Legal status of the diverted forest land shall remain unchanged

ii. Compensatory Afforestation over the non-forest land equal in extent to the forest land (i.e. over 250.0635 ha) being diverted shall be raised and maintained by the State Forest Department at the cost of the User Agency.

iii. The non-forest land identified for raising compensatory afforestation shall be transferred and mutated in favour of the State Forest Department before issue of the Stage-II clearance.

A iv. The land identified for the purpose of CA shall be clearly depicted on a Survey of India toposheet of 1:50.000 scale.

A v. The non-forest land transferred and mutated in favour of the State Forest Department shall be notified by the State Government as RF under Section-4 or PF under Section-29 of the Indian Forest Act, 1927 or under the relevant Section(s) of the local Forest Act, 1927 latest within a period of six months from the date of issue of Stage--II approval. The Nodal Officer shall report compliance in this regard along with a copy of the original notification declaring the non-forest land under Section 4 or Section 29 of the

Indian Forest Act, 1927, as the case may be, within the stipulated period to the Central Government for information and record;

vi. The User Agency shall transfer the cost of raising and maintaining the compensatory afforestation, at the current wage rate, to the State Forest Department. The scheme may include appropriate provision for anticipated cost increase for works scheduled for subsequent years.

vii. User Agency shall deposit the Net Present Value (NPV) of the diverted forest land with the State Forest Department as per the orders of the Hon'ble Supreme Court dated 30.10.2002, 01.08.2003 and 28,.03.2008 in I.A. No. 566 in WP(C) No. 202/1995 and the guidelines issued by this Ministry vide letter No. 5-1/98-FC(Pt.II) dated 18.09.2003 and 22.09.2003 in this regard.

viii. Additional amount of the NPV of the diverted forest land, if any, becoming due after finalization of the same by the Hon'ble Supreme Court of India on receipt of the report from the Expert Committee, shall be charged by the State Government from the User Agency. The User Agency shall furnish an undertaking to this effect.

ix. All the funds received from the User Agency under the project shall be transferred to Ad-hoc CAMPA in saving accounts pertaining to the State concerned.

x. Afforestation of mangrove species over an area equivalent in extent to mangrove forest area being diverted has to be raised and maintained by the user agency at their own cost in consultation with the State Forest Department. It will be in addition to the mangrove area to be raised under CRZ approval.

xi. The User Agency will undertake comprehensive soil conservation measures at the project cost in consultation with the State Forest Department.

xii. The User Agency will assist the State Government in conservation and preservation of flora and fauna of the area in accordance with the plan prepared by the Chief Wildlife Warden of the State.

xiii. All conditions imposed by the Standing Committee of the National Board for Wildlife. communicated vide MoEF's letter no. 6-43/2007-WL (29th Meeting) dated 1.08.2013. will be complied with.

xiv. A Monitoring Committee will monitor the implementation of different measures stipulated herein and will submit six monthly report to the Ministry in this regard. The Committee will be comprised of Principal Chief Conservation of Forests as Chairman, representative of the Regional Office, Bhopal, representative of Bombay Natural History Society and representative of CIDCO and Conservator of Forests (territorial), who will be the Member Secretary of the Monitoring Committee.

xv. The R&R Plan approved by the State Government shall be submitted before Stage-II approval.

xvi. State Government shall ensure that settlement of displaced people does not take place in the forest land.

xvii. Any trees shall be felled only when it becomes necessary and that too under strict supervision of State Forest Department, and at the cost of the User Agency.

xviii. No labour camp shall be established on the forest land. The User Agency shall also provide fuels preferably alternate fuels to the labourers and staff working at the site so as to avoid any damage to the nearby forest areas.

xix. In future, user agency shall not submit any proposal for extension of the project or any other project ancillary/related to this project in the forest land between the present project site and Karnala Bird Sanctuary.

xx. The boundary of the diverted forest land shall be demarcated on the ground with four feet high cement concrete pillar with its serial number and forward and back bearing inscribed on it.

xxi. The layout and plan shall not be changed without prior approval of the Central Government.

xxii. The User Agency shall obtain the Environment Clearance as per the provisions of the Environmental (Protection) Act, 1986, if required;

xxiii. Ex-situ conservation of endemic species of flora/fauna lost/disturbed in the process of execution of the project may be ensured.

xxiv. No damage to the flora and fauna of the area shall be caused. — FC II incl.

xxv. The user agency in consultation with the State Government shall create and maintain alternate habitat/home for the avifauna, whose nesting trees area to be cleared in this project. Birds nests artificially made out of eco-friendly material shall be used in the area, including forest area and human settlements, adjoining the forest area being diverted for the project.

xxvi. The forest land shall not be used for any purpose other than that specified in the proposal and shall, under no circumstances, be transferred to any one without prior approval of the Central Government.

xxvii. All other conditions proposed by the State Government at the time of submission of the proposal to the Central Government shall be complied with by the User Agency.

xxviii. The State Government shall complete settlement of rights, in terms of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, if any, on the forest land to be diverted and submit the documentary evidence as prescribed by this Ministry in its letter No. 11-9/1998-FC (pt.) dated 03.08.2009, in support thereof

xxix. Rehabilitation of project affected families, if any, shall be done as per the National Rehabilitation policy / State Rehabilitation policy whichever is better in consultation with the State Forest Department at the cost of user agencies.

xxx. The user agency shall submit the annual self compliance report in respect of the above conditions to the State Government and to the concerned Regional Office of the Ministry regularly.

xxxi. Any other condition that the concerned Regional Office of this Ministry may stipulate, from time to time, in the interest of conservation, protection and development of forests & wildlife; and

xxxii. The User Agency and the State Government shall ensure compliance to provisions of the all Acts. Rules, Regulations and Guidelines, for the time being in force, as applicable to the project.

xxxiii. Any other condition that the Addl. PCCF (Central), Regional Office, Bhopal may impose from time to time for the protection and improvement of flora and fauna in the forest area.

After receipt of the compliance report on the fulfilment of the above mentioned conditions from the State Government, formal approval will be considered in this regard under Section-2 of the Forest (Conservation) Act, 1980. The transfer of forest land to the User Agency shall not be affected by the State Government till formal order approving the diversion of forest land is issued by the Central Government.

Yours faithfully,

(Priya Ranjan)
Sr. Assistant Inspector General of Forests

Copy to:-

1. The Principal Chief Conservator of Forests, Government of Maharashtra, Nagpur.
2. The Addl. PCCF (Central), Regional Office, Bhopal, MoEF.
3. The Nodal Officer (FCA), O/o the PCCF, Government of Maharashtra, Nagpur.
4. User Agency (M/s Rewas Ports Ltd., Jai Center, 1st Floor, 34 P D'Mello Road, Opp Red Gate, Mumbai 400 009.
5. Monitoring Cell, FC Division, MoEF, New Delhi.
6. Guard File.

(Priya Ranjan)
Sr. Assistant Inspector General of Forests

Annexure IV

Stage II Forest clearance

F. No. 8-95/2012-FC
Government of India
Ministry of Environment, Forests and Climate Change
(Forest Conservation Division)
***

Indira Paryavaran Bhawan,
Aliganj, Jorbagh Road,
New Delhi – 110003
Dated 24 April, 2017

To,

The Principal Secretary (Forests),
Government of Maharashtra,
Mantralaya, Mumbai.

Sub: Diversion of 250.0635 ha of forest land in favour of General Manager (Airport), CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra- regarding.

Sir,

I am directed to refer to the State Government of Maharashtra's letter No. FP/MH/Others/663/2012 dated 20.11.2012 on the subject cited above seeking prior approval of the Central Government under the Forest (Conservation) Act, 1980. After careful consideration of the proposal by the Forest Advisory Committee (FAC) constituted under Section-3 of the said Act, ***In-principle approval/Stage-I Clearance*** was granted vide this Ministry's letter of even number dated 17.12.2013 subject to fulfilment of certain conditions. The State Government has furnished compliance report in respect of the conditions stipulated in the approval and has requested the Central Government to grant final approval.

In this connection, I am directed to say that on the basis of the compliance report furnished by the Government of Maharashtra vide their letters No. 17/NC/II/LD.12060/(49)/2373/15-16 dated 18.03.2016, No. FLD-1315/C.R.352/part-2/F-10 dated 07.09.2016, No. FLD-1315/C.R.352/part-2/F-10 dated 03.11.2016 and no. Desk-17/NC/II/LD.12060/(49)/2372/16-17 dated 21.03.2017 , and **recommendation for deletion of condition no. (xx) and modification of condition No.(xix) of stage-I clearance dated 17.12.2013 by Forestry Advisory Committee in its meeting held on 12.07.2016 and approval of competent authority for the same**, the ***Final /Stage-II approval*** of the Central Government is hereby granted under Section-2 of the Forest (Conservation) Act, 1980 for diversion of 250.0635 ha of forest land in favour of General Manager (Airport), CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra subject to fulfilment of the following conditions:

fr I A (i) Legal status of the diverted forest land shall remain unchanged.

(ii) Compensatory afforestation (CA) over the non-forest land equal in extent to the forest land being diverted (i.e. over 250.0635 ha) shall be raised within three years from the date of issue of stage -II clearance and maintained thereafter as per approved plan by the State Forest Department at the cost of the User Agency. The CA will be done at the rate of 1000 plants per ha (i.e. 2,50,063 plants) over the non-forest land. However, as now forest land identified for CA has only 120.75 ha plantable area which can accommodate only 67,073 plants. The remaining 1,82,990 plants shall be planted over degraded forest land under the control of State Forest Department as identified in the compliance report submitted by State Govt. vide their letter no. Desk-17/NC/II/LD.12060/(49)/2372/16-17 dated 21.03.2017;

(iii) The State Govt. shall ensure that afforestation of mangrove species over an area equivalent in extent to mangrove forest area being diverted has to be raised within three years from the date of stage - II clearance and maintained at the cost of user agency in consultation with the

Dee

State Forest Department. It will be in addition to the mangrove area to be raised under CRZ approval;

(iv) **In future, user agency shall not submit any proposal for extension of project or any other project ancillary/related to this project in forest land falling in eco sensitive zone of Karnala bird sanctuary;**

(v) The non-forest land transferred and mutated in favour of the State Forest Department shall be notified by the State Government as RF under Section-4 or PF under Section-29 of the Indian Forest Act, 1927 or under the relevant Section(s) of the local Forest Act, 1927 latest within a period of six months from the date of issue of Stage--II approval. The Nodal Officer shall report compliance in this regard along with a copy of the original notification declaring the non-forest land under Section 4 or Section 29 of the Indian Forest Act, 1927, as the case may be, within the stipulated period to the Central Government for information and record.

(vi) The User Agency will undertake comprehensive soil conservation measures at the project cost in consultation with the State Forest Department;

FCF (vii) The User Agency shall obtain the Environment Clearance as per the provisions of the Environmental (Protection) Act, 1986, if required;

(viii) The User Agency will assist the State Government in conservation and preservation of flora and fauna of the area in accordance with the plan prepared by the Chief Wildlife Warden of the State;

(ix) The State Govt. shall ensure to comply with all the conditions imposed by the Standing Committee of the National Board for Wildlife, communicated vide MoEF's letter no. 6-43/2007-WL (29th Meeting) dated 1.08.2013;

(x) The User Agency shall pay the additional amount of NPV, if so determined, as per the final decision of the Hon'ble Supreme Court of India;

FCS (xi) The Monitoring Committee as constituted vide order no. FLD-1312/CR 352(part-II)/ F-10 dated 25.07.2014 by Govt. of Maharashtra shall monitor the implementation of different measures stipulated and submit six monthly report to the Ministry/Regional Office Nagpur;

FCI (xii) The approved R&R Plan shall be implemented by the State Government;

(xiii) Rehabilitation of project affected families, if any, shall be done as per the National Rehabilitation policy / State Rehabilitation policy whichever is better in consultation with the State Forest Department at the cost of user agency;

(xiv) State Government shall ensure that settlement of displaced people does not take place in the forest land;

(xv) Any tree felling shall be done only when it is unavoidable and that too under strict supervision of the State Forest Department;

(xvi) The layout plan of the proposal shall not be changed without the prior approval of the Central Government

(xvii) No labour camp shall be established on the forest land;

(xviii) The User Agency shall provide fuels preferably alternate fuels to the labourers and the staff working at the site so as to avoid any damage and pressure on the nearby forest areas

(xix) The State Govt. shall ensure that the User Agency implement the conservation plan prepared by BNHS in connection with conservation of flora & fauna

(xx) The user agency will abide by the applicable recommendations of the State Government including State Forest/Wildlife Departments;

(xxi) The forest land shall not be used for any purpose other than that specified in the proposal.

(xxii) The forest land proposed to be diverted shall under no circumstances be transferred to any other agency, department or person without prior approval of the Central Government;

(xxiii) No damage to the flora and fauna of the adjoining area shall be caused;

(xxiv) The State Government shall ensure the complete compliance on settlement of rights, in terms of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, if any, on the forest land to be diverted and submit the documentary evidence as prescribed by this Ministry in its letter No. 11-9/1998-FC (pt.) dated 03.08.2009 read with 05.07.2013, in support thereof. **The State Government shall accept the conditions put in Gram Sabha Resolution. The State Government shall provide undertaking to MoEF&CC, before commencement of work, that the State Government will comply with all provisions of FRA -2006 as specified by Ministry of tribal affairs;**

(xxv) The User Agency shall submit the annual self compliance report in respect of the above stated conditions to the State Government, concerned Regional Office and to this Ministry by the end of March every year;

(xxvi) Any other condition that the concerned Regional Office of this Ministry may stipulate, from time to time, in the interest of conservation, protection and development of forests & wildlife; and

(xxvii) The user agency shall comply all the provisions of the all Acts, Rules, Regulations, Guidelines & Hon'ble Court Order (s) pertaining to this project, if any, for the time being in force, as applicable to the project.

Yours faithfully

(Sandeep Sharma)
Assistant Inspector General of Forests

Copy to:

1. The Principal Chief Conservator Forests, Government of Maharashtra, Nagpur.
2. Addl. Principal Chief Conservator of Forests (Central), Ministry of Environment & Forests, Regional Office (WZ), Kendriya Paryavaran Bhawan, E-5, Arera Colony, Link Road-3, Ravi Shankar Nagar, Bhopal-462016.
3. The Nodal Officer, O/o the PCCF, Government of Maharashtra, Nagpur
4. User Agency (Executive Engineer, Raigad Irrigation No-2, Konkan Bhavan, Navi Mumbai
5. Monitoring Cell
6. Guard file

(Sandeep Sharma)
Assistant Inspector General of Forests

Annexure V

Honourable High Court approval for clearance of mangroves

IN THE HIGH COURT OF JUDICATURE AT BOMBAY

ORDINARY ORIGINAL CIVIL JURISDICTION

NOTICE OF MOTION NO.419 OF 2011
IN
PUBLIC INTEREST LITIGATION NO.87 OF 2006
...

The Bombay Environmental Action Group & Anr. ..Petitioners

Vs.

The State of Maharashtra & Ors. ...Respondents

And

City & Industrial Development
Corporation of Maharashtra ...Applicant
...
Mr.G.S.Hegde i/b. G.S. Hegde & Co., for applicant.
Ms. Gulnar Mistry i/b. M.V. Jayakar & Co., for the petitioners.
Mr. R.A. Rodrigues with Mr. N.J. Prajapati for respondent Union of India.
Ms. Sharmila Modle for respondent-B.M.C.
Ms. Sharmila Deshmukh for respondent-MCZMA.

...

CORAM: MOHIT S. SHAH, C.J. &
M.S.SANKLECHA, J.
DATE : 29 OCTOBER 2013

P.C.:

This notice of motion has been taken out by CIDCO, Navi Mumbai for modification of the order dated 6 October 2005 and for permission to develop the Green Field Airport at Navi Mumbai without having to seek clearance under the Forest Conservation Act, 1980.

2. Learned counsel for CIDCO has now tendered additional affidavit dated 3 October 2013 placing on record the order dated 11-12 July 2013 passed by Government of India in the Ministry of Environment & Forests Department ,(FC Division) recommending the proposal of CIDCO Ltd. Navi Mumbai for diversion of 250.0635 hectors of forest land in Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra. The recommendation is subject to certain standard conditions and also additional conditions, which are as under:-

> *1. Afforestation of mangroves species over an area equivalent in extent to mangroves forest area being diverted has to be raised and maintained by the user agency at their own cost in consultation with the State Forest Department. It will be in addition to the mangrove area to be raised under CRZ approval.*
>
> *2. All conditions imposed by the Standing Committee of the National Board for Wildlife will be complied with.*
>
> *3. A specific plan shall be prepared by the user agency through a reputed organization like WII, SACON, BNHS, etc. and its recommendations shall be implemented by the User Agency to mitigate the impact of the project on avifauna under the supervision of the State Forest Department at the cost of project.*
>
> *4. A Monitoring Committee will monitor the implementation of different measures stipulated herein and will submit six monthly report to the Ministry in this regard. The Committee will be comprised of Principal Chief Conservator of Forests as Chairman, representative of the Regional Office, Bhopal, representative of Bombay Natural History Society and representative of CIDCO and Conservator of Forests (territorial), who will be the Member Secretary of the Monitoring Committee.*
>
> *5. The R & R Plan approved by the State Government shall be submitted before Stage-II approval.*
>
> *6. State Government shall ensure that settlement of displaced people does not take place in the forest land.*

7. In future, user agency shall not submit any proposal for extension of the project or any other project ancillary/related to this project in the forest land between the present project site and Karnala Bird Sanctuary.

3. In the meantime, at the 29th meeting of the Standing Committee of the National Board for Wildlife held on 6 June 2013 the following decision was recorded thereafter in its minutes on 20 July 2013:-

5(1) Proposal for construction of Navi Mumbai International Airport (NMIA) at Panvel Talukaa, District Raigad in Maharashtra in 10 km eco-sensitive zone/Area (ESA) of Karnala Bird sanctuary (KBS)

The Member Secretary informed the commitrtee that this proposal was discussed during the 28th Meeting of Standing Committee of NBWL and after discussion the committee had decided that a team comprising of Dr.Asad Rahmani and Shri Kishor Rithe would conduct site inspection and submit a report to the Standing Committee of NBWL for consideration. Subsequently, Dr.Asad Rahmani of Bombay Natural History Society (BNHS) informed the MoEF that BNHS had accepted the study from project proponent CIDCO and hence he would be unable to be a part of site inspection team as it would be conflict of interest for him. Therefore, Additional Director General of Forest (Wildlife), Dr.Divyabhanusinh Chavde and Kishor Rithe were directed to conduct the site inspection vide letter (no.6-34/2013WL) dated 3 May 2013. However, Dr.Chavda could not join the site inspection team due to his other engagements.

The site inspection was conducted on 9th and 10th May 2013 and after inspection, the team had recommended the proposal with certain conditions. An important observation that came out during the site inspection was that Shri Debi Goenka of the Conservation Action Trust, Mumbai had filed a Public Interest Litigation (PIL) on mangrove protec tion which will be applicable to mangrove area to be destroyed by proposed project of NMIA.

The committee, after discussion, unanimously decided to recommend the proposal subject to the following conditions, as stipulated in the site inspection report:

i. As there are several project proposals coming to SC-NBWL around KBS, it is recommended that the CWLW should compile the information and proceed to assess the cumulative impart of the those projects on KBS landscape (which includes several Pas mentioned by CWLW and surrounding wildlife habitats (together with forest, wetland and mangroves), and plan about compensating/mitigating the damages collectively. For any further project in 10km ESZ of KBS, this condition must be given due consideration.

ii. Air traffic at NMIA should not use the airspace above the KBS as promised during the meeting. The annual report "Baseline Survey of Avian fauna at and around NMIA" produced by BNHS has, though not sufficient enough, suggested conservation measures in 10 km radius of NMIA. The potential wildlife habitats (wetlands, forest and mangroves) which comes in 10km ESZ of KBS should also be considered for implementing conservation measures.

Iii. In order to have alternate site for migratory birds visiting wetland within proposed NMIA site, Sewri coast wetland should be considered to be developed. The Sewri coast wetland of 1037.3 ha is a marshland protected from Arabian sea near the mouth of Thane creek. Thousands of flamingos along with many other migratory water birds about 150 species (11 are globally threatened) inhabit this marsh partly covered by mangrove. The Government of Maharashtra should nominate the same for Ramsar site.

iv. As per the Hon'ble High Court order dated 27 January 2010 the mangrove Is a protected forest. As the project involves mangrove forest land , the State Government should see if any approval from the Hon'ble High Court is required. Mangrove eco-system has a unique aquatic fauna which carries a great importance. There is dense mangrove cover towards north side of the proposed NMIA site and parts of it also occur inside the NMIA site. To compensate for the loss of important mangrove forest portion inside the NMIA site, the mangrove forest bordering NMIA site (including the mangrove Park) should be declared as a mangrove sanctuary.

v. The project proponent should pay 3% of project cost for a fixed deposit with the wildlife department so that the interest amount can be spent on conservation of man grove in the entire Mumbai wildlife circle.

vi. The government of Maharashtra has presently notified only 12.11 sq.km area as KBS though there are more wildlife potential forest lands available between the KBS and the NMIA site. As those lands will be vulnerable for encroachments, we recommend that the state government should notify all such forest patches between the KBS and NMIA as sanctuary before granting the final clearance. This will not only help to stop further encroachments on forest lands around NMIA site (unlike encroachments around existing Mumbai airport) but also will help to reduce the risk of having any air traffic accident due to garbage attracted bird movements.

vii. Looking at the encroachments around SGNP and the existing Mumbai airport, the Government of Maharashtra need to ensure that the families be relocated at relocation site-2 (55 Ha) at Depoli which requires 40 ha land and at relocation site-3 at Vahal on Amra Marg should not further encroach upon any forest land around these sites or in 10 km ESZ of KBS. There are 10 settlements from 7 revenue villages which need to be acquired for NMIA project and to be relocated at these three sites.

viii. The project proponent should construct the boundary was specially for relocation site-2 (along with 100 ha non-aeronautical activity area) during the construction of the project. This will also help to minimise the garbage issue which attracts birds and other wild animals and also stop encroachments on surrounding forest areas.

ix. Project propo0nent should allocate enough display space at the prominent location in the NMIA (As per the requirement of CWLW Maharashtra) free of cost to depict and highlight/ publicise the importance of protected areas of Maharashtra to the tourists arriving at NMIA till the lifetime of NMIA.

x. CWLW Maharashtra should incorporate the measures in the Management plan of KBS.

Thus, the Standing Committee of National Board for Wildlife recorded its recommendation to the proposal subject to ten conditions stipulated hereinabove.

4. Learned counsel for CIDCO submits that in view of the above recommendations of the National Board for Wildlife at the meeting of the Standing Committee held on 6 June 2013 and recommendations of the Forest Advisory Committee in the Ministry of Environment & Forests (MOEF) at the meeting held on 11-12 July 2013, there is no impediment to the permission being granted to CIDCO for removal of mangroves from 108.50 hectors. Learned counsel for CIDCO states that MOEF had already amended the CRZ Notification of 1991 thereby permitting the development of Airport in June 2009 and by letter dated 22 November 2010 the MOEF had also given environmental and CRZ clearance for the proposed Airport at Navi Mumbai. CIDCO had delineated an area of 108.50 hectors of mangroves for clearing the same to enable development of Airport and associated off-site infrastructure. As per the approval of MOEF, CIDCO is permitted to clear the mangroves in 108.50 hectors subject to development of 245 hectors of mangroves and protect 370 hectors of mangroves. CIDCO has also produced the plan at Exh.F to the affidavit in support of the notice of motion showing the area from which the mangroves are to be cleared and compensatory aforestation is to be done.

4. In view of the above, having heard the learned counsel for parties, we permit CIDCO to clear mangroves from 108.50 hectors subject to condition that CIDCO shall plant and develop 245 hectors of mangroves at the site indicated in Exh.F and also to protect 370 hectors of mangroves as indicated in Exh.F to the affidavit dated 18 August 2011 in support of Notice of Motion No.419 of 2011. CIDCO is directed to comply with all conditions stipulated by Forest Advisory Committee as well as the Standing Committee of National Board for Wildlife in the aforesaid approvals/recommendations.

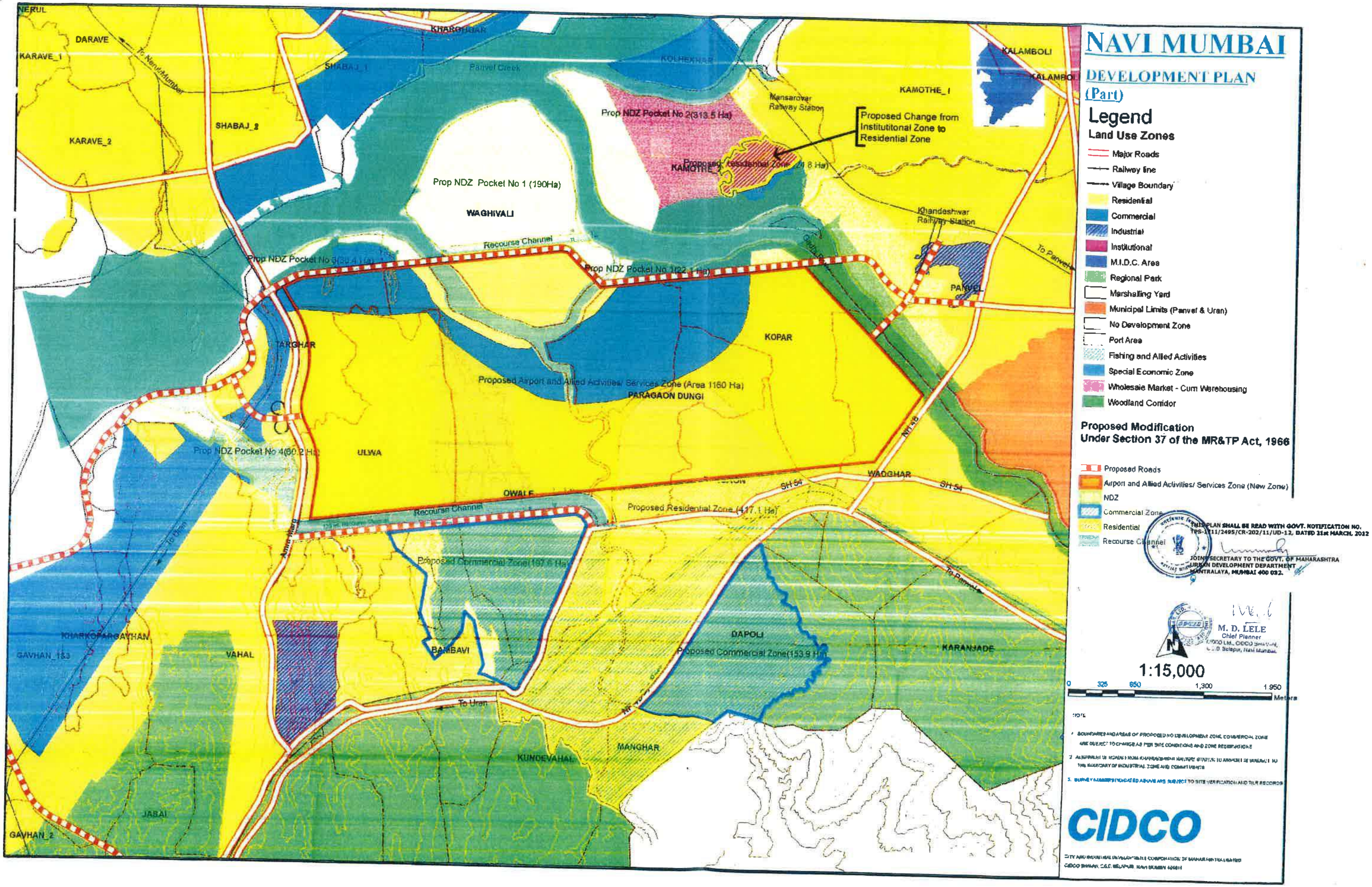
5. Notice of motion, accordingly, stands disposed of.

CHIEF JUSTICE

(M.S.SANKLECHA, J.)

Annexure VI

UDD, GoM sanctioned modification to NMDP incorporating provision of NMIA



NAVI MUMBAI
DEVELOPMENT PLAN
(Part)
Legend
Land Use Zones
Major Roads
Railway line
Village Boundary
Residential
Commercial
Industrial
Institutional
M.I.D.C. Area
Regional Park
Marshalling Yard
Municipal Limits (Panvel & Uran)
No Development Zone
Port Area
Fishing and Allied Activities
Special Economic Zone
Wholesale Market - Cum Warehousing
Woodland Corridor
Proposed Modification
Under Section 37 of the MR&TP Act, 1966
Proposed Roads
Airport and Allied Activities/ Services Zone (New Zone)
NDZ
Commercial Zone
Residential
Recourse Channel
THIS PLAN SHALL BE READ WITH GOVT. NOTIFICATION NO. TPS-1711/2495/CR-202/11/UD-12, DATED 21st MARCH, 2012
JOINT SECRETARY TO THE GOVT. OF MAHARASHTRA
URBAN DEVELOPMENT DEPARTMENT
MANTRALAYA, MUMBAI 400 032.
M. D. LELE
Chief Planner
CIDCO Ltd., CIDCO Bhavan,
C.B.D. Belapur, Navi Mumbai.
1:15,000
0 325 650 1,300 1,950
Meters
NOTE
CIDCO
NERUL
DARAVE
KARAVE_1
To Nerul-Mumbai
KARAVE_2
SHABAJ_1
SHABAJ_2
KHARGHAR
Panvel Creek
KOLHEKHAR
KALAMBOLI
KAMOTHE_I
Mansarovar Railway Station
Proposed Change from Institutitonal Zone to Residential Zone
Prop NDZ Pocket No 2(313.5 Ha)
KAMOTHE_2
Prop NDZ Pocket No 1 (190Ha)
WAGHIVALI
Recourse Channel
Khandeshwar Railway Station
To Panvel
PANVEL
TARGHAR
KOPAR
Proposed Airport and Allied Activities/ Services Zone (Area 1160 Ha)
PARAGAON DUNGI
ULWA
OWALE
WADGHAR
SH 54
Proposed Residential Zone (417.1 Ha)
Proposed Commercial Zone(197.6 Ha)
BAMBAVI
DAPOLI
Proposed Commercial Zone(153.9 Ha)
KARANJADE
To Panvel
KHARKOPARGAVHAN
GAVHAN_1&3
VAHAL
To Uran
KUNDEVAHAL
MANGHAR
JASAI
GAVHAN_2

Annexure VII

CZMP sheet No. E43 H1/NW- Map No. MH-74 of NMIA Area

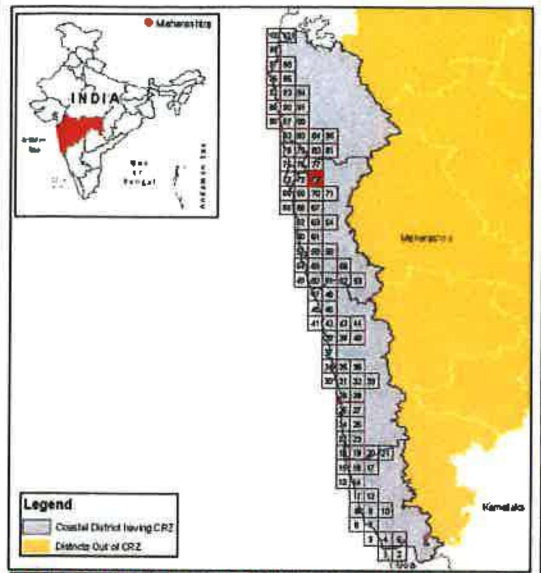
DRAFT CZMP MAP AS PER CRZ NOTIFICATION 2019
MAHARASHTRA STATE

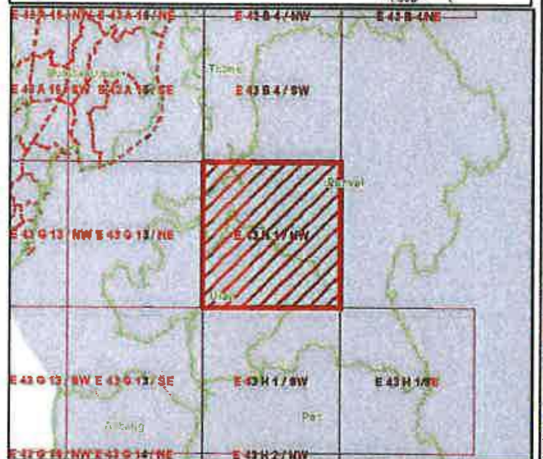
SHEET NO : E 43 H 1 / NW

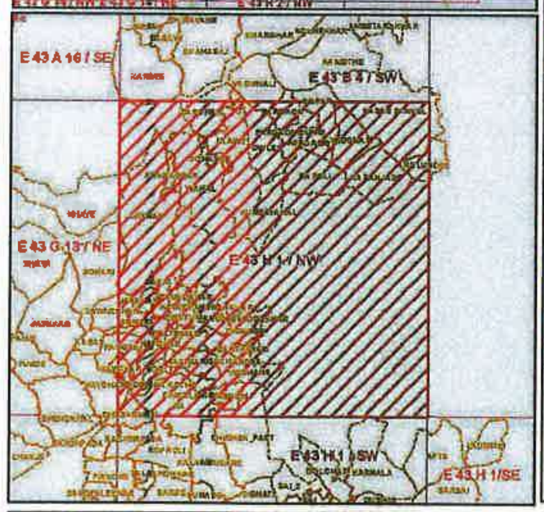
Map No: MH 74

Projection :- UTM Datum :- WGS 1984

0 1 2
Kilometers
Scale : 1 : 25,000







Legend
Data Provided: MCZMA

- Road
- Bridge
- Ferry
- Railway Line
- Stream
- Ward Boundary
- Municipal or Corporation Boundary
- Taluk Boundary
- Village Boundary
- Survey Plots

Data Source: NCSCM

- Lighthouse
- Bund
- Seawall
- Jetty or Breakwater
- High Tide Line
- Low Tide Line
- CVCA

CRZ lines

- CRZ line for River or Creek
- 20m CRZ Line for Islands
- 50m CRZ line for Bay
- 50m CRZ Line - CRZ IIIA (NDZ)
- 200m CRZ Line - CRZ IIIB (NDZ)
- 500m CRZ line
- Hazard Line - (Data Source, SOI)

CRZ CATEGORY
CRZ - I

- Nesting Grounds of Birds - CRZ IA
- Turtle Nesting Grounds - CRZ IA
- 50m Mangrove Buffer Zone - CRZ IA
- Marine Protected Area - CRZ IA
- Archaeological & Heritage Sites - CRZ IA
- Corals and Coral Reefs - CRZ IA
- Reserve Forests - CRZ IA
- Salt Marsh - CRZ IA
- Sand Dunes - CRZ IA
- Mangroves - CRZ IA
- Mudflats - CRZ IA
- Beach - CRZ IB
- Rock Outcrop - CRZ IB
- Intertidal Zone - CRZ IB

CRZ - II

- CRZ landward of HTL - CRZ II

CRZ - III

- 50 to 500m from HTL - CRZ IIIA
- 200 to 500m from HTL - CRZ IIIB
- No Development Zone - NDZ
- NDZ - Within CRZ II - Greater Mumbai
- NDZ - Within CRZ II - Greater Mumbai

CRZ - IV

- Waterbody - CRZ IVA
- Waterbody - CRZ IVB

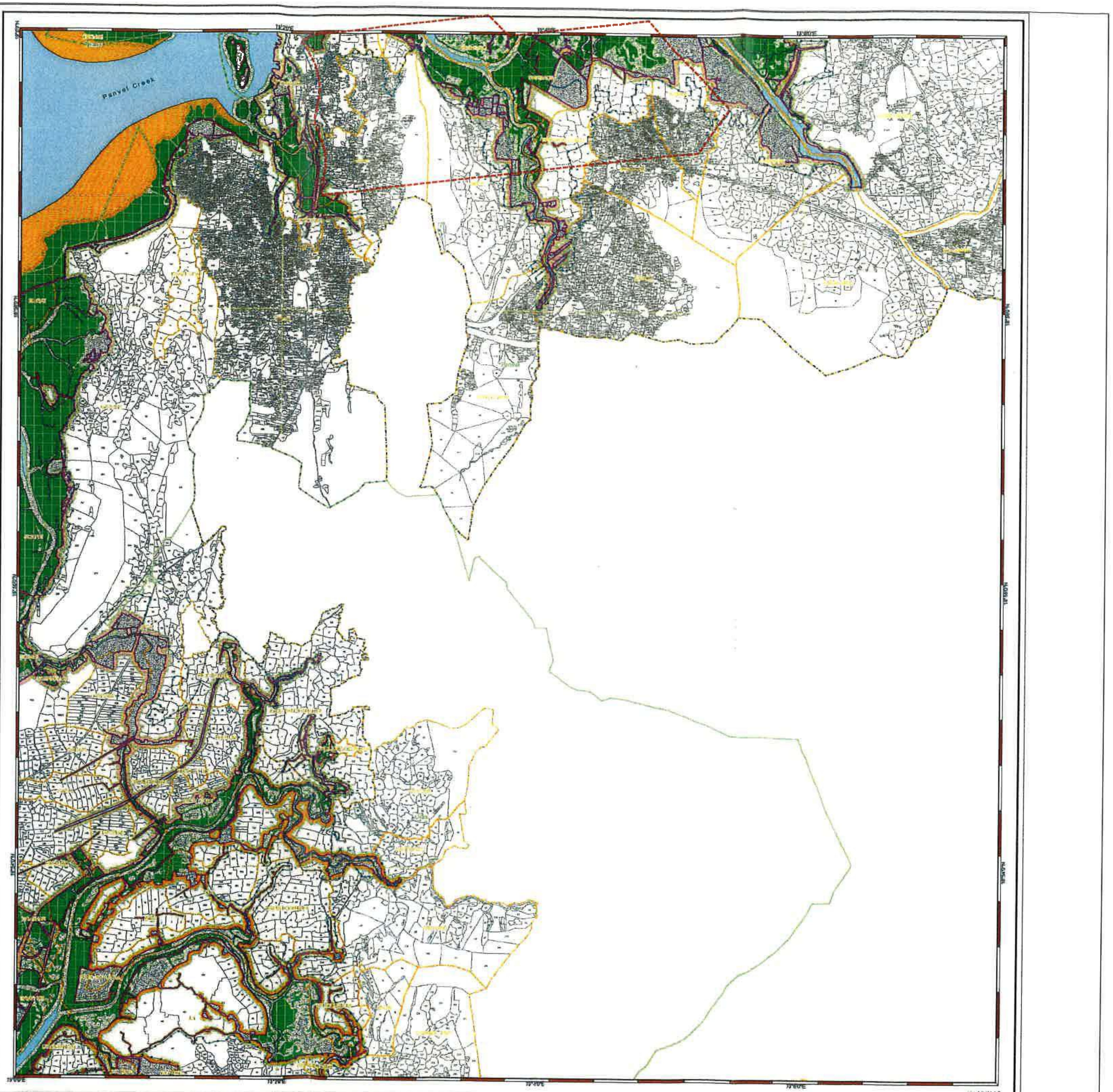
Prepared by

NCSCM

National Centre for Sustainable Coastal Management
(Ministry of Environment, Forest & Climate Change)
Chennai - 25

Prepared for

MAHARASHTRA STATE COASTAL ZONE MANAGEMENT AUTHORITY



Ver. MHM 1.5

Note:
1) If the CRZ III areas marked in the draft CZMP Maps (except Greater Mumbai) are falling within Municipal/Corporation areas then the areas will be reclassified into CRZ II during finalizations of CZMPs.
2) 50 m Mangrove Buffer Zone is provided for both Govt. Land and Private land.

Annexure VIII

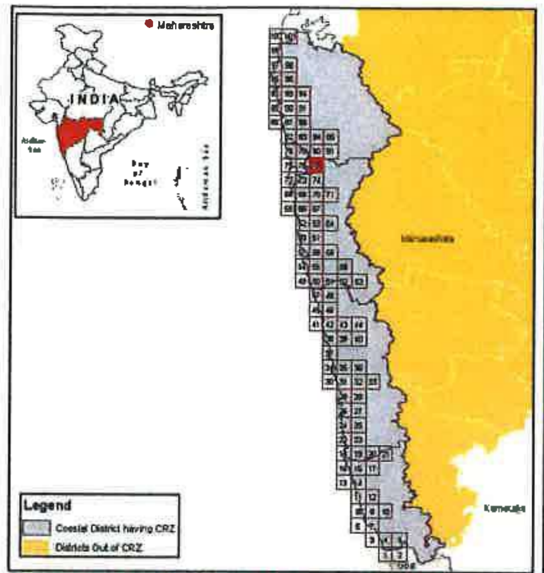
CZMP sheet No. E43 B4/SW- Map No. MH-77 of NMIA Area

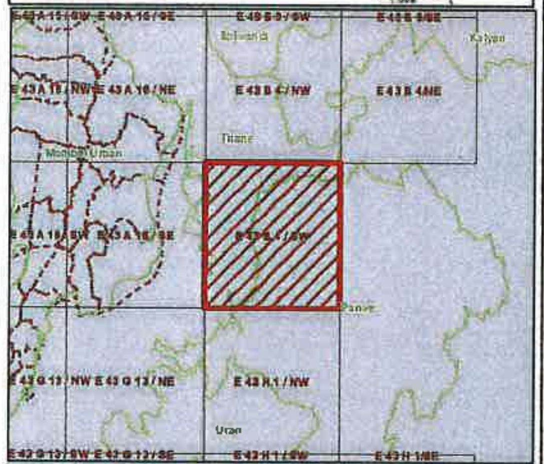
DRAFT CZMP MAP AS PER CRZ NOTIFICATION 2019
MAHARASHTRA STATE
SHEET NO : E 43 B 4 / SW

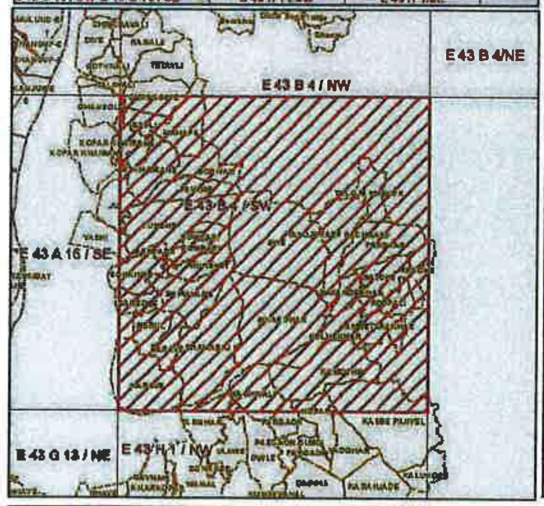
Projection :- UTM Datum :- WGS 1984

Map No: MH 77

Kilometers
Scale : 1 : 25,000







Legend
Data Provided: MCZMA

- Road
- Bridge
- Railway Line
- Ward Boundary
- Municipal or Corporation Boundary
- Taluk Boundary
- Village Boundary
- Survey Plots

Data Source: NCSCM

- Lighthouse
- Bund
- Seawall
- Jetty or Breakwater
- High Tide Line
- Low Tide Line
- CVCA

CRZ lines

- CRZ line for River or Creek
- 20m CRZ Line for Islands
- 50m CRZ line for Bay
- 50m CRZ Line - CRZ IIIA (NDZ)
- 200m CRZ Line - CRZ IIIB (NDZ)
- 500m CRZ line
- Hazard Line - (Data Source: SOI)

CRZ CATEGORY
CRZ - I

- Nesting Grounds of Birds - CRZ IA
- Turtle Nesting Grounds - CRZ IA
- 50m Mangrove Buffer Zone - CRZ IA
- Marine Protected Area - CRZ IA
- Archaeological & Heritage Sites - CRZ IA
- Corals and Coral Reefs - CRZ IA
- Reserve Forests - CRZ IA
- Salt Marsh - CRZ IA
- Sand Dunes - CRZ IA
- Mangroves - CRZ IA
- Mudflats - CRZ IA
- Beach - CRZ IB
- Rock Outcrop - CRZ IB
- Intertidal Zone - CRZ IB

CRZ - II

- CRZ landward of HTL - CRZ II

CRZ - III

- 50 to 500m from HTL - CRZ IIIA
- 200 to 500m from HTL - CRZ IIIB
- No Development Zone - NDZ
- NDZ - Within CRZ II - Greater Mumbai
- NDZ - Within CRZ II - Greater Mumbai

CRZ - IV

- Waterbody - CRZ IVA
- Waterbody - CRZ IVB

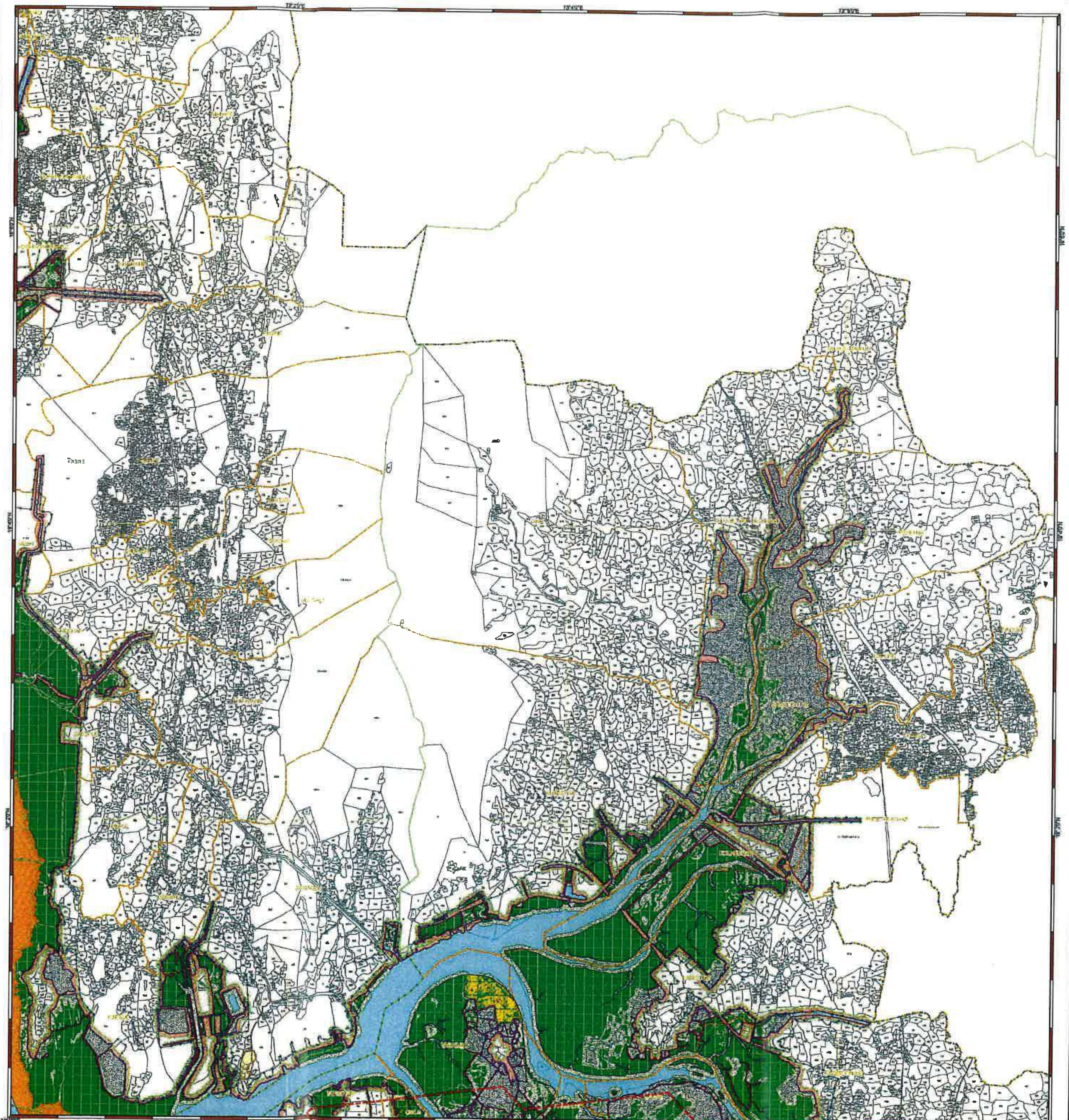
Prepared by

NCSCM

National Centre for Sustainable Coastal Management
(Ministry of Environment, Forest & Climate Change)
Chennai - 25

Prepared for

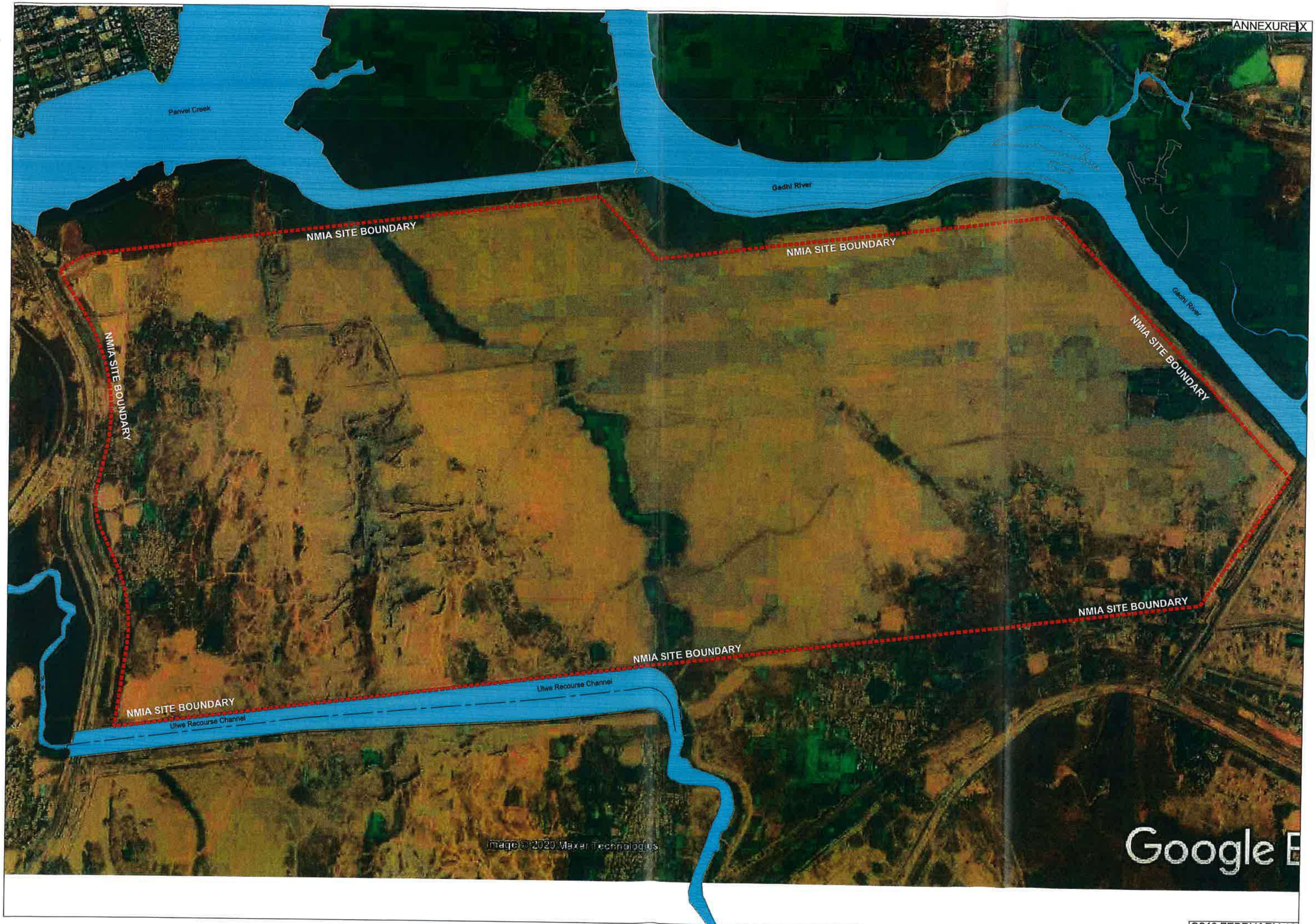
MAHARASHTRA STATE COASTAL ZONE MANAGEMENT AUTHORITY



Annexure IX

Google Image of October 16, 2018 showing NMIA Site Boundary with Ulwe River

ANNEXURE X

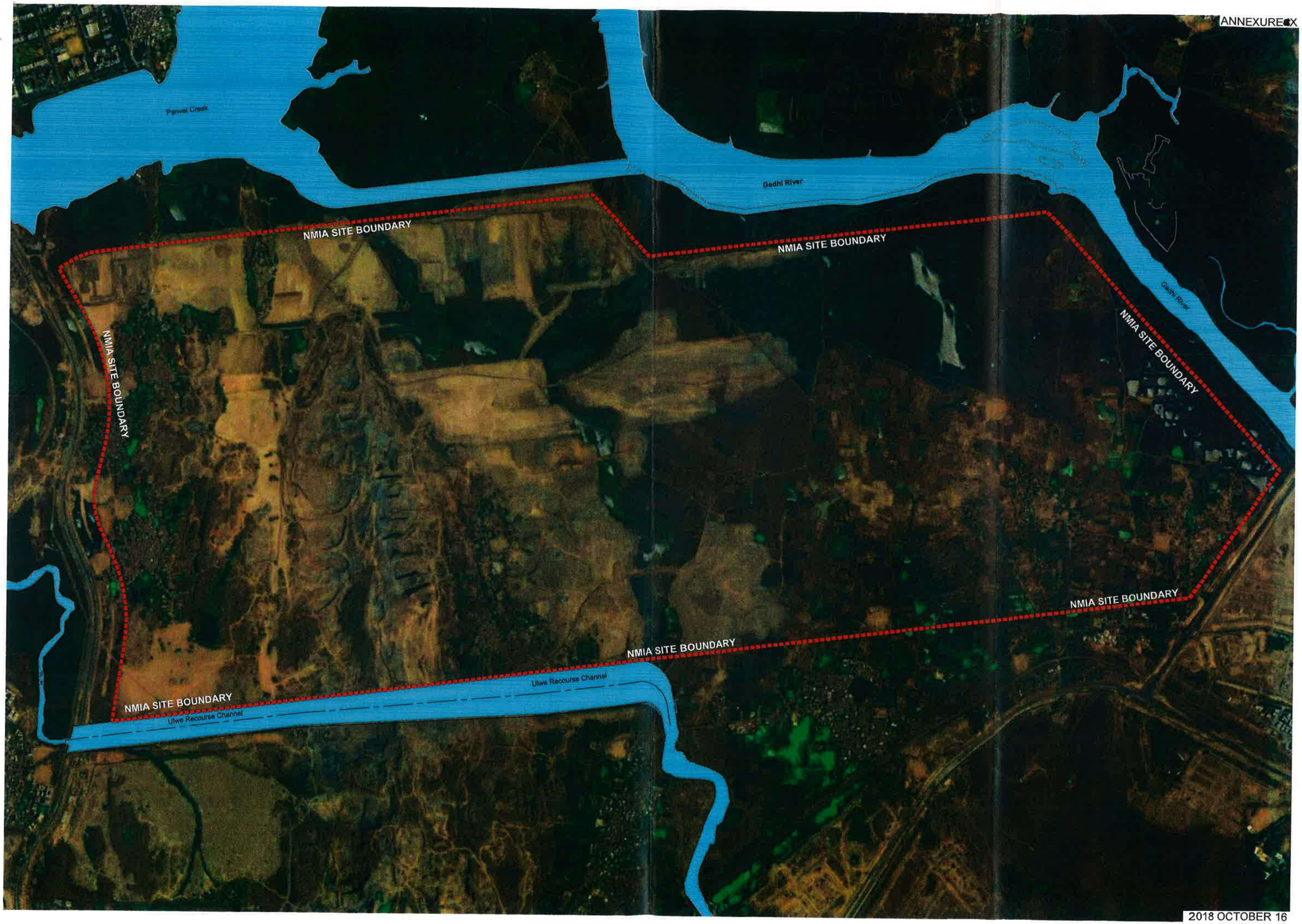


2019 FEBRUARY 12

Annexure X

Google Image of February 12, 2019 during filling work of Ulwe River

ANNEXURE X

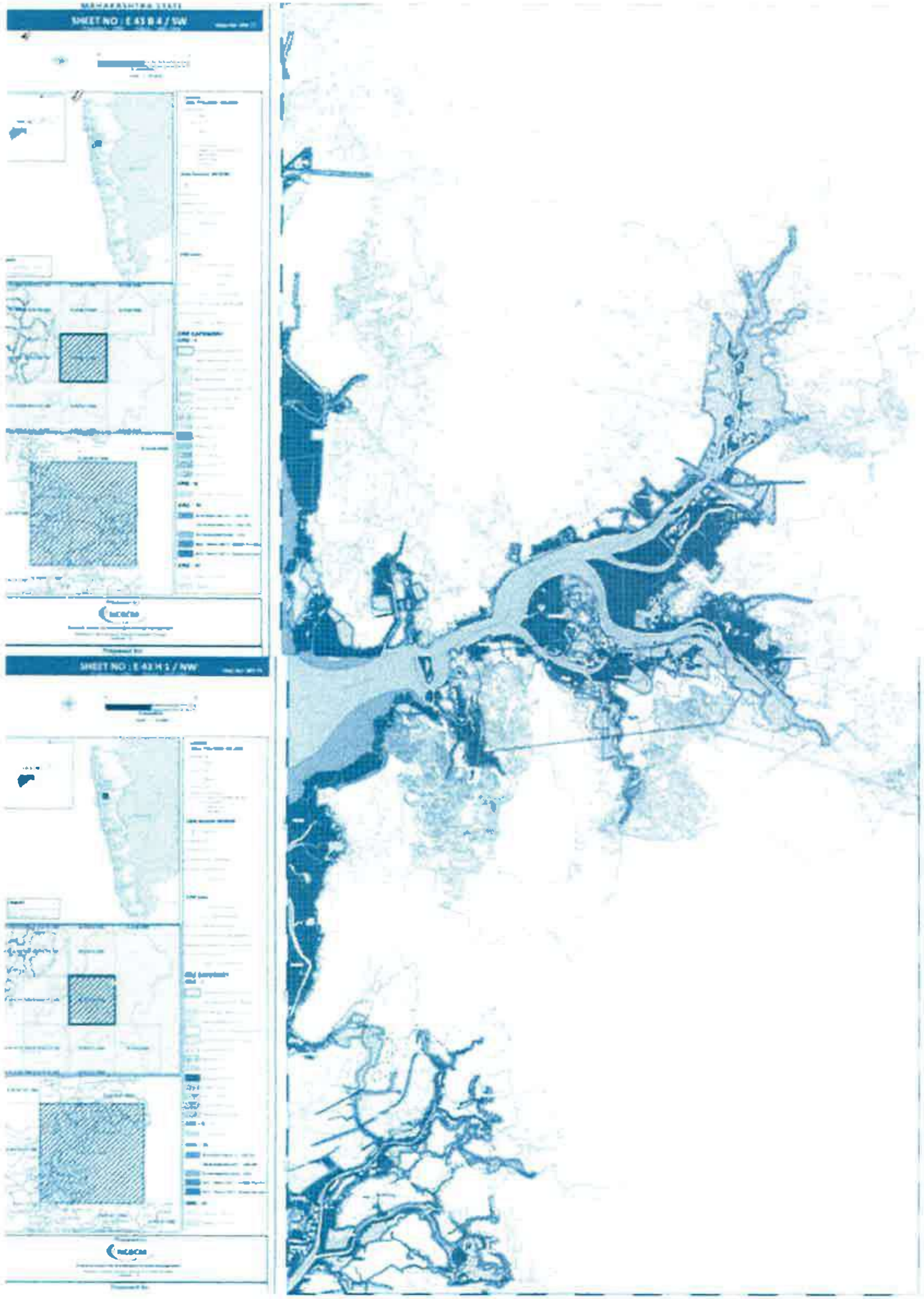


2018 OCTOBER 16

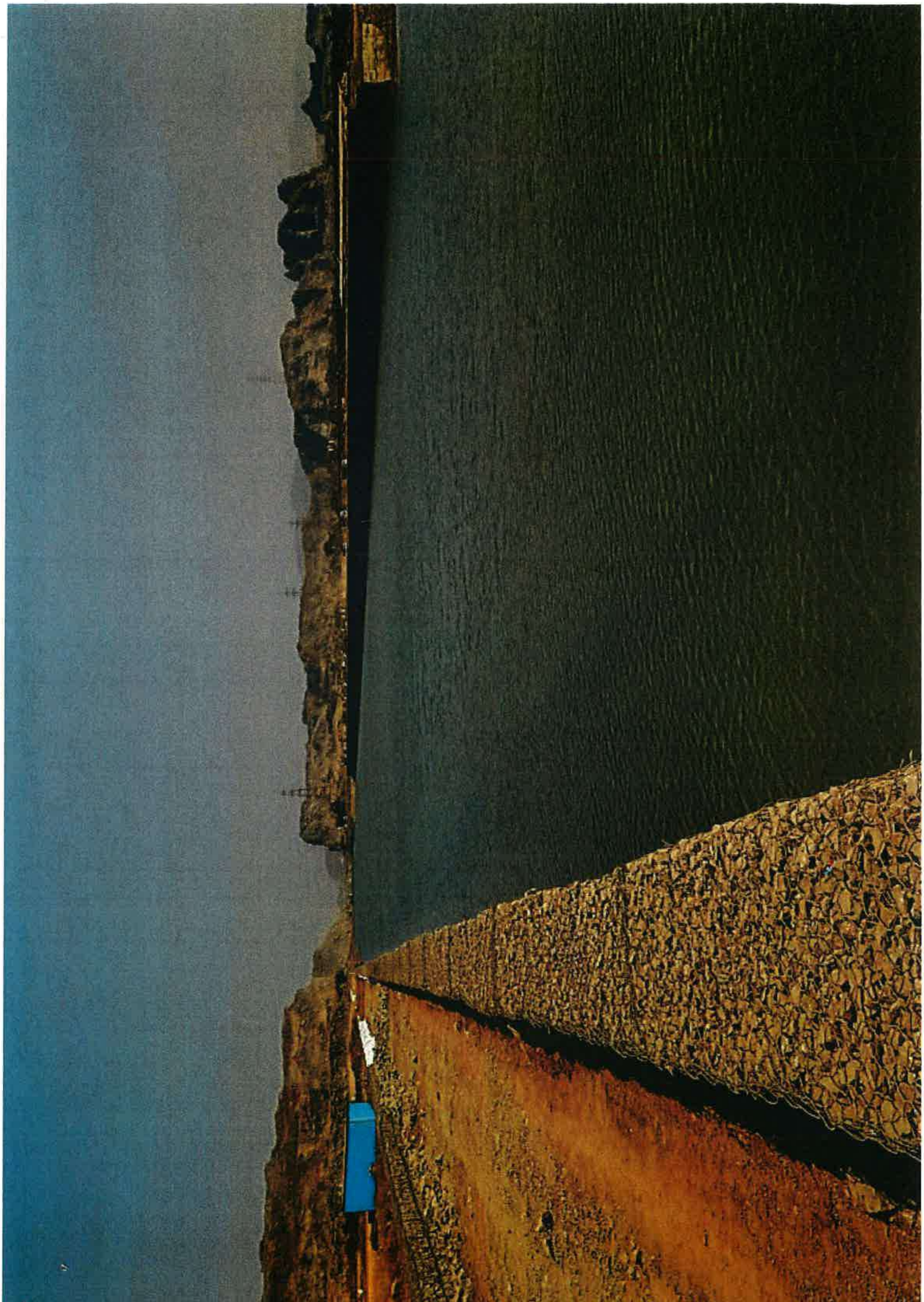
Annexure XI

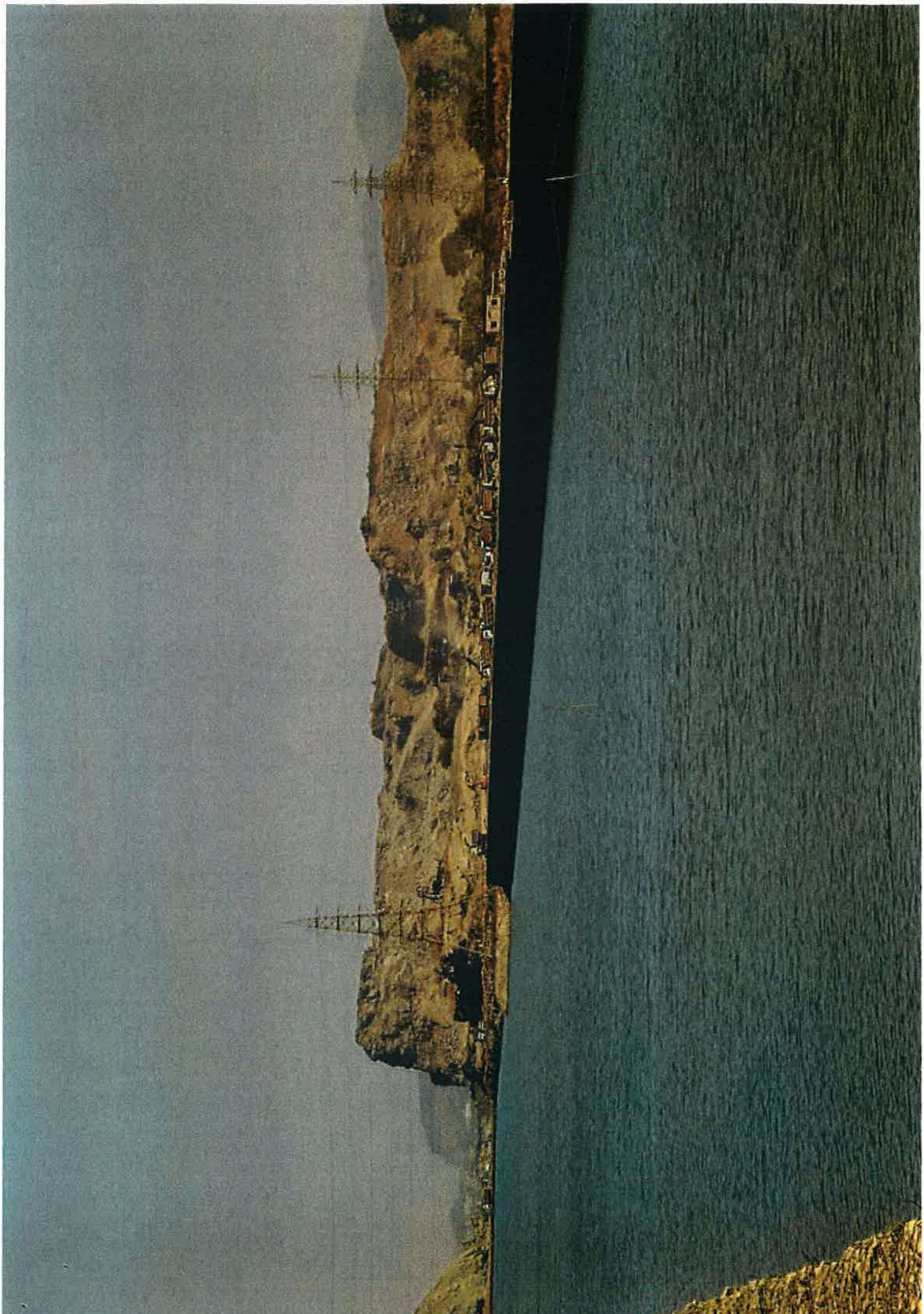
Photographs showing Ulwe River Recourse Channel (URC)

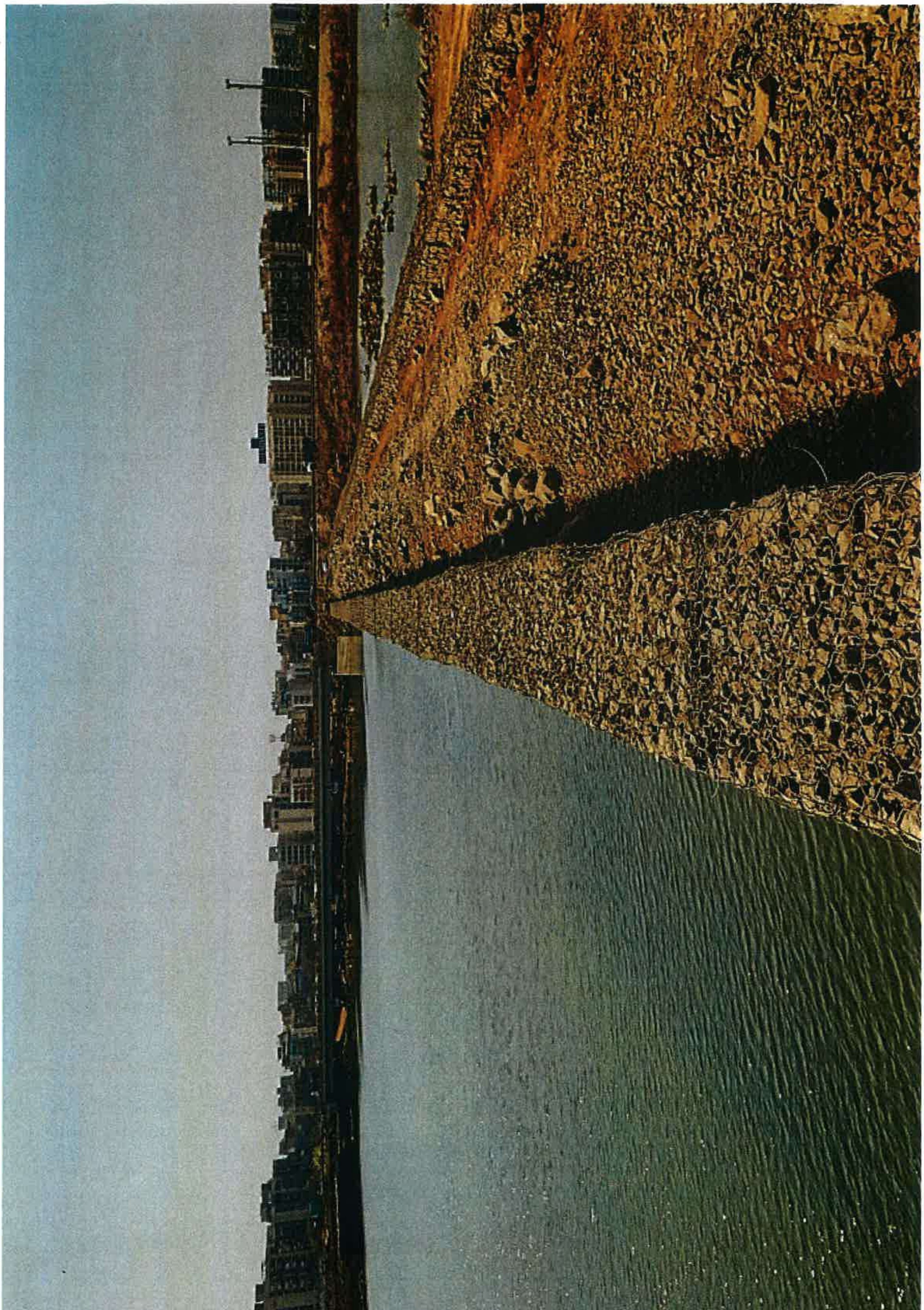
Annexure XI

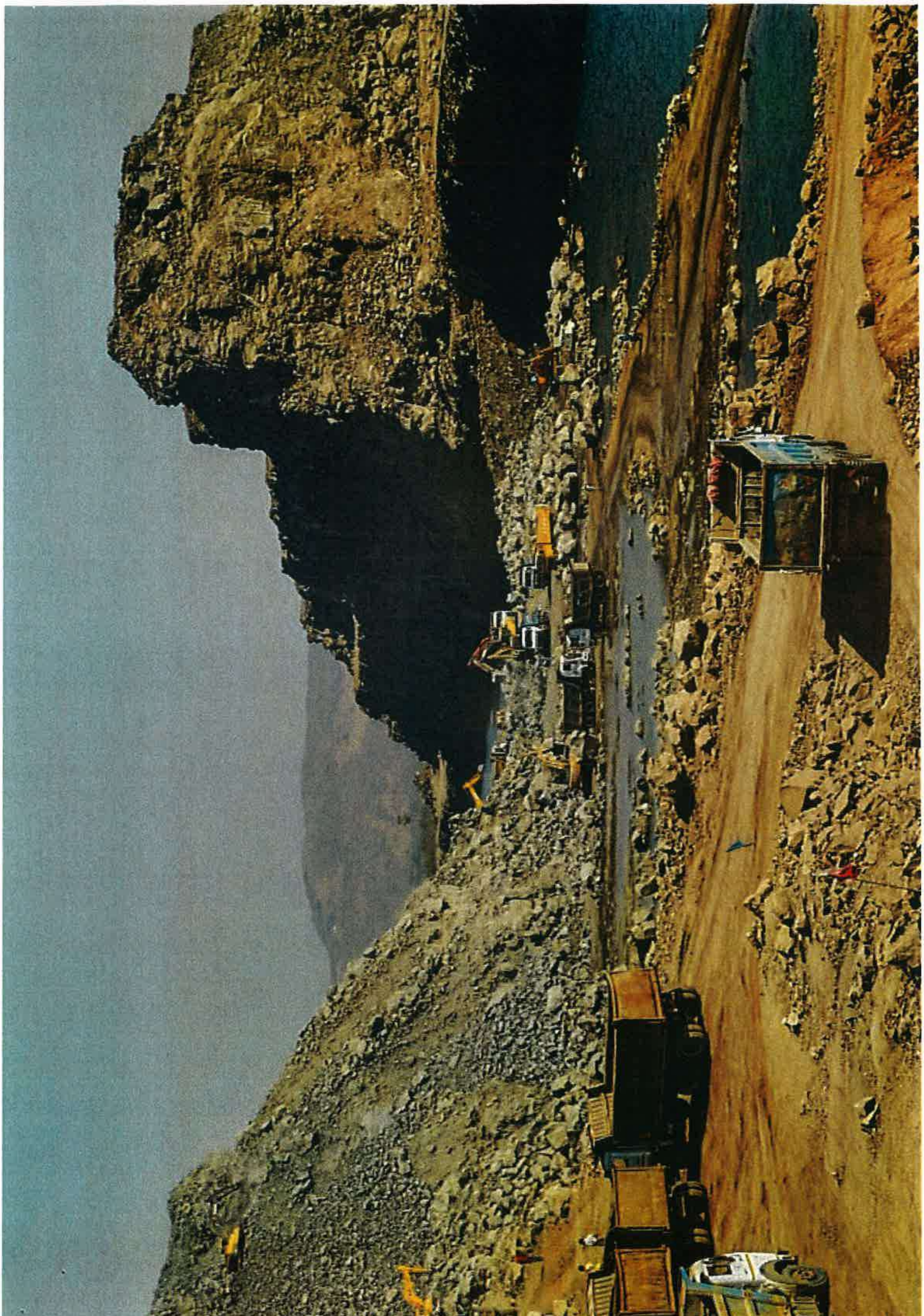


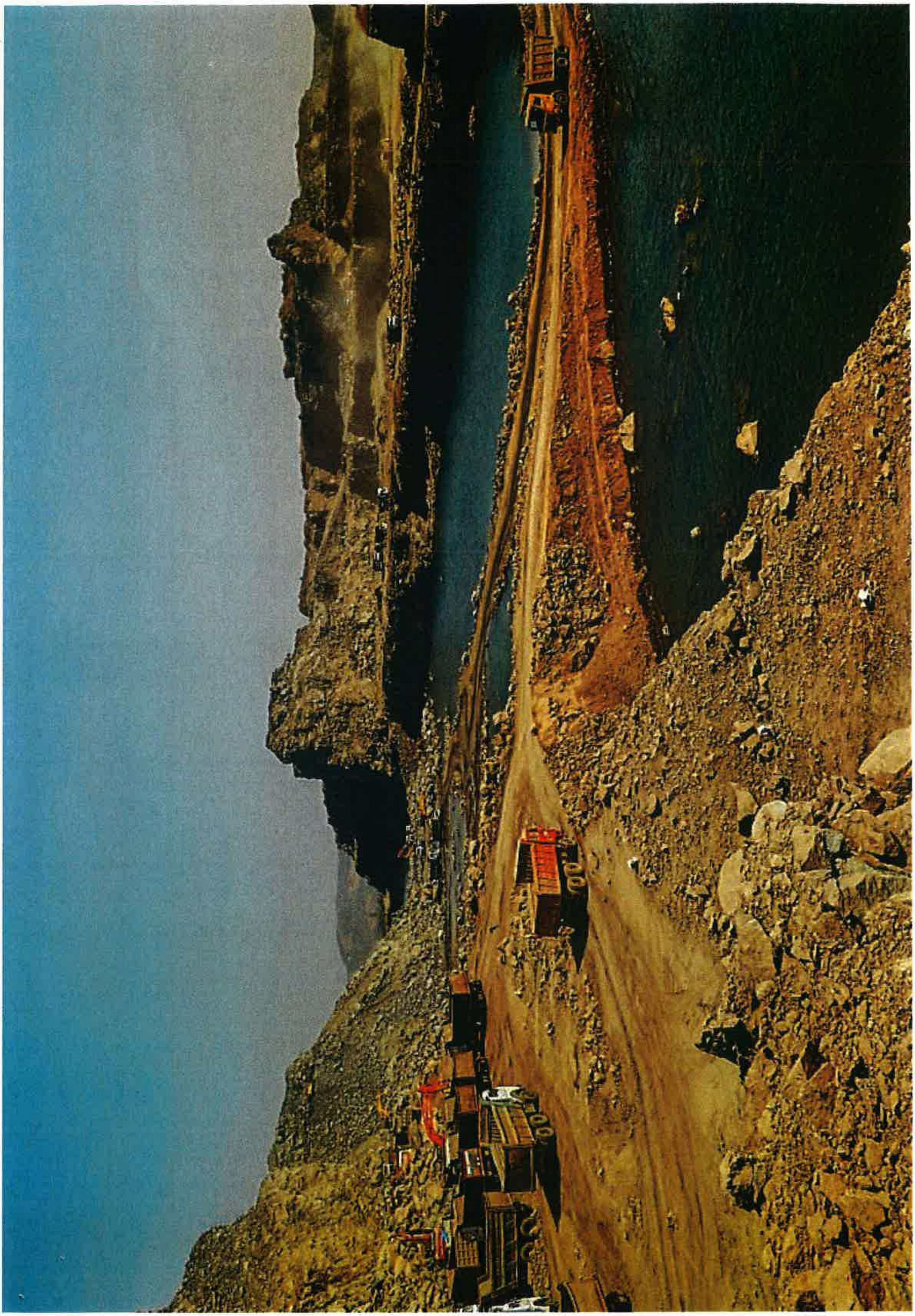
Recent Photographs of Ulwe River Recourse Channel (URC)

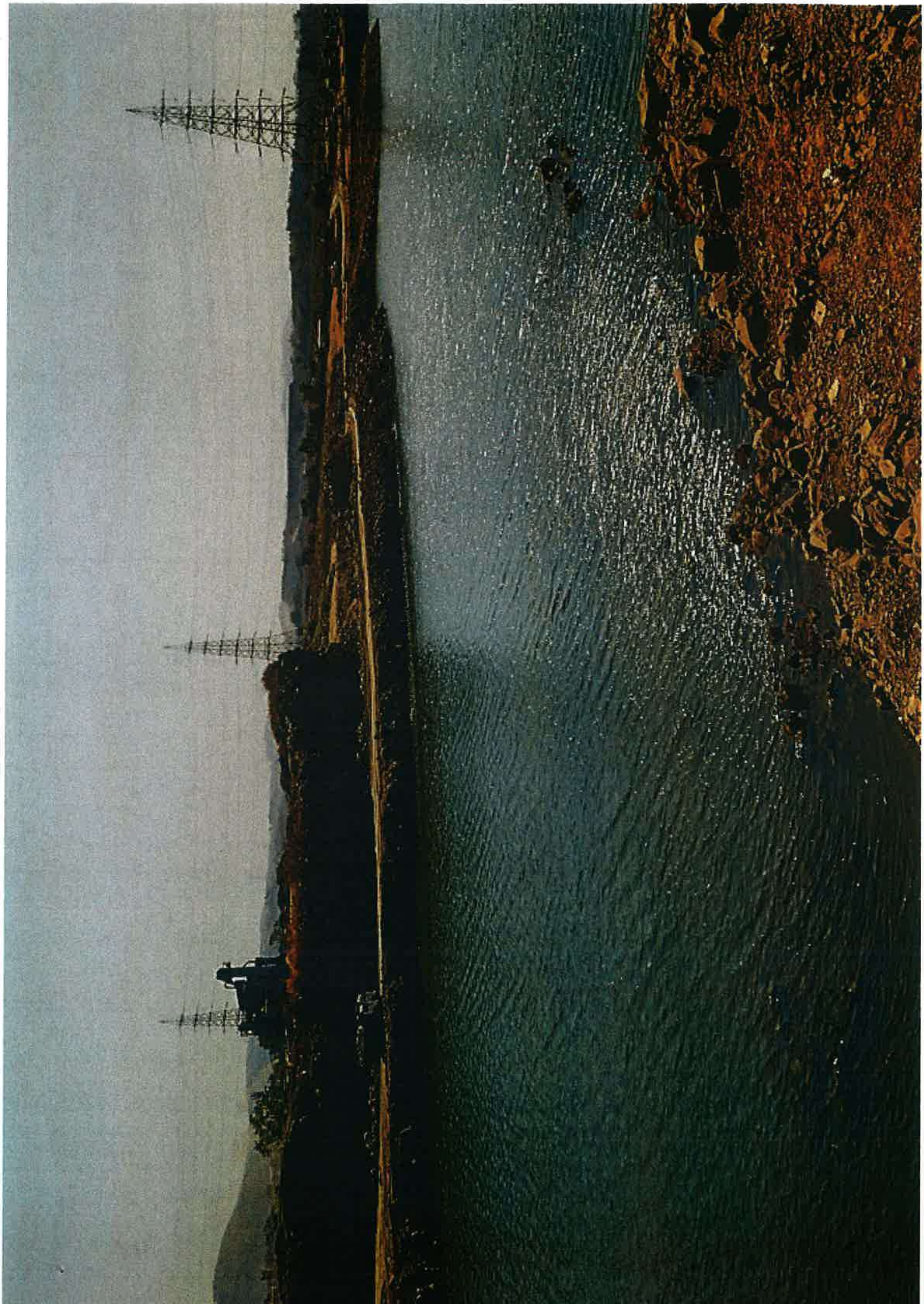


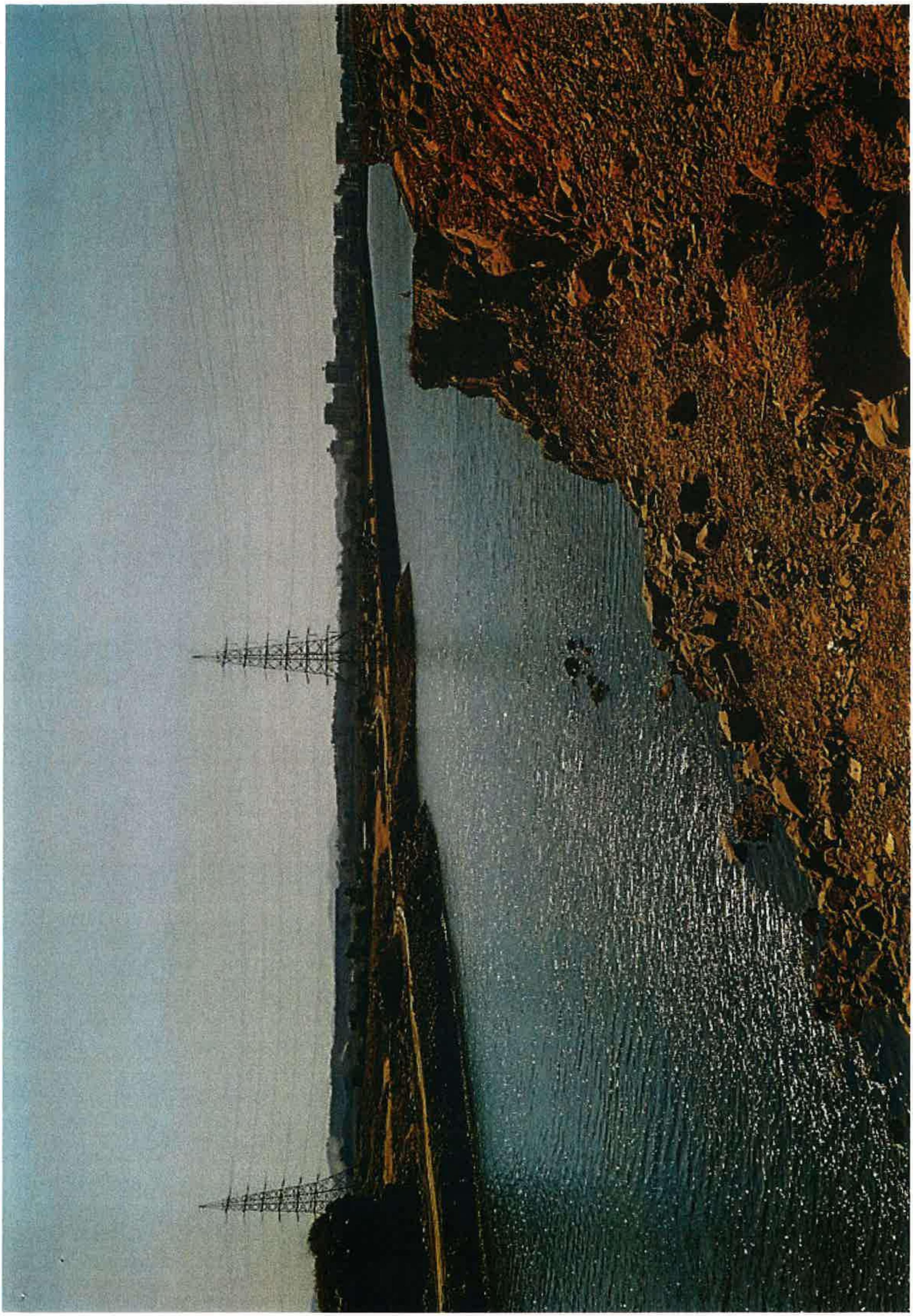


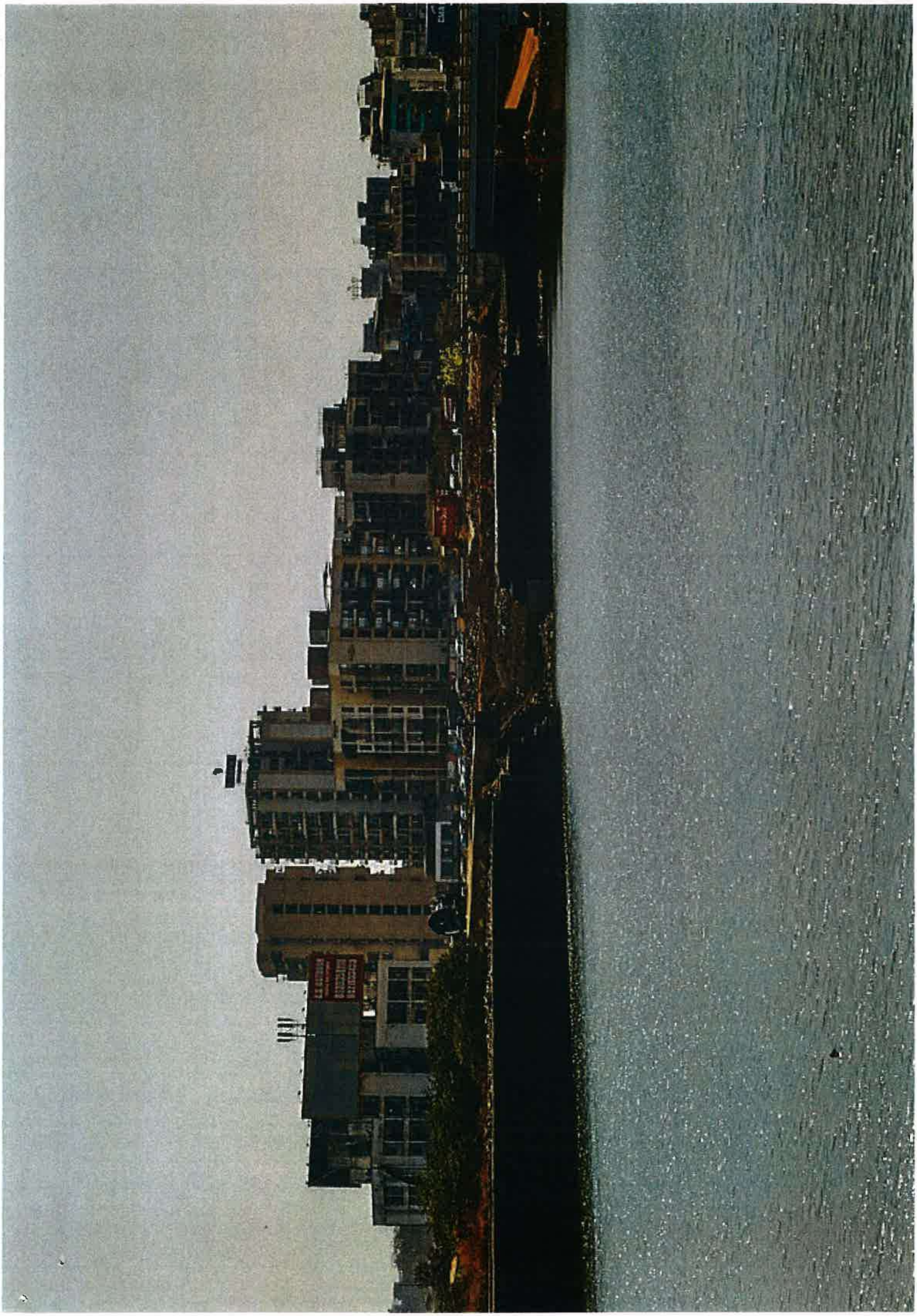










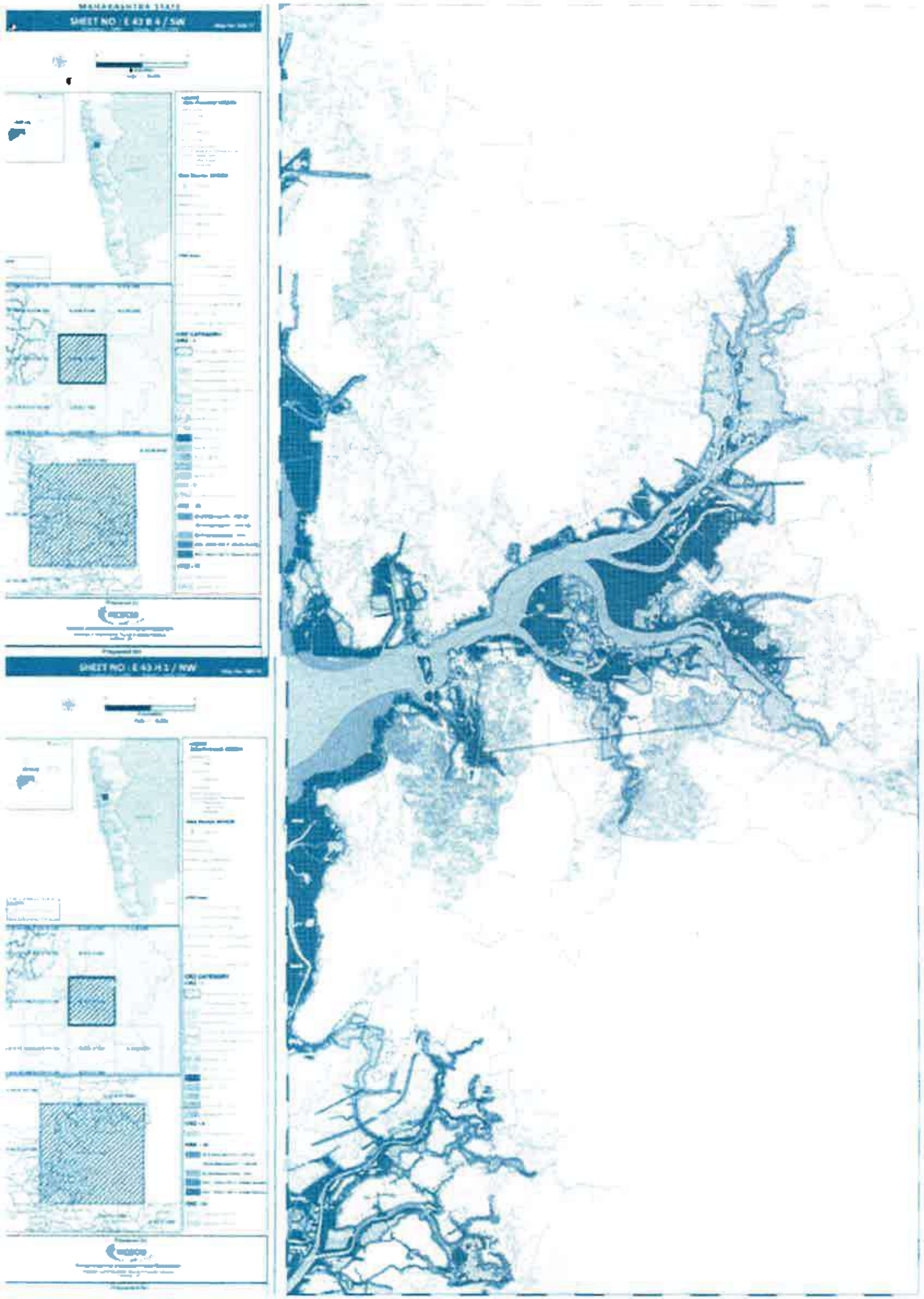


Annexure XII

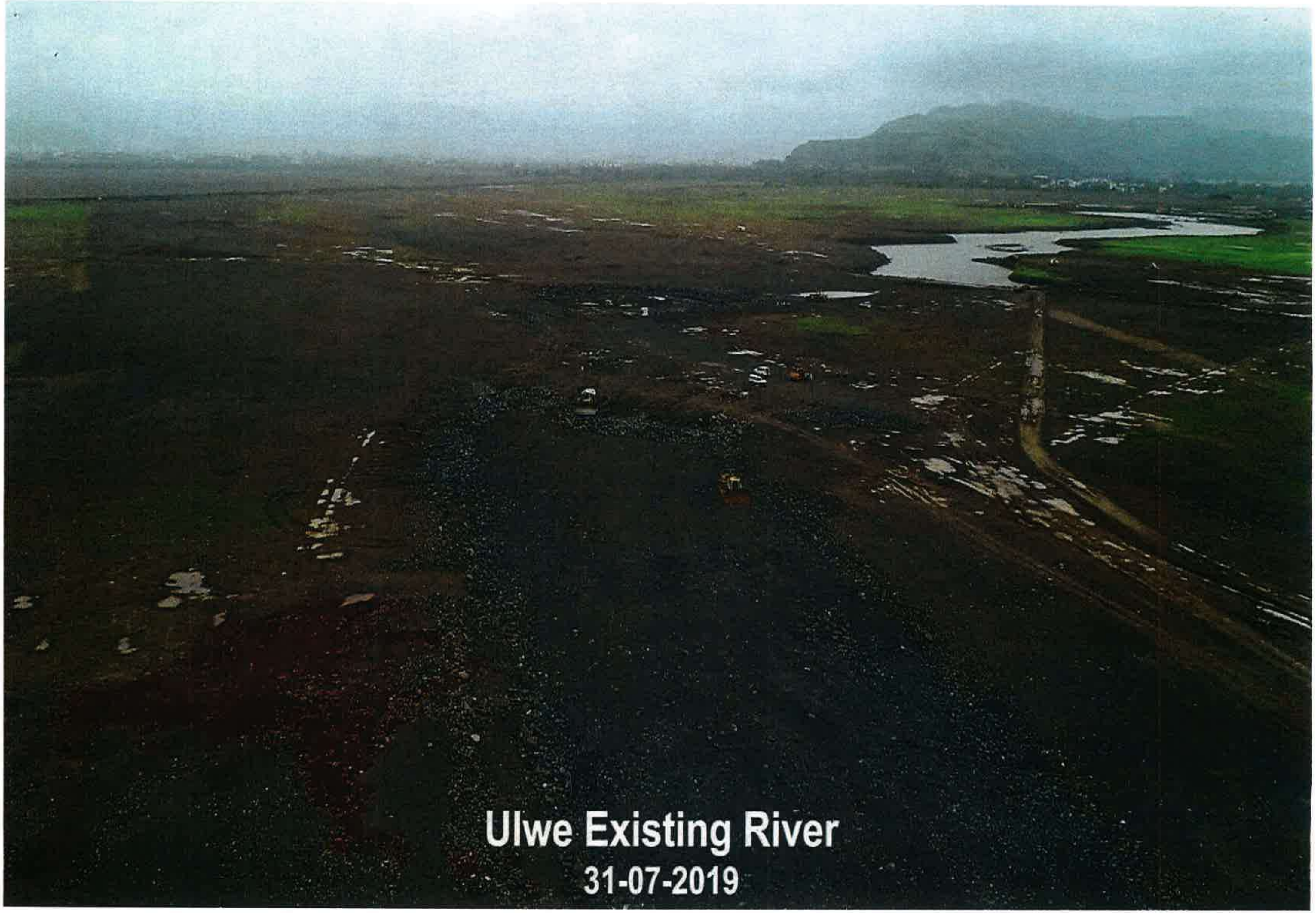
Photographs showing the site condition after filling-up of Ulwe River

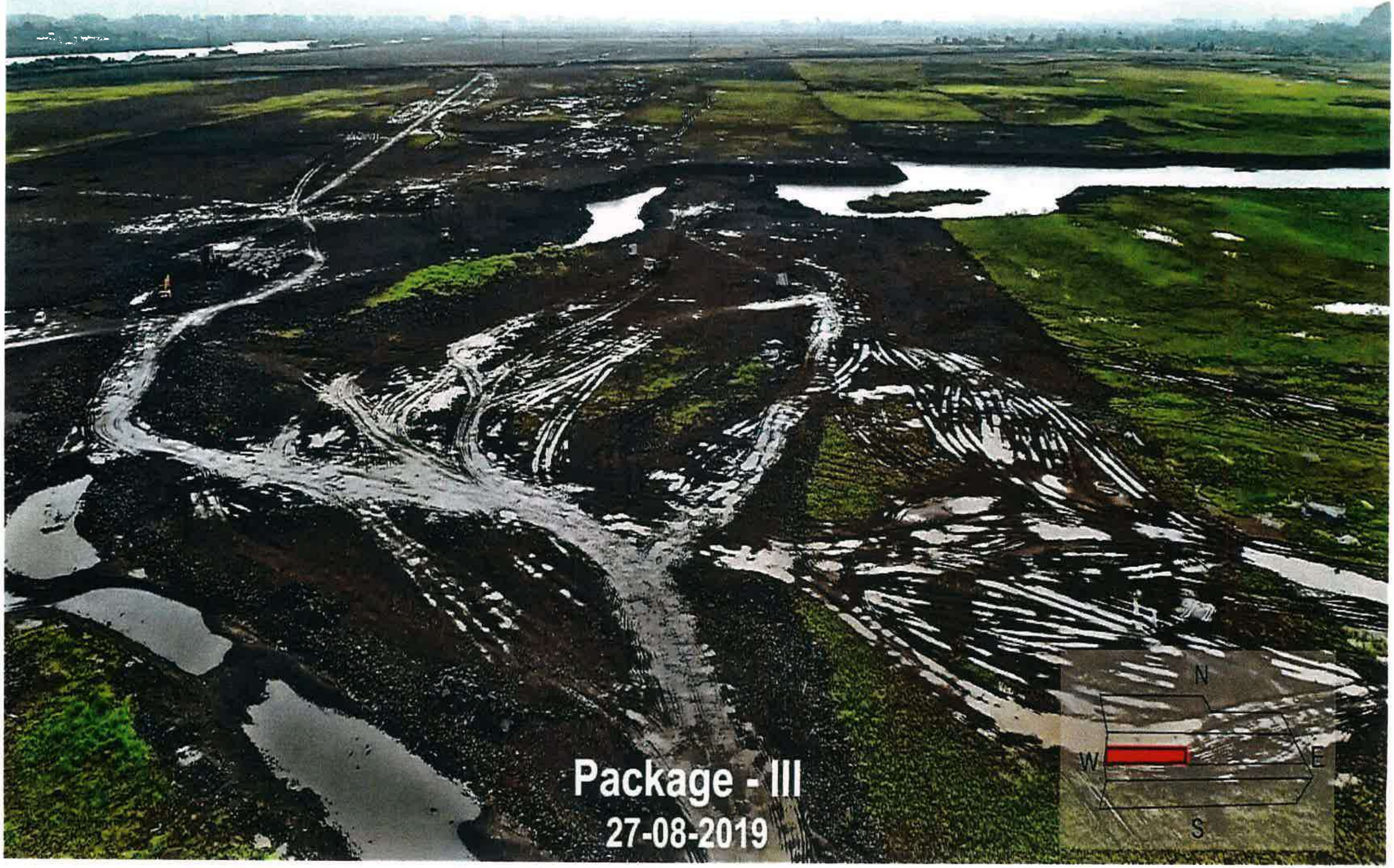
Annexure XII

Photographs of NMIA Site and adjoining Area

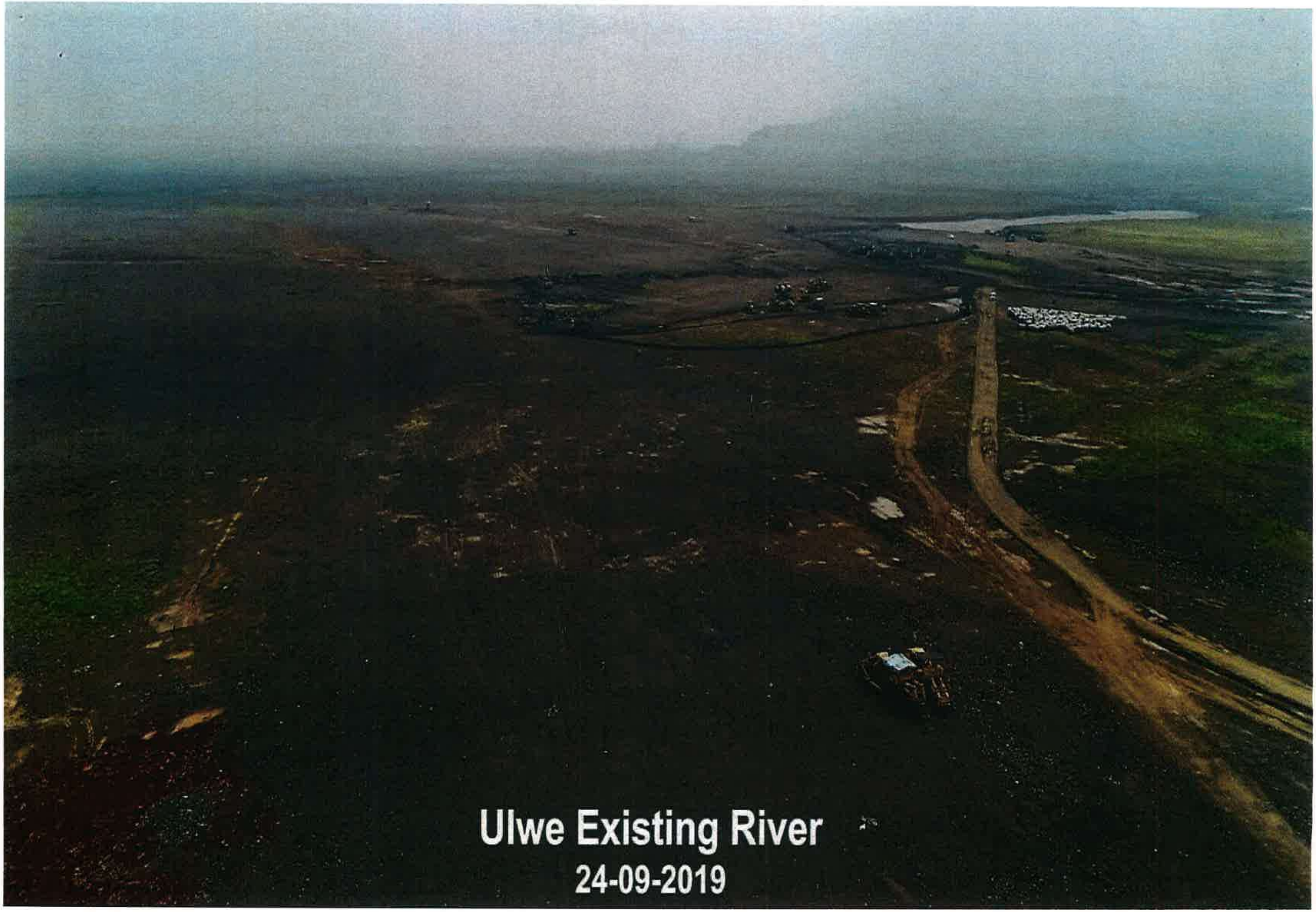


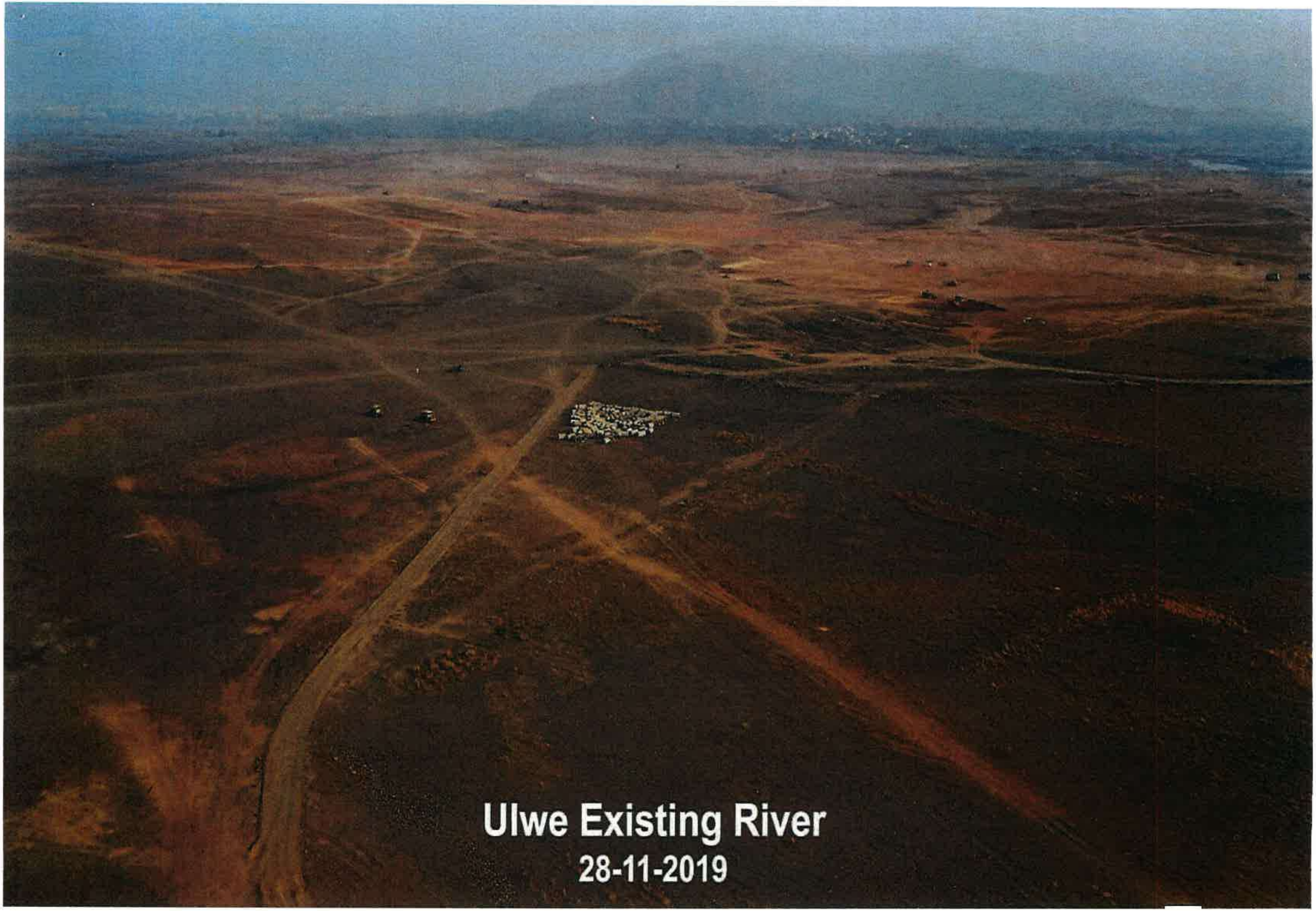

Package - III
27-06-2019
N
W
E
S


Ulwe Existing River
31-07-2019

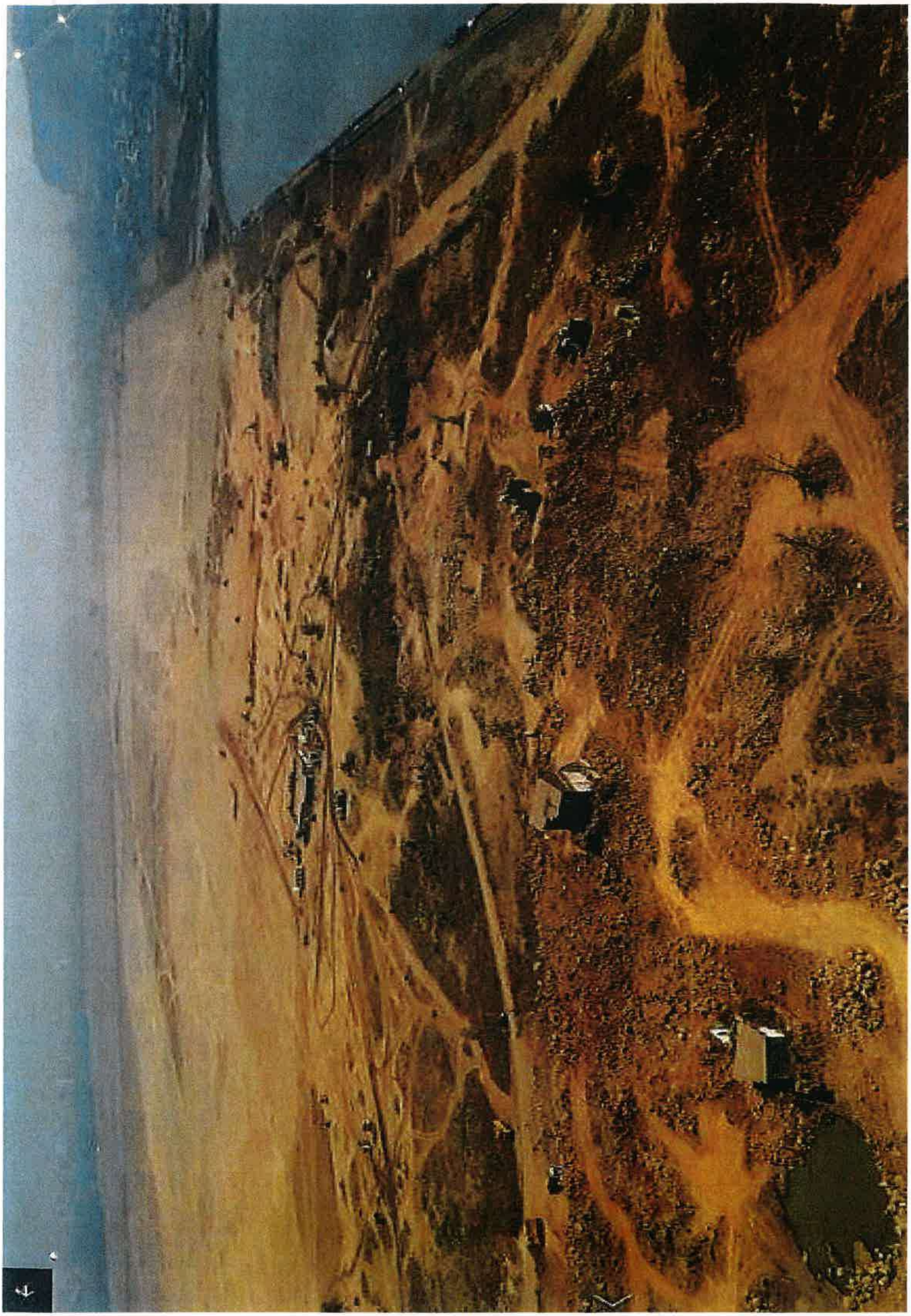

Package - III
27-08-2019
N
W
E
S


Ulwe Existing River
30-10-2019


Ulwe Existing River
24-09-2019


Ulwe Existing River
28-11-2019


NOVEMBER 2019



ANNEXURE-XV(B)

NMIA letter dated 22nd May 2020 addressed to Hon'ble District Collector Raigad

NMIAL/COLLECTOR/DIRUP/EC2020/0027 May 22, 2020

The District Collector, Riagad
Near Heera Court Lake, Police Line,
Alibug, Maharashtra – 402 201

Subject: **Suggestion/Objection/Clarification regarding draft CZMP for Panvel Taluka (sheet No. E43 H1/NW- Map No. MH-74 & sheet No. E43 B4/SW- Map No. MH-77) with respect to NMIA project site.**

Ref: **EC and CRZ clearance F. No. 10-53/20009 -I.A. III dated November 22, 2010 and Extension Of Validity vide F. No. 10-53/2009-IA. III valid up-to November 21, 2020.**

Sir,

Navi Mumbai International Airport limited (NMIAL) has been appointed as the Concessionaire for the development of Navi Mumbai International Airport (NMIA).CIDCO is a partner in NMIAL in developing this prestigious project. It is a project of national importance, and particularly for Mumbai Metropolitan Region (MMR). As you are aware, Navi Mumbai International Airport (NMIA) is being developed on 1160 Hectare of Land including Village Targhar, Ulwe, Owale, Waghiwali, Pargoan, Pargoan Dungi, Kopar and Vadghar including Ulwe River. NMIA Project has received Environment & CRZ Clearance from MoEFCC vide F. No. 10-53/20009 -I.A. III dated November 22, 2010 (**Annexure – I**) and also granted extension of validity for the Environmental clearance vide F. No. 10-53/2009-IA. III valid up-to November 21, 2020 (**Annexure – II**).

As you are also aware, the CRZ Notification of 6th Jan 2011 has been amended to permit the development of Navi Mumbai International Airport (NMIA) in CRZ area as under:

- Exempted from the list of prohibited activities under clause 3 (i) (d)
- Permitted for development in CRZ-I under clause 8 (I) (f)
- Permitted for development even in NDZ area of CRZ III and CRZ – III area under clause 8 (III) (A) (iii) (m) and 8 (III) (B) (x).

For construction of NMIA, MoEFCC had permitted diversion of Ulwe River which earlier passed through NMIA site. Also, MoEFCC had permitted clearance of Mangroves located on project site and vicinity (admeasuring approximately 108 Ha)

Navi Mumbai International Airport Pvt Ltd
Address for Correspondence :
11th Floor, V Times Square, Plot no 3, Sector 15, CBD Belapur, Navi Mumbai – 400614, India
T +91 22 68519500

Registered Office :
Chhatrapati Shivaji Maharaj International Airport, 1st Floor, Terminal 1B, Santacruz (E), Mumbai 400 099, India
T +91 22 6685 0900 / 6685 0901

CIN - U45200MH2007PTC169174

and acquisition of Forest land admeasuring 250 Ha. The Forest Department had also granted Stage I clearance for clearance of Mangroves and diversion of Forest land vide letter No. F. No. 8-95/2012-FC dated December 17, 2013 (stage I) and Stage II dated April 24, 2017. (**Annexure – III& IV**). Honourable High Court of Mumbai had also approved clearance of mangroves vide its Order dated (vide Order dated October 29, 2013) (**Annexure– V**). Urban Development Department, Government of Maharashtra has also approved and amended Navi Mumbai Development Plan (NMDP) incorporating NMIA in NMDP (enclosed as **Annexure – VI**).

After obtaining all clearances & approvals from respective Government organizations, CIDCO commenced Land development works in May 2016 including construction of Ulwe Recourse Channel. As per approvals, CIDCO has diverted the Ulwe River outside southern boundary of NMIA Site and created 120 - 200 Mtrs wide Ulwe Recourse Channel (URC) outside southern boundary of NMIA Site. The Ulwe River within NMIA Site has been filled up and URC is operational from June 2019.

There are no mangroves or intertidal zone present within NMIA Site now. The NMIA Site is filled upto 5.5. Mtrs AMSL. CIDCO has also started construction of North Road, South Road, East Road, rerouting of EHVT Lines, drainage outfalls at 6 different locations, etc.

With reference to draft Coastal Zone Management Plan (CZMP) uploaded on Maharashtra Coastal Zone Management Authority (MCZMA) portal dated January 22, 2019 (sheet No. E43 H1/NW- Map No. MH-74 and sheet No. E43 B4/SW- Map No. MH-77) (copies enclosed at **Annexure VII& VIII**) is outdated. It is observed that these Draft CZMP Plans do not reflect the present physical condition of NMIA Site.

Google Image of October 16, 2018 showing NMIA Site Boundary with then existing Ulwe River (**Annexure IX**), Google Image of February 12, 2019 during filling work of Ulwe River (**Annexure X**), recent Photographs of Ulwe River Recourse Channel (**Annexure XI**), and recent Photographs showing the site condition after filling-up of Ulwe River(**Annexure XII**) is enclosed for your reference. You are also requested to visit NMIA Site and verify the same.

In view of the above facts, you are requested to kindly consider above mentioned points and update the draft CZMP to indicate correct existing site conditions at this location within NMIA Site.

Thanking You,

Navi Mumbai International Airport Pvt Ltd
Address for Correspondence :
11th Floor, V Times Square, Plot no 3, Sector 15, CBD Belapur, Navi Mumbai – 400614, India
T +91 22 68519500

Registered Office :
Chhatrapati Shivaji Maharaj International Airport, 1st Floor, Terminal 1B, Santacruz (E), Mumbai 400 099, India
T +91 22 6685 0900 / 6685 0901

CIN - U45200MH2007PTC169174

Yours faithfully,

For Navi Mumbai International Airport Private Limited

(Charudatta Deshmukh)
Director – Urban Planning

Enclosure:

Annexure I -	Environment & CRZ Clearance from MoEFCC;
Annexure II -	Extension of EC;
Annexure III -	Stage I Forest clearance;
Annexure IV -	Stage II Forest clearance;
Annexure V -	Honourable High Court approval for clearance of mangroves;
Annexure VI -	UDD, GoM sanctioned modification to NMDP incorporating provision of NMIA;
Annexure VII -	CZMP sheet No. E43 H1/NW- Map No. MH-74 of NMIA Area;
Annexure VIII -	CZMP sheet No. E43 B4/SW- Map No. MH-77 of NMIA Area;
Annexure IX -	Google Image of October 16, 2018 showing NMIA Site Boundary with Ulwe River;
Annexure X -	Google Image of February 12, 2019 during filling work of Ulwe River;
Annexure XI -	Photographs showing Ulwe River Recourse Channel (URC);
Annexure XII -	Photographs showing the site condition after filling-up of Ulwe River;

Copy to:
The Regional Officer- Raigad,
Maharashtra Pollution Control Board,
6th floor, Raigad Bhavan,
CBD Belapur, Navi Mumbai- 400 614

Navi Mumbai International Airport Pvt Ltd
Address for Correspondence :
11th Floor, V Times Square, Plot no 3, Sector 15, CBD Belapur, Navi Mumbai – 400614, India
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Registered Office :
Chhatrapati Shivaji Maharaj International Airport, 1st Floor, Terminal 1B, Santacruz (E), Mumbai 400 099, India
T +91 22 6685 0900 / 6685 0901

CIN - U45200MH2007PTC169174

Annexure I

F.No.10-53/2009-IA.III
Government of India
Ministry of Environment & Forests
(IA-III Division)

MD's @ Belapur Office INW. No.: 1941 Date: 26/11/10

Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi - 110 003,

Dated: 22nd November, 2010

To
Vice Chairman & Managing Director,
City & Industrial Dev. Corpn. of Maharashtra Ltd.,
CIDCO Bhawan, CBD-Belapur,
Navi Mumbai-400 614.

Subject: Environmental and CRZ Clearance for establishment of Navi Mumbai International Airport by M/s. City & Industrial Development Corporation of Maharashtra Ltd. - Reg.

This has reference to your letter no. CIDCO/T&C/ACTE/MD/2009/567 dated 16.06.2009 and subsequent letters dated 06.07.2010, 07.08.2010, 10.10.2010 and 12.11.2010 seeking Environmental and CRZ Clearance under the Environment Impact Assessment Notification, 2006 and Coastal Regulation Zone (CRZ) Notification, 1991. The proposal has been appraised as per prescribed procedure in the light of provisions under the Environment Impact Assessment Notification, 2006 as amended in 2009 and CRZ Notification, 1991 on the basis of the mandatory documents enclosed with the application viz., Questionnaire, EIA/EMP and recommendations of Coastal Zone Management Authority, the additional clarifications furnished in response to the observations of the Expert Appraisal Committee constituted by the competent authority in its meetings held on 20th – 22nd July 2009, 21st – 23rd July 2010, 18th – 20th August 2010, 21st – 23rd September 2010, 20th – 22nd October 2010 and 09th – 10th November, 2010.

ACTE

23/11

2. It is interalia, noted that the proposed site of Airport is situated on National Highway No. 4B at a distance of approx. 35 kms. from the existing airport near Panvel in the geographical centre of Navi Mumbai having longitude of 73°.4'.18" and latitude 18°.59'.33". The main access to the proposed airport from the east is existing 4 lane National Highway 4B abutting the eastern boundary of the airport and 4 lane concrete road called Aamra Marg touches the western boundary of the airport. The proposed airport is also accessible by present commuter railway line called Mankhurd-Belapur-Panvel commuter railway line from the Khandeshwar Railway Station.

3. The proposal of Navi Mumbai International Airport is proposed to be established on an area of 1160 ha. The airfield of Navi Mumbai International Airport is designed to accommodate the new large aircraft (A-380 and equivalent) compatible to ICAO Standard of aerodrome 4-F. The ultimate capacity of airport will be 60 MPPA which will reach in four stages

CIDCO LTD.
T & C / ACTE
Inward No. 701
Date: 24/11/10

commencing from 10 MPPA in 2014. The Airport accommodates two parallel independent runways with the spacing of 1.55 kms. for simultaneous and independent operation with the provision of full length parallel taxi way along runways. The length of runway is of 3700 mts. X 60 mts. with runway safety area of 150 mts. X 60 mts., approach lighting of 900 mts., terminal building of domestic and international including Cargo admeasuring about 5,00,000 sq.mt. with other facilities such as; parking stands, GSE storage area, ATC Tower, airport ground lighting, airport lighting, cargo apron, maintenance and hanger along with other allied facilities etc. The other project activities involved are land development by cutting of hill and filling, development of airport in phases, re-coursing of the tidally influenced water body outlets from Ulwe, shifting of EHVT line, development of non-aeronautical activities, off-site physical infrastructure in terms of roads, interchange, water supply, power, etc., re-settlement & re-habilitation, and development of utility lines required for airport zone. The estimated basic cost (2008-09) of the project is Rs. 8722 Cr. spread over 4 phases i.e. in the first phase Rs 4424 Cr. in 2015 for 10 MPPA and Rs.1934 Cr. in 2020 for 25 MPPA in second phase; and Rs.1728 Cr. in 2025 for 45 MPPA in 3rd phase and finally Rs.636 Cr. in 4th phase for 2030 for 60 MPPA.

4. The non-aeronautical activities related to airport have been planned in the south of airport on an area of 276 ha. Further an area of 60 ha. will be required for diversion of tidally influenced water body of Ulwe River and 279 ha for off site infrastructure for roads, and crossings/intersection improvements.

5. A ToR for the project was issued on 04.08.2009. The Expert Committee also visited the site on 23rd December, 2009 and an additional TOR was issued on 8th February 2010. The public hearing was conducted on 5th May 2010 at Panvel Taluka, Dist. Raigad by Maharashtra Pollution Control Board (MPCB), Maharashtra and final EIA/EMP was submitted by CIDCO on 6th July 2010 for the issue of Environmental and CRZ Clearance. The recommendations of MCZMA were also submitted on 6th July 2010.

6. The Expert Appraisal Committee, after due consideration of the relevant documents submitted by the project proponent, additional clarifications furnished in response to its observations and various representations received on the project, have recommended for the grant of Environmental and CRZ Clearance for the project. Accordingly, the Ministry hereby accords necessary Environment and CRZ Clearance for the above project as per the provisions of Environment Impact Assessment Notification, 2006 and CRZ Notification 1991 and their subsequent amendments, subject to strict compliance of the terms and conditions as follows:

7. Specific Conditions:

I. Construction Phase

(i) "Consent for Establishment" shall be obtained from State Pollution Control Board under Air and Water Act and a copy shall be submitted to the Ministry before start of any construction work at the site.

(ii) CIDCO shall rehabilitate about 3000 families of 10 settlements from 7 villages falling within the airport zone as per the R & R policy of the Government of India or the Government of Maharashtra, which ever is more beneficial to the project affected persons.

(iii) CIDCO shall obtain necessary permission from Hon'ble High Court of Bombay for cutting or damaging of mangroves and clearance under Forest Conservation Act 1980 as per the orders in respect of notice of Motion no. 417 of 2006 in PIL no. 87/2006, as required.

(iv) The plantation and protection of mangroves over an area of 615 ha (245 hectares of good quality Mangroves Park shall be developed at Vaghivli on the north of the airport area + 60 hectare area located on the west side of the airport site around Moha creek and Panvel Creek + 310 hectares area on the northeast of the airport site between Gadhi River, Mankhurd Panvel Rail corridor and National Highway 4B shall be declared as No-development zone and CIDCO shall under take the development as Mangroves park/green area) would be developed and maintained in the shape of Biodiversity Mangrove Parks well before the airport project is initiated and its progress reported to the high level committee mentioned below at (xxxiii). CIDCO shall formally amend the land use in the sectioned development plan of Navi Mumbai following the due procedure under MRTP Act to achieve this objective.

(v) The proposed re-coursing of tidally influenced water body outlets from Ulwe river has a large cross sectional area at the middle with the river/creek on either end remaining unchanged with its natural course. The whole system should function as was functioning earlier without airport project. Surface runoff should not be let into the channel just because the area of cross section is large. The whole airport area will be reclaimed and the level raised to 7m whereas the existing level all around the airport will continue to be low in its natural state. There will be flow all around due to surface runoff. This additional quantity must be collected by appropriate drainage system and let into Gadhi River and not into the re-coursing channel. The recourse channel may be able to take it but not the river or creek on either side of the channel. This aspect shall be examined by CIDCO in details to avoid the flooding of the low-lying areas besides inducting other hydrological and environmental studies.

(vi) The entire system shall be studied as one composite system with appropriate boundary conditions to reflect the worst conditions – minimum 100 years to be specified and compliance ensured such as -flooding, surface runoff not only from the airport but also from surrounding areas as well, normal flow, tidal flow due to tidal surge having a long return period, possible obstructions to flow, tributaries joining the main river etc so as to take appropriate protection and remedial measures. Due to construction of recourse Channels and also due to tail end of the Gadhi & Ulwe Rivers into Panvel Creek, there is a need to prepare a Comprehensive Master Plan for Surface drainage and Flood protection, keeping in view the proposed developments. CIDCO shall submit the above Master Plan to the Ministry.

(vii) Systemic and periodic monitoring mechanism need to be put in place by CIDCO to assess the impact on sub-surface flow/ impact on aquifers as well as surface water bodies in different seasons. Necessary additional environmental protection measures to be adopted to address the impact of proposed development in coastal sub-subsurface flow as well as impact on aquifers.

(viii) CIDCO shall prepare a Management Plan to handle the runoff from the airport and to ensure that runoff associated risks/ impacts such as siltation in receiving water body are avoided and are taken care within airport area during monsoons.

(ix) On the northern part of the airport there is a secondary channel of the Gadhi River which will be filled up for the airport runway construction. This will be replaced by a shorter channel along the northern boundary of the airport. The channel shall be designed appropriately through overall modeling study so that the channel provides tidal water to the mangrove park and moderate tidal flows under worst environmental conditions. Need for widening and deepening of Gadhi River may also be studied simultaneously, if required. The revised widths and depths of recourse channels shall be determined with modified drainage and worst rainfall/tide conditions including appropriate factor of safety.

(x) The flow channels and the low lying mangrove area which will receive water from diverted recourse/ Channels should remain undisturbed. No road, embankment or any other construction shall be permitted. Any island formed due to deposition of sediment in front of Panvel creek shall be periodically removed.

(xi) A detailed map shall be submitted by CIDCO to the Ministry with quantification of affected mangrove area with density i.e. initial proposal & modified proposal and proposed mangrove forestation with species. The work on the proposed compensatory mangrove park should commence well before the construction of the airport is undertaken. The mangrove irrigation systems and diverse species selections for all the four areas may be scientifically made. The river front development in all the areas not protected by adequate mangrove buffer along the Panvel creek and Gadhi river may be considered through studies.

(xii) Whatever EIA data was submitted and presented was related to a situation for "no airport condition". The project proposal has under gone many changes in terms of converting the lagoon as Mangrove Park, shifting of non-aeronautical activities to the south etc. Updated EIA report with all the modifications and commitments given by CIDCO shall be submitted to the MoEF, MPCB and to MCZMA. This updated EIA report will serve as the preliminary baseline data. CIDCO shall submit the second report (EIA Report II) after finalization of all the facilities followed by Comprehensive EIA report prepared with approved layout of the airport, new hydrological scenario, altered topography and land use. The Comprehensive EIA report should also include ecological aspects answering quires raised by BNHS and several other points raised during the meeting. After completion of Phase I of the project, the CIDCO shall conduct the "Environmental Audit" with a reputed organization and the audit shall also include the "Validation of the conclusions drawn in the EIA Report" and to submit to MoEF, MPCB and to MCZMA and shall be uploaded on the website.

(xiii) The water quality of the River Gadhi, Ulwe, the Panvel Creek and the ground water is to be monitored on quarterly basis for TOC, Pb, Cd and Hg at all the locations identified in the EIA study for a period of at least 2 years from the commencement for the construction work and the quarterly reports to be submitted to Ministry of Environment and Forests Govt. of India and Maharashtra State Pollution Control Board.

(xiv) The waste water generated from the aircraft maintenance hangers may contain hazardous materials like lead, chromium, Sulphates, Phenolic compounds, V.O.C's etc. The surface runoff from the airport area shall also contain oils, grease, Sulphates etc, which cannot be sent directly to sewage treatment plant for the treatment. A separate treatment plant for managing the waste water shall be specified and adopted.

(xv) Based on the geological profile underneath the proposed airport, suitable consolidation factor shall be arrived to assess the additional noise/ vibration levels that would be produced during impact of landing & take off the air crafts simultaneously on both the runways. Further, the partially quarried hills in the vicinity will become a rebound shell for noise. CIDCO shall examine the details of noise/ vibration levels those are likely to be increased both during day and night time and the mitigative measures shall be installed to reduce the (noise/ vibration levels) impacts.

(xvi) Standard instrument arrival and departure procedure shall be designed to minimise the noise levels within the permissible limits for the area falling in the funnel near the airport on either side.

(xvii) Energy conservation to the extent of 20% shall be incorporated in the bidding documents including water conservation (reuse/recycle, rain water harvesting and water efficient fixtures) and other green building practices for various buildings proposed within the airport complex. CIDCO shall consider ECBC Guidelines 2009 to achieve the energy – efficient design.

(xviii) CIDCO shall prepare a detailed traffic management plan to take care of increased vehicular traffic which should also cover/ clearly delineate widening/ increasing the existing roads and associated road infrastructure approving/ installation of road safety features/ pedestrian facility/FOB/under passes etc (that can be done by carrying out road safety audits). Measures shall be taken to prevent encroachment along/within the ROWs on connecting/ main arterial roads.

(xix) Necessary road (National and State Highways) and rail connectivity shall also be upgraded to handle the increased passenger and cargo traffic, in addition to metro for transition of passengers. The proposal of Havorport shall not be taken up on the north part of the airport area as this shall damage the mangroves.

(xx) The measures should be taken to improve public transportation including dedicated road / MRTS corridors to access to Airport, may also be considered for the same. Energy Efficient dedicated rail based public transport facility; suburban/ metro train in particular, may be created between the Santa Cruz and the Navi Mumbai Airport in addition to all other links connecting various parts of Mumbai city.

(xxi) Traffic Management during construction phase should be clearly planned so that the traffic situation is not further worsened on the existing connecting roads. Installations of Noise barrier/ Green Belts should be clearly indicated in the plan (After identifying critical locations).

(xxii) To avoid accidental damage (fire, hazardous material waste handling, oil spills, wastewater disposal) in the adjacent ecologically fragile surroundings and mangrove area – a risk assessment plan and disaster management plan should be prepared and with periodic compliance of safety measures in place to avoid loss due accidental damage that could have been otherwise avoided. Further CIDCO shall appoint a dedicated professional team/cell to handle disaster and associated risks.

(xxiii) In addition to the above –CIDCO shall ensure that all the risks (such as fire, hazardous material waste handling, oil spills, waste – both liquid/solid wastes) associated/ resultant risk during various stages of development (like planning, construction, operation) are managed within the airport area. In case of any unforeseen event as stated above the liability – environmental and social will rest with the developer/CIDCO, the decision of the high level Committee, stipulated below will be full and final for liability fixations.

(xxiv) The compliance report of the monitoring committee shall be made 'public' (put online and/or also displayed for wider dissemination of compliance) at all stages (planning, construction, operation) to ensure effective monitoring and compliance of conditions.

(xxv) Environment Management Plan or associated monitoring plan shall ensure that mitigation measures detailed out in terms of role, responsibility, budgetary provisions, timeline for completion, frequency of monitoring and compliance etc.

(xxvi) In order to meet all the essential aeronautical requirements and the further airport expansions, no property development shall be undertaken within the proposed aeronautical Airport Zone area (1160ha).

(xxvii) The Master plan/Development plan of Navi Mumbai shall be revised and recasted in view of the airport development to avoid and unplanned haphazard growth around the airport. The landuse should take care of bird menace including that from the Mangrove Parks.

(xxviii) All other nearby villages, if not required to be relocated should be provided with best possible infrastructure so that they compare well with the adjoining ultra modern airport infrastructure.

(xxix) CRZ provisions shall be applicable on the tidally influenced diverted channels of Ulwe and Gadhi Rivers and CIDCO shall finalise the Airport plans accordingly.

(xxx) Any cutting or filling up the airport site will create significant turbidity problem. CIDCO shall examine the impact on the marine life. The details will be put up on the website every 3 months.

(xxxi) CIDCO shall conduct the baseline survey of avian fauna before the start of construction and the details shall be put up every 3 months on the website in association with BNHS.

(xxxii) The Environmental Clearance/ CRZ Clearance is recommended below is only for the Navi Mumbai Airport project. CIDCO shall obtain the Environmental and CRZ clearance separately for off airport facilities and other off infrastructure projects after finalising the locations and details as may be required under the EIA Notification 2006 and the CRZ Notification.

(xxxiii) Taking a cue from the man-made 26/11 incident arising out of external threat to our country, a strategic airport safety and security plan covering also surrounding inhabited areas of the airport shall be prepared and put in place in consultation with appropriate government departments

(xxxiv) A high level advisory and monitoring committee which should include International experts of repute, reporting directly to the highest Airport Management Authority shall be constituted by CIDCO to plan, execute and maintain the environmental issues/ recommendations mentioned above. The monitoring shall be done at various stages (planning, construction, operation) of project for compliance of conditions. Budgetory provisions shall be made to the satisfaction of this Committee. The committee shall meet at least once in three months and the decisions taken in the meetings shall be put up on the web site for public information.

(xxxv) Regular modeling study of air, noise shall be carried out due to the increase in traffic

(xxxvi) The solid waste shall be properly collected, segregated and disposed as per the provision of Solid Waste (Management and Handling) Rules, 2000.

(xxxvii) Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche etc. The housing may be in the form of temporary structures to be removed after the completion of the project.

(xxxviii) A First Aid Room will be provided in the project both during construction and operation of the project.

(xxxix) Disposal of muck during construction phase should not create any adverse effect on the neighboring communities and be disposed taking the necessary precautions for general safety and health aspects of people, only in approved sites with the approval of competent authority.

(xl) Soil and ground water samples will be tested to ascertain that there is no threat to ground water quality by leaching of heavy metals and other toxic contaminants.

(xli) Construction spoils, including bituminous material and other hazardous materials, must not be allowed to contaminate watercourses and the dump sites for such material must be secured so that they should not leach into the ground water.

(xlii) Installation and operation of DG set shall comply with the guidelines of CPCB.

(xliii) The diesel generator sets to be used during construction phase should be low sulphur diesel type and should conform to

Environment (Protection) Rules prescribed for air and noise emission standards.

(xliv) The diesel required for operating DG sets shall be stored in underground tanks and if required, clearance from Chief Controller of Explosives shall be taken.

(xlv) Vehicles hired for bringing construction material to the site should be in good condition and should have a pollution check certificate and should conform to applicable air and noise emission standards and should be operated only during non-peak hours.

(xlvi) Ambient noise levels should conform to residential standards both during day and night. Incremental pollution loads on the ambient air and noise quality should be closely monitored during construction phase. Adequate measures should be made to reduce ambient air and noise level during construction phase, so as to conform to the stipulated standards by CPCB/ MPCB.

(xlvii) Fly ash should be used as building material in the construction as per the provisions of Fly Ash Notification of September, 1999 and amended as on 27th August, 2003.

(xlviii) Ready mixed concrete must be used in building construction.

(xlix) Storm water control and its re-use as per CGWB and BIS standards for various applications.

(l) Water demand during construction should be reduced by use of pre-mixed concrete, curing agents and other best practices referred.

(li) Use of glass may be reduced by upto 40% to reduce the electricity consumption and load on airconditioning. If necessary, use high quality double glass with special reflective coating in windows.

(lii) The approval of the competent authority shall be obtained for structural safety of the buildings due to earthquake, adequacy of fire fighting equipments, etc. as per National Building Code including protection measures from lightening etc.

(liii) Regular supervision of the above and other measures for monitoring should be in place all through the construction phase, so as to avoid disturbance to the surroundings.

II. Operation Phase

i) Diesel power generating sets proposed as source of back up power for elevators and common area illumination during operation phase should be of enclosed type and conform to rules made under the

Environment (Protection) Act, 1986. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. Use of low sulphur diesel. The location of the DG sets may be decided with in consultation with Maharashtra Pollution Control Board.

ii) Noise should be controlled to ensure that it does not exceed the prescribed standards. During night time the noise levels measured at the boundary of the building shall be restricted to the permissible levels to comply with the prevalent regulations.

iii) The green belt of the adequate width and density preferably with local species along the periphery of the plot shall be raised so as to provide protection against particulates and noise.

iv) Weep holes in the compound walls shall be provided to ensure natural drainage of rain water in the catchment area during the monsoon period.

v) Rain water harvesting for roof run- off and surface run- off, should be implemented. Before recharging the surface run off, pre-treatment must be done to remove suspended matter, oil and grease. The borewell for rainwater recharging should be kept at least 5 mts. above the highest ground water table.

vi) The ground water level and its quality should be monitored regularly in consultation with Central Ground Water Authority.

vii) Traffic congestion near the entry and exit points from the roads adjoining the proposed project site must be avoided. Parking should be fully internalized and no public space should be utilized.

viii) Energy conservation measures like installation of CFLs/TFLs for the lighting the areas outside the building should be integral part of the project design and should be in place before project commissioning. Use CFLs and TFLs should be properly collected and disposed off/sent for recycling as per the prevailing guidelines/ rules of the regulatory authority to avoid mercury contamination. Use of solar panels may be done to the extent possible.

ix) Efforts should be made to use solar energy to the maximum extent possible.

III. <u>General Conditions</u>:

(i) In the event of any change in the project profile a fresh reference shall be made to the Ministry of Environment and Forests.

(ii) This Ministry reserves the right to revoke this clearance, if any, of the conditions stipulated are not complied with to the satisfaction of this Ministry.

(iii) This Ministry or any other competent authority may stipulate any additional conditions subsequently, if deemed necessary, for environmental protection, which shall be complied with.

(iv) Full support should be extended to the officers of this Ministry's Regional Office at Bhopal and the offices of the Central and State Pollution Control Board by the project proponents during their inspection for monitoring purposes, by furnishing full details and action plans including the action taken reports in respect of mitigative measures and other environmental protection activities.

8. These stipulations would be enforced among others under the provisions of water (Prevention and Control of Pollution) Act, 1974 the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and Municipal Solid Wastes (Management and Handling) Rules, 2000 including the amendments and rules made thereafter.

9. All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department and Civil Aviation Department from height point of view, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.

10. The project proponent should advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment and Forests at http://www.envfor.nic.in. The advertisement should be made within 10 days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bhopal.

11. Environmental clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004, if applicable to this project.

12. A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad / Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/ representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.

13. The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall

update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB. The criteria pollutant levels namely; SPM, RSPM, SO_2, NOx (ambient levels as well as stack emissions) or critical sectoral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.

14. The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.

15. The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEF by e-mail.

(Bharat Bhushan)
Director (IA-III)
22.11.2010

Copy to:

1. The Secretary, Department of Environment, Govt. of Maharashtra, Mantralaya, Mumbai – 400 032.
2. The Joint Secretary (AS), Ministry of Civil Aviation, Rajiv Gandhi Bhawan, Safdarjung Airport, New Delhi 110003.
3. The Chairman, CPCB, Parivesh Bhawan, CBD-cum-Office Complex, East Arjun Nagar, Delhi – 32.
4. The Chairman, Maharashtra Coastal Zone Management Authority, Room No.217 (Annexe), Mantralaya, Mumbai – 400 032.
5. The Chairman, Maharashtra Pollution Control Board, Kalpataru Points, 3rd & 4th floor, Opp. Cine Planet, Sion Circle, Sion (E) Mumbai-400 022.
6. The Chief Conservator of Forests, Ministry of Environment and Forests, Regional Office, Western Region, Kendriya Paryavaran Bhavan, Link Road No. 3, Ravishankar Nagar, Bhopal – 462016 (M.P.)
7. Guard File.
8. Monitoring Cell.

(Bharat Bhushan)
Director (IA)

Annexure II

F.No.10-53/2009-IA.III
Government of India
Ministry of Environment, Forest and Climate Change
(IA-III Section)

Indira Paryavaran Bhawan,
Jor Bagh Road, New Delhi - 3

Date: 20th December, 2017

To,

The General Manager (Environment),
City and Industrial Development Corporation of Maharashtra Ltd (CIDCO),
Navi Mumbai International Airport Office,
3rd Floor, Tower No.10,
Belapur Railway Station Complex, C.B.D. Belapur,
Navi Mumbai-400614 (Maharashtra) Fax: 022-22022509/66500933
Email: consultant.env@cidcoindia.com

Subject: Environmental and CRZ Clearance for establishment of Navi Mumbai International Airport at Mumbai by M/s City and Industrial Development Corporation of Maharashtra Ltd – Extension of validity of Environmental and CRZ Clearance - reg.

Sir,

This has reference to your online proposal No. IA/MH/MIS/235/2009 dated 6th September, 2017 submitted to this Ministry for extension of validity of Environmental and CRZ Clearance granted vide letter No. 10-53/2009 dated 22nd November, 2010 for 'Establishment of Navi Mumbai International Airport at Mumbai' in favour of M/s City and Industrial Development Corporation of Maharashtra Ltd, in terms of the provisions of the Environment Impact Assessment (EIA) Notification, 2006 under the Environment (Protection) Act, 1986 and CRZ Notification, 2011.

2. The proposal for grant of extension of validity of Environmental and CRZ Clearance to the above referred project was considered by the Expert Appraisal Committee (Infra-2) in its 24th meeting held in 30-31 October, 2017.

3. The EAC in its 24th meeting held in 30-31 October, 2017 has recommended the project for grant of extension of the validity of EC&CRZ clearance issued vide letter dated 22nd November, 2010 for a period of three years. As per recommendations of the EAC, the Ministry of Environment, Forest and Climate Change hereby extend the validity of Environmental and CRZ Clearance up to 21st November, 2020. The following additional conditions were also recommended.

(i) A certified report on the sources and availability of water from the local body supplying water along with the permission received by them for the same shall be submitted. This report shall specify the total annual water availability with the organization (local body), the quantity of water already committed to other development projects, the quantity of water committed for this project and the balance water available for distribution. This should be specified separately for ground water and surface water sources and ensure that there is no impact on other users.

(ii) A detailed traffic management and a traffic decongestion plan, to ensure that the current level of service of the roads within a 05 kms radius of the project site is maintained and improved upon, shall be drawn up through an organization of repute and specializing in Transport Planning within the next 6 months. This should be based on the cumulative impact of all development and increased inhabitation being carried out or proposed to be carried out by the project or other agencies in this 05 kms radius from the site under different scenarios of space and time and shall be implemented to the satisfaction of the State Urban Development and Transport Departments with the consent of all the concerned implementing agencies.

(iii) Treated effluents shall also be used for irrigation and in Road side plantation after taking due permission from the concerned authorities/ Forest department

(iv) The project proponents shall satisfactorily address to all the complaints that have been received against the project and submit a compliance report to the Ministry

(v) The extension of validity is being granted for the original proposals for which Environmental and CRZ Clearance was granted earlier. The project proponents will not make any changes in the project nature, structure or configuration and limit themselves to activities for which the Environmental and CRZ Clearance has been given earlier.

4. All other conditions stipulated in the Environmental and CRZ Clearance granted vide letter No. 10-53/2009 dated 22nd November, 2010, shall remain unchanged.

5. This issues with the approval of the Competent Authority.

(Kushal Vashist)
Director

Copy to:

1) The Principal Secretary, Environment Department, Government of Maharashtra, 15th Floor, New Administrative Building, Mantralaya, Mumbai - 400 032.

2) The Joint Secretary (AS), Ministry of Civil Aviation, Rajiv Gandhi Bhawan, Safdarjung Airport, New Delhi – 110 003.

3) The APCCF (C), MoEF&CC, Regional Office (WCZ), Ground Floor, East Wing, New Secretariat Building, Civil Lines, Nagpur - 440001.

4) The Chairman, Maharashtra Coastal Zone Management Authority, Room No. 217 (Annexe), Mantralya, Mumbai – 400 032.

5) The Chairman, Central Pollution Control Board Parivesh Bhavan, CBD-cum-Office Complex, East Arjun Nagar, New Delhi - 110 032.

6) The Chairman, Maharashtra Pollution Control Board, Kalpataru Point, 3rd and 4th floor, Opp. Cine Planet, Sion Circle, Mumbai - 400 022.

7) Monitoring Cell, MoEF&CC, Indira Paryavaran Bhavan, New Delhi.

8) Guard File/ Record File/ Notice Board.

(Kushal Vashist)
Director

Annexure III

Forest clearance

I

F. No. 8-95/2012-FC
Government of India
Ministry of Environment & Forests
(FC Division)
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Paryavaran Bhawan,
C.G.O Complex, Lodhi Road,
New Delhi - 110510.
Dated: 17th December, 2013.

To

The Principal Secretary (Forests),
Government of Maharashtra,
Mantralaya, Mumbai.

Sub: Diversion of 250.0635 ha of forest land in favour of General Manager (Airport) CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra- regarding.

Sir,

I am directed to refer to the State Government's letter no. FP/MH/Others/663/2012 dated 20.11.2012 on the above subject seeking prior approval of the Central Government under the Forest (Conservation) Act, 1980 and to say that the proposal has been examined by the Forest Advisory Committee constituted by the Central Government under section-3 of the said Act.

After careful examination of the proposal of the State Government and on the basis of the recommendation of the Forest Advisory Committee, the Central Government hereby conveys the 'in-principle' approval for diversion of 250.0635 ha of forest land in favour of General Manager (Airport) CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra subject to fulfilment of the following conditions:

i. Legal status of the diverted forest land shall remain unchanged

ii. Compensatory Afforestation over the non-forest land equal in extent to the forest land (i.e. over 250.0635 ha) being diverted shall be raised and maintained by the State Forest Department at the cost of the User Agency.

A

iii. The non-forest land identified for raising compensatory afforestation shall be transferred and mutated in favour of the State Forest Department before issue of the Stage-II clearance.

A iv. The land identified for the purpose of CA shall be clearly depicted on a Survey of India toposheet of 1:50.000 scale.

A v. The non-forest land transferred and mutated in favour of the State Forest Department shall be notified by the State Government as RF under Section-4 or PF under Section-29 of the Indian Forest Act, 1927 or under the relevant Section(s) of the local Forest Act, 1927 latest within a period of six months from the date of issue of Stage--II approval. The Nodal Officer shall report compliance in this regard along with a copy of the original notification declaring the non-forest land under Section 4 or Section 29 of the

Indian Forest Act, 1927, as the case may be, within the stipulated period to the Central Government for information and record;

vi. The User Agency shall transfer the cost of raising and maintaining the compensatory afforestation, at the current wage rate, to the State Forest Department. The scheme may include appropriate provision for anticipated cost increase for works scheduled for subsequent years.

vii. User Agency shall deposit the Net Present Value (NPV) of the diverted forest land with the State Forest Department as per the orders of the Hon'ble Supreme Court dated 30.10.2002, 01.08.2003 and 28,.03.2008 in I.A. No. 566 in WP(C) No. 202/1995 and the guidelines issued by this Ministry vide letter No. 5-1/98-FC(Pt.II) dated 18.09.2003 and 22.09.2003 in this regard.

viii. Additional amount of the NPV of the diverted forest land, if any, becoming due after finalization of the same by the Hon'ble Supreme Court of India on receipt of the report from the Expert Committee, shall be charged by the State Government from the User Agency. The User Agency shall furnish an undertaking to this effect.

ix. All the funds received from the User Agency under the project shall be transferred to Ad-hoc CAMPA in saving accounts pertaining to the State concerned.

x. Afforestation of mangrove species over an area equivalent in extent to mangrove forest area being diverted has to be raised and maintained by the user agency at their own cost in consultation with the State Forest Department. It will be in addition to the mangrove area to be raised under CRZ approval.

xi. The User Agency will undertake comprehensive soil conservation measures at the project cost in consultation with the State Forest Department.

xii. The User Agency will assist the State Government in conservation and preservation of flora and fauna of the area in accordance with the plan prepared by the Chief Wildlife Warden of the State.

xiii. All conditions imposed by the Standing Committee of the National Board for Wildlife, communicated vide MoEF's letter no. 6-43/2007-WL (29th Meeting) dated 1.08.2013, will be complied with.

xiv. A Monitoring Committee will monitor the implementation of different measures stipulated herein and will submit six monthly report to the Ministry in this regard. The Committee will be comprised of Principal Chief Conservation of Forests as Chairman, representative of the Regional Office, Bhopal, representative of Bombay Natural History Society and representative of CIDCO and Conservator of Forests (territorial), who will be the Member Secretary of the Monitoring Committee.

xv. The R&R Plan approved by the State Government shall be submitted before Stage-II approval.

xvi. State Government shall ensure that settlement of displaced people does not take place in the forest land.

xvii. Any trees shall be felled only when it becomes necessary and that too under strict supervision of State Forest Department, and at the cost of the User Agency.

xviii. No labour camp shall be established on the forest land. The User Agency shall also provide fuels preferably alternate fuels to the labourers and staff working at the site so as to avoid any damage to the nearby forest areas. C

xix. In future, user agency shall not submit any proposal for extension of the project or any other project ancillary/related to this project in the forest land between the present project site and Karnala Bird Sanctuary.

xx. The boundary of the diverted forest land shall be demarcated on the ground with four feet high cement concrete pillar with its serial number and forward and back bearing inscribed on it.

xxi. The layout and plan shall not be changed without prior approval of the Central Government. C

xxii. The User Agency shall obtain the Environment Clearance as per the provisions of the Environmental (Protection) Act, 1986, if required;

A xxiii. Ex-situ conservation of endemic species of flora/fauna lost/disturbed in the process of execution of the project may be ensured.

C xxiv. No damage to the flora and fauna of the area shall be caused. — FC II incl.

A xxv. The user agency in consultation with the State Government shall create and maintain alternate habitat/home for the avifauna, whose nesting trees area to be cleared in this project. Birds nests artificially made out of eco-friendly material shall be used in the area, including forest area and human settlements, adjoining the forest area being diverted for the project.

A xxvi. The forest land shall not be used for any purpose other than that specified in the proposal and shall, under no circumstances, be transferred to any one without prior approval of the Central Government.

A xxvii. All other conditions proposed by the State Government at the time of submission of the proposal to the Central Government shall be complied with by the User Agency.

xxviii. The State Government shall complete settlement of rights, in terms of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, if any, on the forest land to be diverted and submit the documentary evidence as prescribed by this Ministry in its letter No. 11-9/1998-FC (pt.) dated 03.08.2009, in support thereof

A xxix. Rehabilitation of project affected families, if any, shall be done as per the National Rehabilitation policy / State Rehabilitation policy whichever is better in consultation with the State Forest Department at the cost of user agencies.

A xxx. The user agency shall submit the annual self compliance report in respect of the above conditions to the State Government and to the concerned Regional Office of the Ministry regularly.

A xxxi. Any other condition that the concerned Regional Office of this Ministry may stipulate, from time to time, in the interest of conservation, protection and development of forests & wildlife; and

xxxii. The User Agency and the State Government shall ensure compliance to provisions of the all Acts. Rules, Regulations and Guidelines, for the time being in force, as applicable to the project.

xxxiii. Any other condition that the Addl. PCCF (Central), Regional Office, Bhopal may impose from time to time for the protection and improvement of flora and fauna in the forest area.

After receipt of the compliance report on the fulfilment of the above mentioned conditions from the State Government, formal approval will be considered in this regard under Section-2 of the Forest (Conservation) Act, 1980. The transfer of forest land to the User Agency shall not be affected by the State Government till formal order approving the diversion of forest land is issued by the Central Government.

Yours faithfully,

(Priya Ranjan)
Sr. Assistant Inspector General of Forests

Copy to:-

1. The Principal Chief Conservator of Forests, Government of Maharashtra, Nagpur.
2. The Addl. PCCF (Central), Regional Office, Bhopal, MoEF.
3. The Nodal Officer (FCA), O/o the PCCF, Government of Maharashtra, Nagpur.
4. User Agency (M/s Rewas Ports Ltd., Jai Center, 1st Floor, 34 P D'Mello Road, Opp Red Gate, Mumbai 400 009.
5. Monitoring Cell, FC Division, MoEF, New Delhi.
6. Guard File.

(Priya Ranjan)
Sr. Assistant Inspector General of Forests

Annexure IV

F. No. 8-95/2012-FC
Government of India
Ministry of Environment, Forests and Climate Change
(Forest Conservation Division)
***

Indira Paryavaran Bhawan,
Aliganj, Jorbagh Road,
New Delhi – 110003
Dated 24 April, 2017

To,

The Principal Secretary (Forests),
Government of Maharashtra,
Mantralaya, Mumbai.

Sub: Diversion of 250.0635 ha of forest land in favour of General Manager (Airport), CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra- regarding.

Sir,

I am directed to refer to the State Government of Maharashtra's letter No. FP/MH/Others/663/2012 dated 20.11.2012 on the subject cited above seeking prior approval of the Central Government under the Forest (Conservation) Act, 1980. After careful consideration of the proposal by the Forest Advisory Committee (FAC) constituted under Section-3 of the said Act, ***In-principle approval/Stage-I Clearance*** was granted vide this Ministry's letter of even number dated 17.12.2013 subject to fulfilment of certain conditions. The State Government has furnished compliance report in respect of the conditions stipulated in the approval and has requested the Central Government to grant final approval.

In this connection, I am directed to say that on the basis of the compliance report furnished by the Government of Maharashtra vide their letters No. 17/NC/II/LD.12060/(49)/2373/15-16 dated 18.03.2016, No. FLD-1315/C.R.352/part-2/F-10 dated 07.09.2016, No. FLD-1315/C.R.352/part-2/F-10 dated 03.11.2016 and no. Desk-17/NC/II/LD.12060/(49)/2372/16-17 dated 21.03.2017 , and **recommendation for deletion of condition no. (xx) and modification of condition No.(xix) of stage-I clearance dated 17.12.2013 by Forestry Advisory Committee in its meeting held on 12.07.2016 and approval of competent authority for the same**, the ***Final/Stage-II approval*** of the Central Government is hereby granted under Section-2 of the Forest (Conservation) Act, 1980 for diversion of 250.0635 ha of forest land in favour of General Manager (Airport), CIDCO Ltd., Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra subject to fulfilment of the following conditions:

(i) Legal status of the diverted forest land shall remain unchanged.

(ii) Compensatory afforestation (CA) over the **non-forest land equal** in extent to the forest land being diverted (i.e. over 250.0635 ha) **shall be raised within three years from the date of** issue of stage -II clearance and maintained **thereafter as per approved plan by the State** Forest Department at the cost of **the User Agency. The CA will be done at the rate of 1000** plants per ha (i.e. **2,50,063 plants)** over the non-forest land. However, as now forest land identified for CA has only 120.75 ha plantable area which can accommodate only 67,073 plants. The remaining 1,82,990 plants shall be planted over degraded forest land under the control of State Forest Department as identified in the compliance report submitted by State Govt. vide their letter no. Desk-17/NC/II LD.12060/(49)/2372/16-17 dated 21.03.2017;

(iii) The State Govt. shall ensure that afforestation of mangrove species over an area equivalent in extent to mangrove forest area being diverted has to be raised within three years from the date of stage - II clearance and maintained at the cost of user agency in consultation with the

State Forest Department. It will be in addition to the mangrove area to be raised under CRZ approval;

(iv) **In future, user agency shall not submit any proposal for extension of project or any other project ancillary/related to this project in forest land falling in eco sensitive zone of Karnala bird sanctuary;**

(v) The non-forest land transferred and mutated in favour of the State Forest Department shall be notified by the State Government as RF under Section-4 or PF under Section-29 of the Indian Forest Act, 1927 or under the relevant Section(s) of the local Forest Act, 1927 latest within a period of six months from the date of issue of Stage--II approval. The Nodal Officer shall report compliance in this regard along with a copy of the original notification declaring the non-forest land under Section 4 or Section 29 of the Indian Forest Act, 1927, as the case may be, within the stipulated period to the Central Government for information and record;

(vi) The User Agency will undertake comprehensive soil conservation measures at the project cost in consultation with the State Forest Department;

FCF (vii) The User Agency shall obtain the Environment Clearance as per the provisions of the Environmental (Protection) Act, 1986, if required;

(viii) The User Agency will assist the State Government in conservation and preservation of flora and fauna of the area in accordance with the plan prepared by the Chief Wildlife Warden of the State;

(ix) The State Govt. shall ensure to comply with all the conditions imposed by the Standing Committee of the National Board for Wildlife, communicated vide MoEF's letter no. 6-43/2007-WL (29th Meeting) dated 1.08.2013;

(x) The User Agency shall pay the additional amount of NPV, if so determined, as per the final decision of the Hon'ble Supreme Court of India;

FCI (xi) The Monitoring Committee as constituted vide order no. FLD-1312/CR 352(part-II)/ F-10 dated 25.07.2014 by Govt. of Maharashtra shall monitor the implementation of different measures stipulated and submit six monthly report to the Ministry/Regional Office Nagpur;

FCI (xii) The approved R&R Plan shall be implemented by the State Government;

(xiii) Rehabilitation of project affected families, if any, shall be done as per the National Rehabilitation policy / State Rehabilitation policy whichever is better in consultation with the State Forest Department at the cost of user agency;

(xiv) State Government shall ensure that settlement of displaced people does not take place in the forest land;

(xv) Any tree felling shall be done only when it is unavoidable and that too under strict supervision of the State Forest Department;

(xvi) The layout plan of the proposal shall not be changed without the prior approval of the Central Government.

(xvii) No labour camp shall be established on the forest land;

(xviii) The User Agency shall provide fuels preferably alternate fuels to the labourers and the staff working at the site so as to avoid any damage and pressure on the nearby forest areas.

(xix) The State Govt. shall ensure that the User Agency implement the conservation plan prepared by BNHS in connection with conservation of flora & fauna;

(xx) The user agency will abide by the applicable recommendations of the State Government including State Forest/Wildlife Departments;

(xxi) The forest land shall not be used for any purpose other than that specified in the proposal.

(xxii) The forest land proposed to be diverted shall under no circumstances be transferred to any other agency, department or person without prior approval of the Central Government;

(xxiii) No damage to the flora and fauna of the adjoining area shall be caused;

(xxiv) The State Government shall ensure the complete compliance on settlement of rights, in terms of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, if any, on the forest land to be diverted and submit the documentary evidence as prescribed by this Ministry in its letter No. 11-9/1998-FC (pt.) dated 03.08.2009 read with 05.07.2013, in support thereof. **The State Government shall accept the conditions put in Gram Sabha Resolution. The State Government shall provide undertaking to MoEF&CC, before commencement of work, that the State Government will comply with all provisions of FRA -2006 as specified by Ministry of tribal affairs;**

(xxv) The User Agency shall submit the annual self compliance report in respect of the above stated conditions to the State Government, concerned Regional Office and to this Ministry by the end of March every year;

(xxvi) Any other condition that the concerned Regional Office of this Ministry may stipulate, from time to time, in the interest of conservation, protection and development of forests & wildlife; and

(xxvii) The user agency shall comply all the provisions of the all Acts, Rules, Regulations, Guidelines & Hon'ble Court Order (s) pertaining to this project, if any, for the time being in force, as applicable to the project.

Yours faithfully,

(Sandeep Sharma)
Assistant Inspector General of Forests

Copy to:

1. The Principal Chief Conservator Forests, Government of Maharashtra, Nagpur.
2. Addl. Principal Chief Conservator of Forests (Central), Ministry of Environment & Forests, Regional Office (WZ), Kendriya Paryavaran Bhawan, E-5, Arera Colony, Link Road-3, Ravi Shankar Nagar, Bhopal-462016.
3. The Nodal Officer, O/o the PCCF, Government of Maharashtra, Nagpur
4. User Agency (Executive Engineer, Raigad Irrigation No-2, Konkan Bhavan, Navi Mumbai
5. Monitoring Cell.
6. Guard file.

(Sandeep Sharma)
Assistant Inspector General of Forests

Annexure V

IN THE HIGH COURT OF JUDICATURE AT BOMBAY

ORDINARY ORIGINAL CIVIL JURISDICTION

NOTICE OF MOTION NO.419 OF 2011
IN
PUBLIC INTEREST LITIGATION NO.87 OF 2006

...

The Bombay Environmental Action Group & Anr. ..Petitioners

Vs.

The State of Maharashtra & Ors. ...Respondents

And

City & Industrial Development
Corporation of Maharashtra ...Applicant

...

Mr.G.S.Hegde i/b. G.S. Hegde & Co., for applicant.
Ms. Gulnar Mistry i/b. M.V. Jayakar & Co., for the petitioners.
Mr. R.A. Rodrigues with Mr. N.J. Prajapati for respondent Union of India.
Ms. Sharmila Modle for respondent-B.M.C.
Ms. Sharmila Deshmukh for respondent-MCZMA.

...

CORAM: MOHIT S. SHAH, C.J. &
M.S.SANKLECHA, J.
DATE : 29 OCTOBER 2013

P.C.:

This notice of motion has been taken out by CIDCO, Navi Mumbai for modification of the order dated 6 October 2005 and for permission to develop the Green Field Airport at Navi Mumbai without having to seek clearance under the Forest Conservation Act, 1980.

2. Learned counsel for CIDCO has now tendered additional affidavit dated 3 October 2013 placing on record the order dated 11-12 July 2013 passed by Government of India in the Ministry of Environment & Forests Department ,(FC Division) recommending the proposal of CIDCO Ltd. Navi Mumbai for diversion of 250.0635 hectors of forest land in Navi Mumbai for establishment of Navi Mumbai International Airport in Alibag Forest Division in District Raigad of Maharashtra. The recommendation is subject to certain standard conditions and also additional conditions, which are as under:-

> 1. *Afforestation of mangroves species over an area equivalent in extent to mangroves forest area being diverted has to be raised and maintained by the user agency at their own cost in consultation with the State Forest Department. It will be in addition to the mangrove area to be raised under CRZ approval.*
>
> 2. *All conditions imposed by the Standing Committee of the National Board for Wildlife will be complied with.*
>
> 3. *A specific plan shall be prepared by the user agency through a reputed organization like WII, SACON, BNHS, etc. and its recommendations shall be implemented by the User Agency to mitigate the impact of the project on avifauna under the supervision of the State Forest Department at the cost of project.*
>
> 4. *A Monitoring Committee will monitor the implementation of different measures stipulated herein and will submit six monthly report to the Ministry in this regard. The Committee will be comprised of Principal Chief Conservator of Forests as Chairman, representative of the Regional Office, Bhopal, representative of Bombay Natural History Society and representative of CIDCO and Conservator of Forests (territorial), who will be the Member Secretary of the Monitoring Committee.*
>
> 5. *The R & R Plan approved by the State Government shall be submitted before Stage-II approval.*
>
> 6. *State Government shall ensure that settlement of displaced people does not take place in the forest land.*

> *7. In future, user agency shall not submit any proposal for extension of the project or any other project ancillary/related to this project in the forest land between the present project site and Karnala Bird Sanctuary.*

3. In the meantime, at the 29th meeting of the Standing Committee of the National Board for Wildlife held on 6 June 2013 the following decision was recorded thereafter in its minutes on 20 July 2013:-

> *5(1) Proposal for construction of Navi Mumbai International Airport (NMIA) at Panvel Talukaa, District Raigad in Maharashtra in 10 km eco-sensitive zone/Area (ESA) of Karnala Bird sanctuary (KBS)*
>
> *The Member Secretary informed the commitrtee that this proposal was discussed during the 28th Meeting of Standing Committee of NBWL and after discussion the committee had decided that a team comprising of Dr.Asad Rahmani and Shri Kishor Rithe would conduct site inspection and submit a report to the Standing Committee of NBWL for consideration. Subsequently, Dr.Asad Rahmani of Bombay Natural History Society (BNHS) informed the MoEF that BNHS had accepted the study from project proponent CIDCO and hence he would be unable to be a part of site inspection team as it would be conflict of interest for him. Therefore, Additional Director General of Forest (Wildlife), Dr.Divyabhanusinh Chavde and Kishor Rithe were directed to conduct the site inspection vide letter (no.6-34/2013WL) dated 3 May 2013. However, Dr.Chavda could not join the site inspection team due to his other engagements.*
>
> *The site inspection was conducted on 9th and 10th May 2013 and after inspection, the team had recommended the proposal with certain conditions. An important observation that came out during the site inspection was that Shri Debi Goenka of the Conservation Action Trust, Mumbai had filed a Public Interest Litigation (PIL) on mangrove protec tion which will be applicable to mangrove area to be destroyed by proposed project of NMIA.*
>
> *The committee, after discussion, unanimously decided to recommend the proposal subject to the following conditions, as stipulated in the site inspection report:*

i. As there are several project proposals coming to SC-NBWL around KBS, it is recommended that the CWLW should compile the information and proceed to assess the cumulative impart of the those projects on KBS landscape (which includes several Pas mentioned by CWLW and surrounding wildlife habitats (together with forest, wetland and mangroves), and plan about compensating/mitigating the damages collectively. For any further project in 10km ESZ of KBS, this condition must be given due consideration.

ii. Air traffic at NMIA should not use the airspace above the KBS as promised during the meeting. The annual report "Baseline Survey of Avian fauna at and around NMIA" produced by BNHS has, though not sufficient enough, suggested conservation measures in 10 km radius of NMIA. The potential wildlife habitats (wetlands, forest and mangroves) which comes in 10km ESZ of KBS should also be considered for implementing conservation measures.

Iii. In order to have alternate site for migratory birds visiting wetland within proposed NMIA site, Sewri coast wetland should be considered to be developed. The Sewri coast wetland of 1037.3 ha is a marshland protected from Arabian sea near the mouth of Thane creek. Thousands of flamingos along with many other migratory water birds about 150 species (11 are globally threatened) inhabit this marsh partly covered by mangrove. The Government of Maharashtra should nominate the same for Ramsar site.

iv. As per the Hon'ble High Court order dated 27 January 2010 the mangrove is a protected forest. As the project involves mangrove forest land , the State Government should see if any approval from the Hon'ble High Court is required. Mangrove eco-system has a unique aquatic fauna which carries a great importance. There is dense mangrove cover towards north side of the proposed NMIA site and parts of it also occur inside the NMIA site. To compensate for the loss of important mangrove forest portion inside the NMIA site, the mangrove forest bordering NMIA site (including the mangrove Park) should be declared as a mangrove sanctuary.

v. The project proponent should pay 3% of project cost for a fixed deposit with the wildlife department so that the interest amount can be spent on conservation of man grove in the entire Mumbai wildlife circle.

vi. The government of Maharashtra has presently notified only 12.11 sq.km area as KBS though there are more wildlife potential forest lands available between the KBS and the NMIA site. As those lands will be vulnerable for encroachments, we recommend that the state government should notify all such forest patches between the KBS and NMIA as sanctuary before granting the final clearance. This will not only help to stop further encroachments on forest lands around NMIA site (unlike encroachments around existing Mumbai airport) but also will help to reduce the risk of having any air traffic accident due to garbage attracted bird movements.

vii. Looking at the encroachments around SGNP and the existing Mumbai airport, the Government of Maharashtra need to ensure that the families be relocated at relocation site-2 (55 Ha) at Dapoli which requires 40 ha land and at relocation site-3 at Vahai on Amra Marg should not further encroach upon any forest land around these sites or in 10 km ESZ of KBS. There are 10 settlements from 7 revenue villages which need to be acquired for NMIA project and to be relocated at these three sites.

viii. The project proponent should construct the boundary was specially for relocation site-2 (along with 100 ha non-aeronautical activity area) during the construction of the project. This will also help to minimise the garbage issue which attracts birds and other wild animals and also stop encroachments on surrounding forest areas.

ix. Project propo0nent should allocate enough display space at the prominent location in the NMIA (As per the requirement of CWLW Maharashtra) free of cost to depict and highlight/ publicise the importance of protected areas of Maharashtra to the tourists arriving at NMIA till the lifetime of NMIA.

x. CWLW Maharashtra should incorporate the measures in the Management plan of KBS.

Thus, the Standing Committee of National Board for Wildlife recorded its recommendation to the proposal subject to ten conditions stipulated hereinabove.

4. Learned counsel for CIDCO submits that in view of the above recommendations of the National Board for Wildlife at the meeting of the Standing Committee held on 6 June 2013 and recommendations of the Forest Advisory Committee in the Ministry of Environment & Forests (MOEF) at the meeting held on 11-12 July 2013, there is no impediment to the permission being granted to CIDCO for removal of mangroves from 108.50 hectors. Learned counsel for CIDCO states that MOEF had already amended the CRZ Notification of 1991 thereby permitting the development of Airport in June 2009 and by letter dated 22 November 2010 the MOEF had also given environmental and CRZ clearance for the proposed Airport at Navi Mumbai. CIDCO had delineated an area of 108.50 hectors of mangroves for clearing the same to enable development of Airport and associated off-site infrastructure. As per the approval of MOEF, CIDCO is permitted to clear the mangroves in 108.50 hectors subject to development of 245 hectors of mangroves and protect 370 hectors of mangroves. CIDCO has also produced the plan at Exh.F to the affidavit in support of the notice of motion showing the area from which the mangroves are to be cleared and compensatory aforestation is to be done.

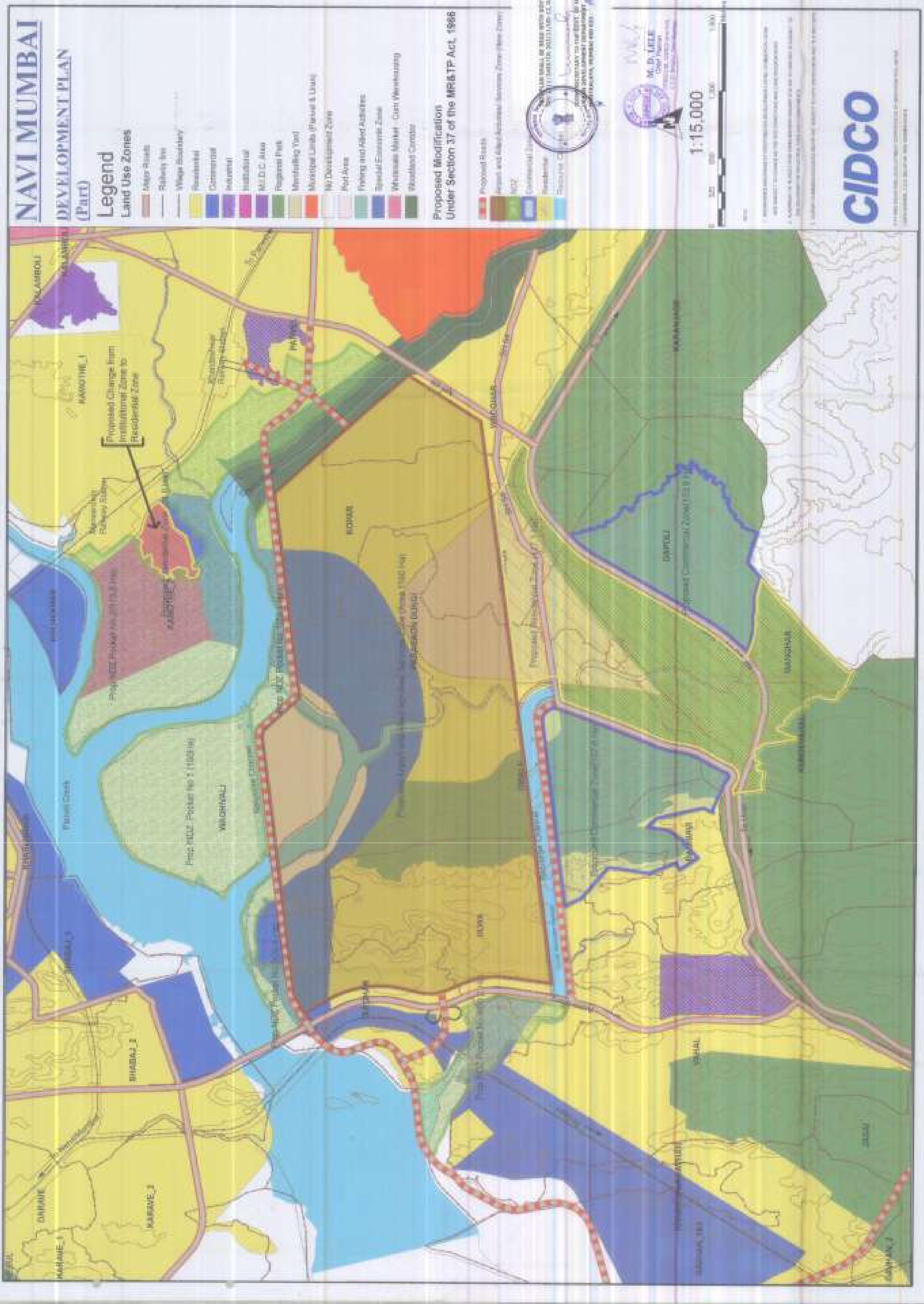
4. In view of the above, having heard the learned counsel for parties, we permit CIDCO to clear mangroves from 108.50 hectors subject to condition that CIDCO shall plant and develop 245 hectors of mangroves at the site indicated in Exh.F and also to protect 370 hectors of mangroves as indicated in Exh.F to the affidavit dated 18 August 2011 in support of Notice of Motion No.419 of 2011. CIDCO is directed to comply with all conditions stipulated by Forest Advisory Committee as well as the Standing Committee of National Board for Wildlife in the aforesaid approvals/recommendations.

5. Notice of motion, accordingly, stands disposed of.

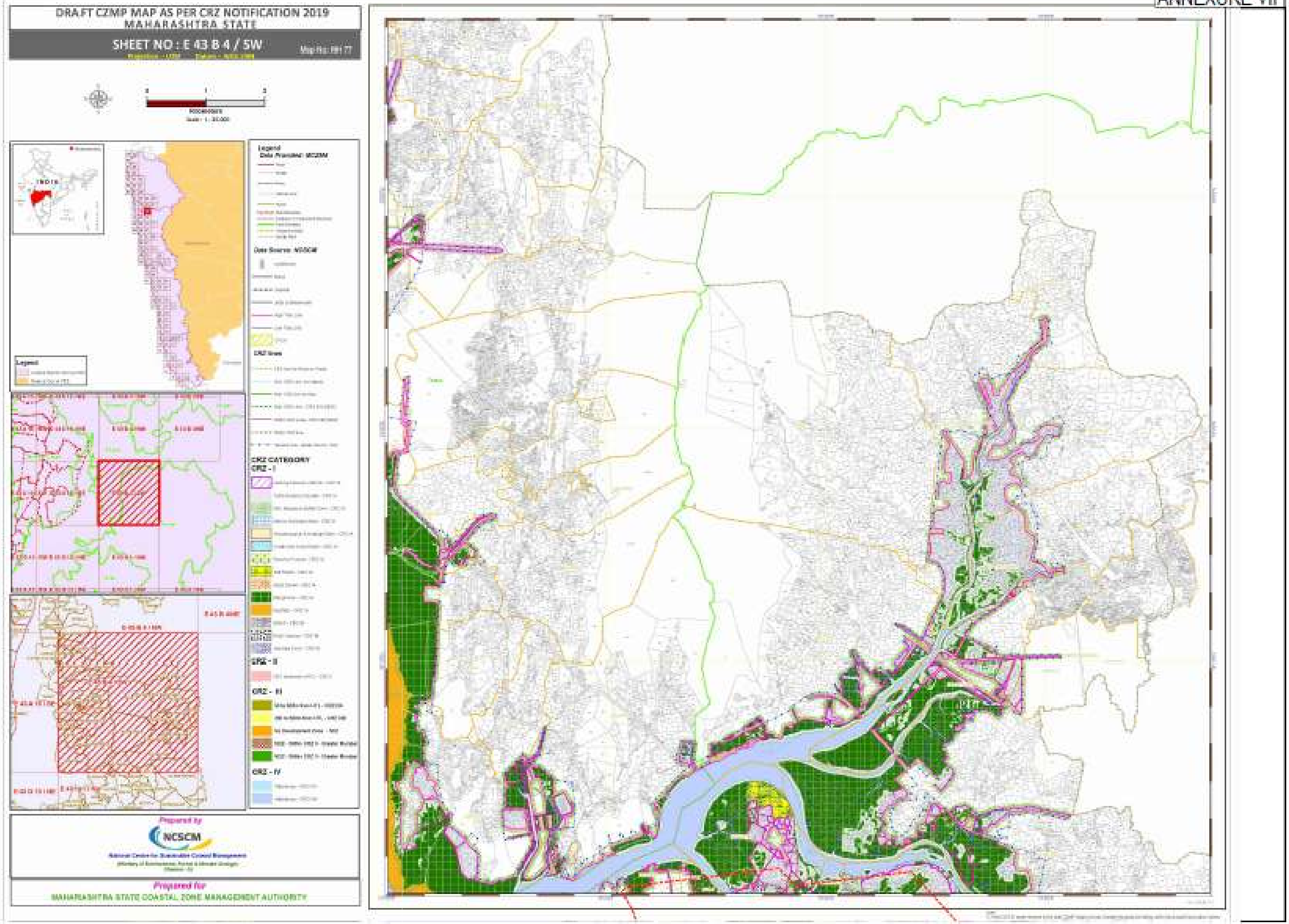
CHIEF JUSTICE

(M.S.SANKLECHA, J.)

Annexure VI

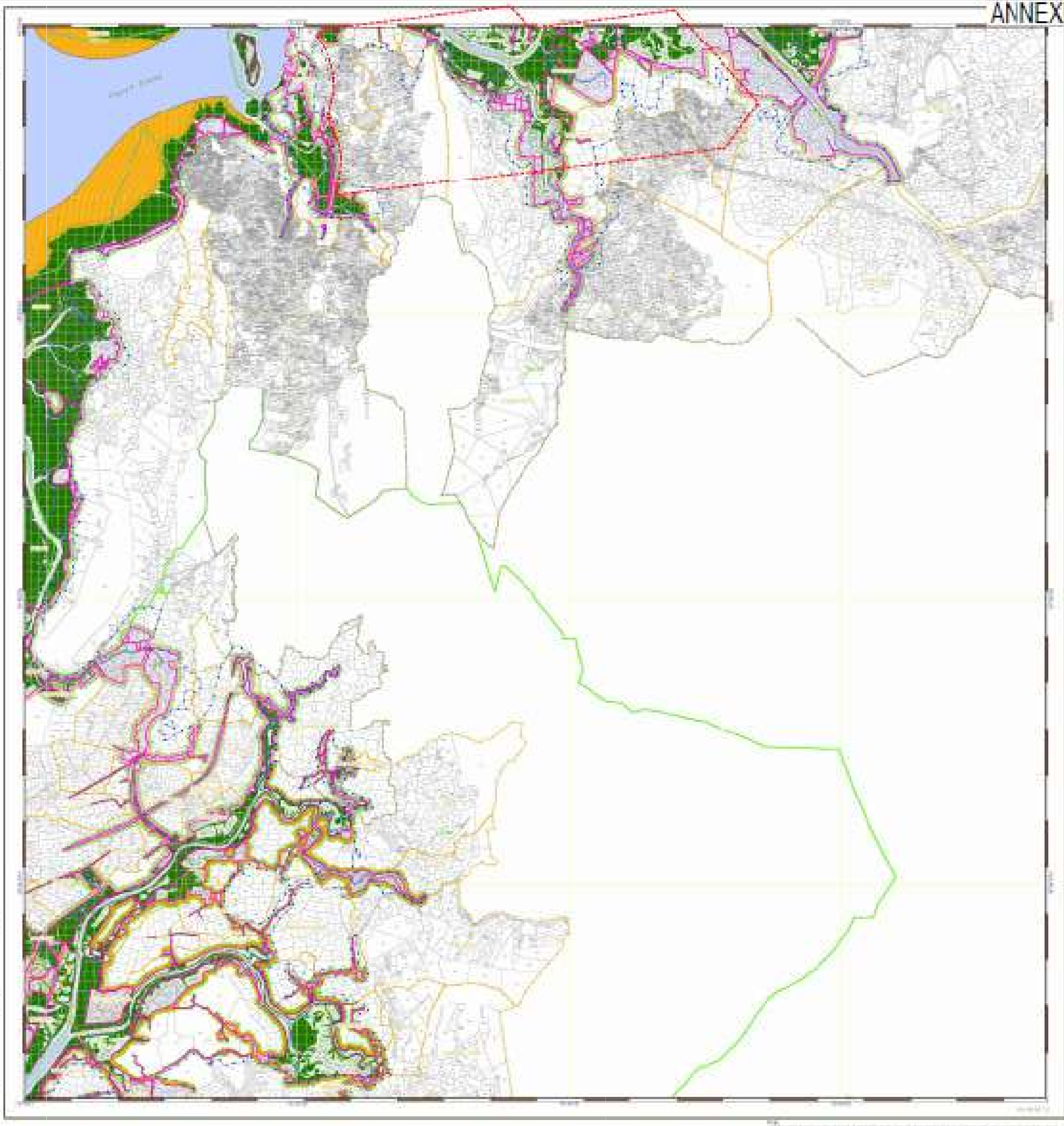

NAVI MUMBAI
DEVELOPMENT PLAN
(Part)
Legend
Land Use Zones
Proposed Modification
Under Section 37 of the MR&TP Act, 1966
1:15,000
CIDCO

ANNEXURE VII



ANNEXURE VIII

DRAFT CZMP MAP AS PER CRZ NOTIFICATION 2019
MAHARASHTRA STATE
SHEET NO : E 43 H 1 / NW



Legend
Data Provided: MCZMA

Data Source: NCSCM

CRZ lines

CRZ CATEGORY
CRZ - I
CRZ - II
CRZ - III
CRZ - IV

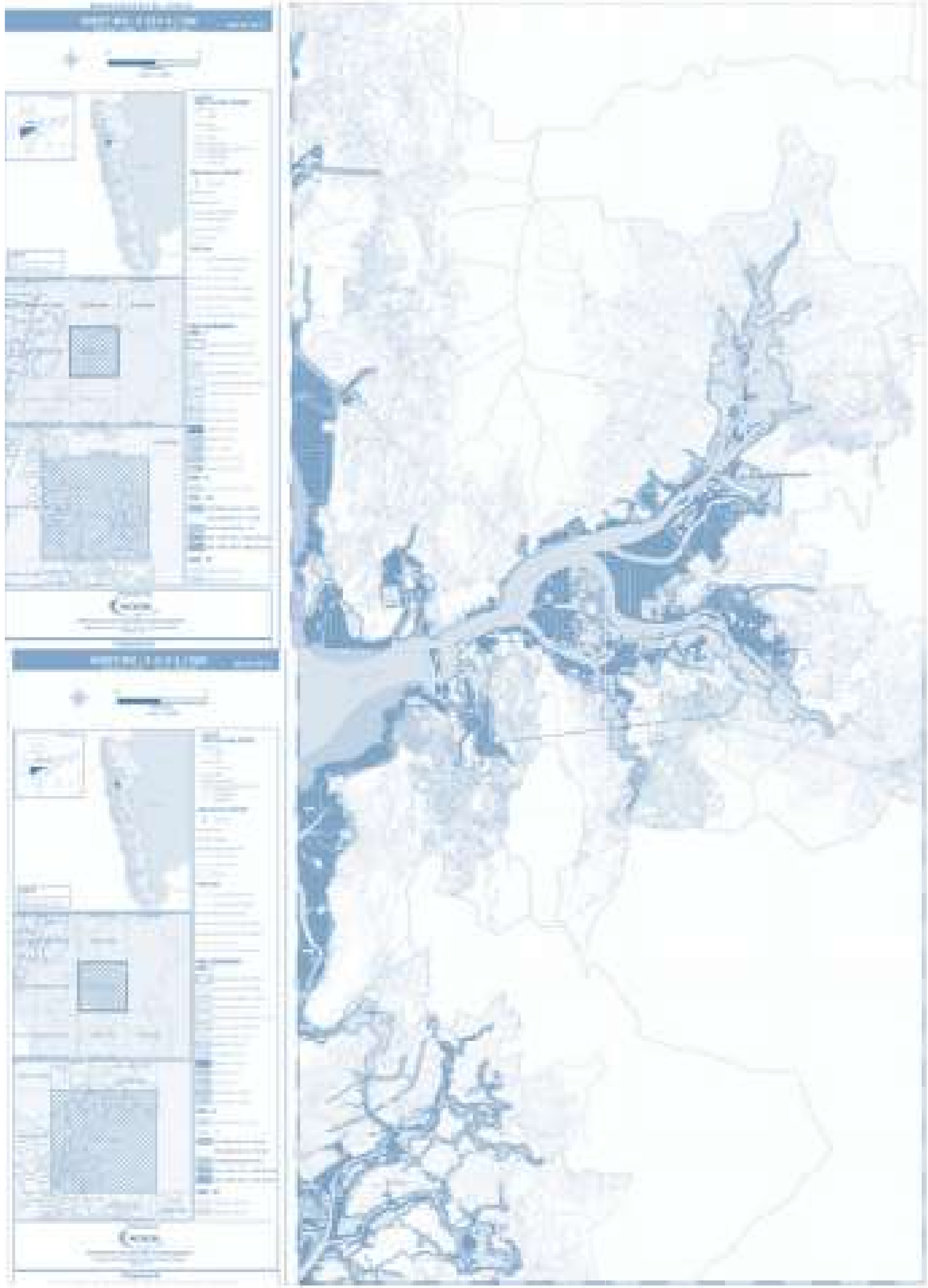
Prepared by
NCSCM
National Centre for Sustainable Coastal Management

Prepared for
MAHARASHTRA STATE COASTAL ZONE MANAGEMENT AUTHORITY

ANNEXURE IX
Panvel Creek
Gadhi River
Gadhi River
NMIA SITE BOUNDARY
NMIA SITE BOUNDARY
NMIA SITE BOUNDARY
NMIA SITE BOUNDARY
NMIA SITE BOUNDARY
NMIA SITE BOUNDARY
NMIA SITE BOUNDARY
Ulwe Recourse Channel
Ulwe Recourse Channel
2018 OCTOBER 16

ANNEXURE X

2019 FEBRUARY 12



Annexure XI

Recent Photographs of Ulwe River Recourse Channel (URC)


River Diversion 30-01-2020


River Diversion 30-01-2020


River Diversion 30-01-2020


River Diversion 30-01-2020


River Diversion 30-01-2020


River Diversion 30-01-2020


River Diversion 30-01-2020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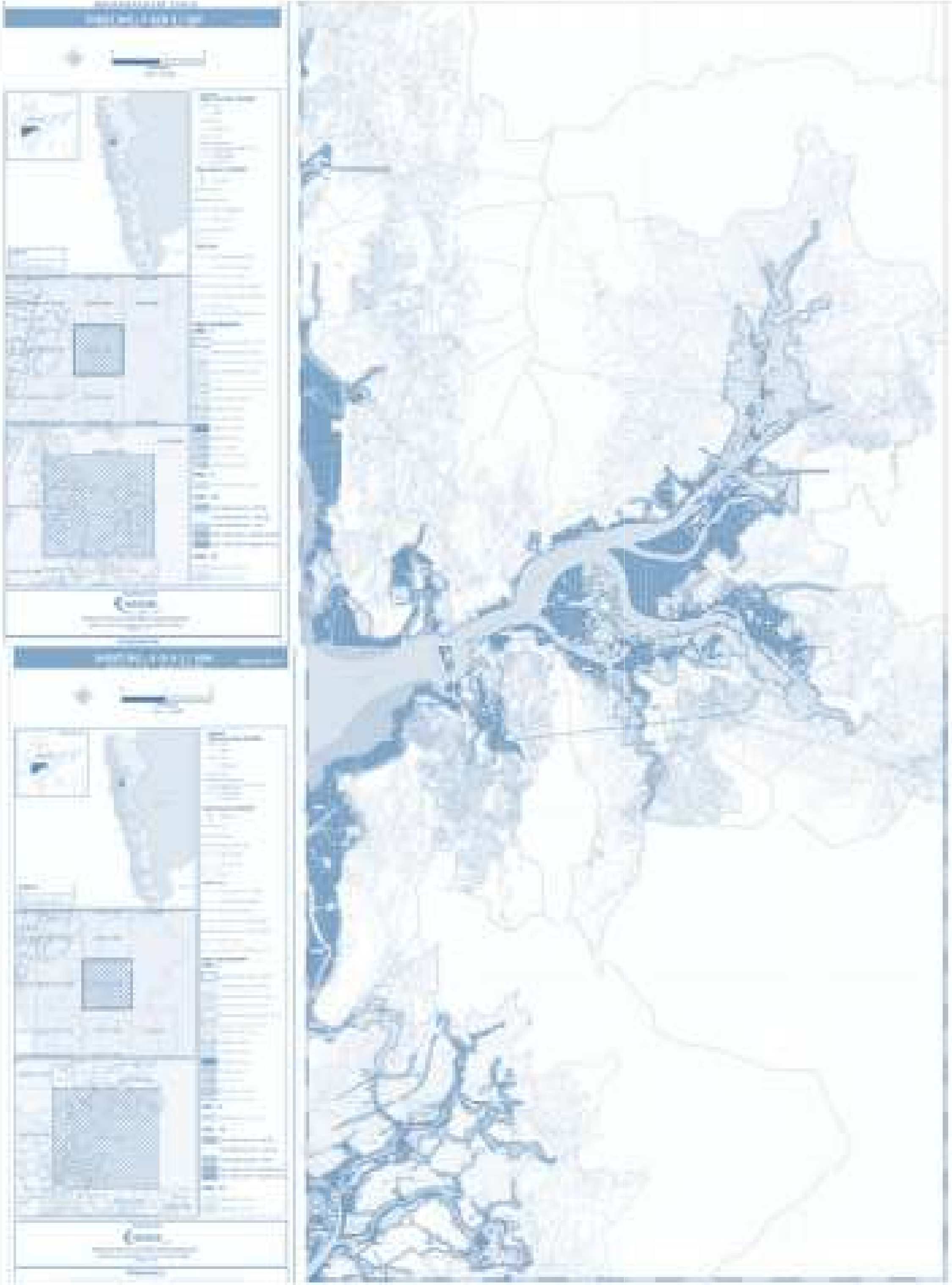
River Diversion 30-01-2020



Annexure XI

Photographs of NMIA Site and adjoining Area

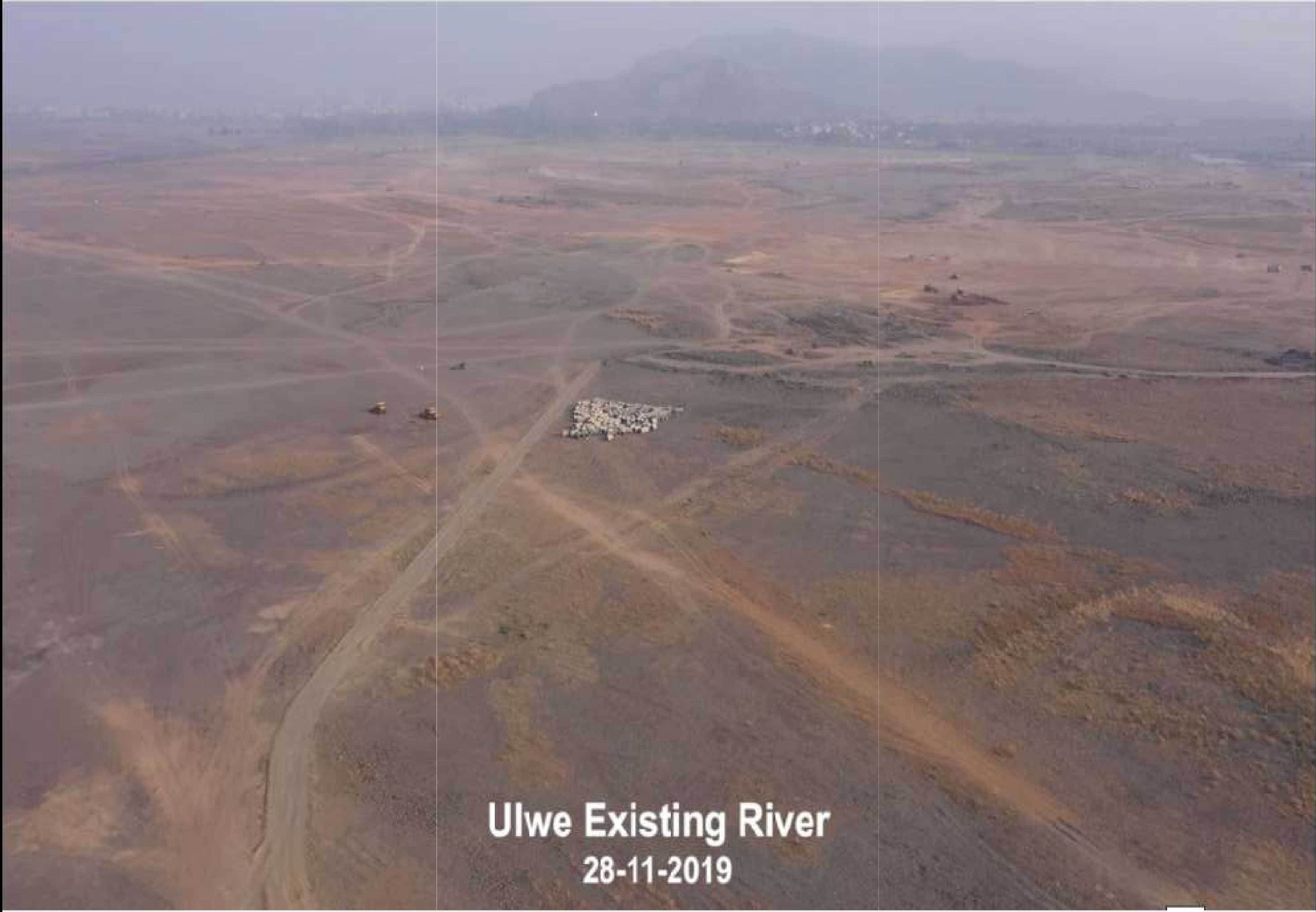

Package - III
27-06-2019
N
W
E
S


Ulwe Existing River
31-07-2019

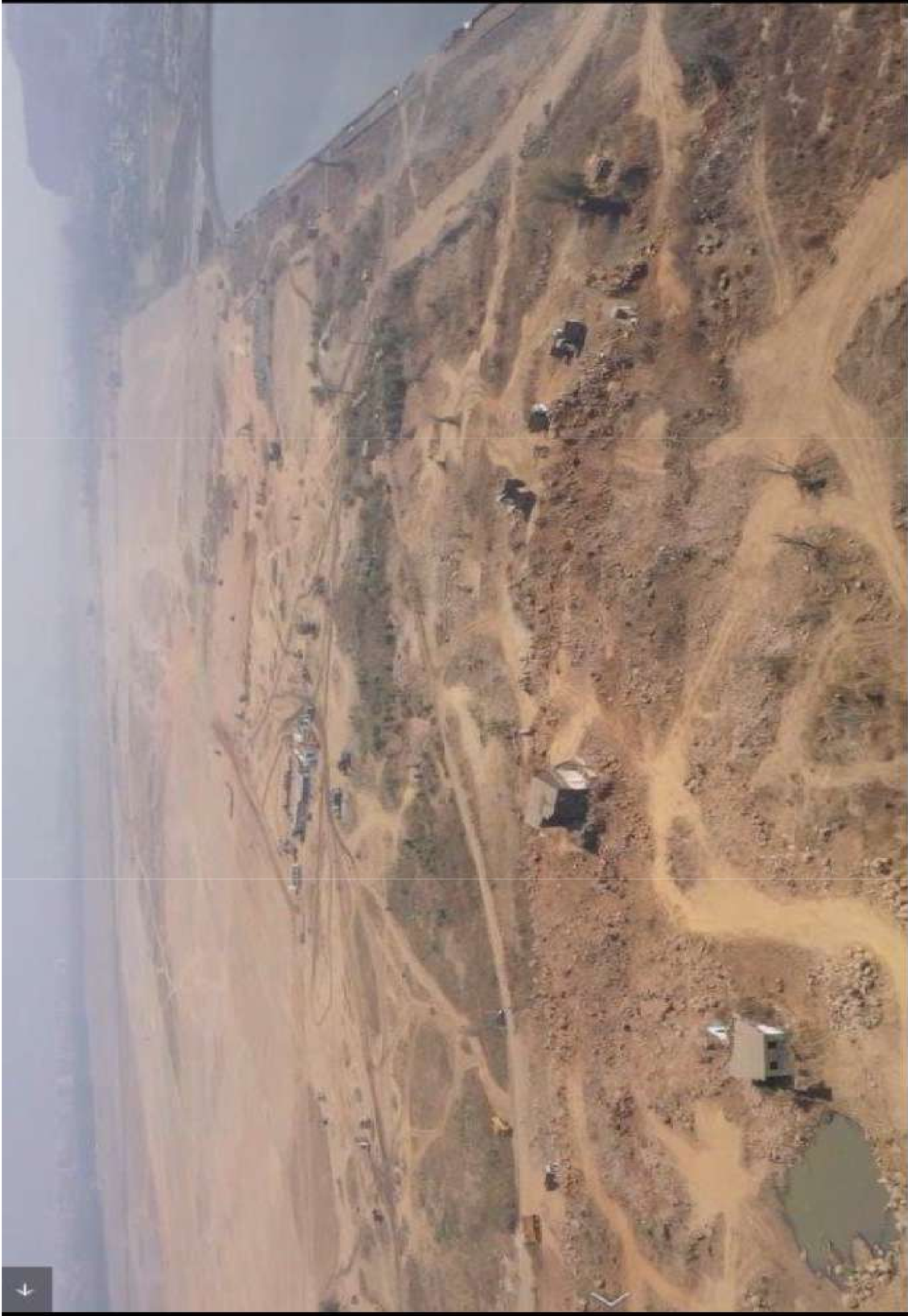

Package - III
27-08-2019
N
W
E
S


Ulwe Existing River
24-09-2019


Ulwe Existing River
30-10-2019


Ulwe Existing River
28-11-2019


NOVEMBER 2019



ANNEXURE-XVI
EXISTING INFRASTRUCTURE FACILITIES

ANNEXURE-XVI(1)
INFRASTRUCTURE
(Rural Educational Facilities)

Sr. No	Village Name	Govt Primary School (Numbers)	Private Primary School (Numbers)	Govt Middle School (Numbers)	Private Middle School (Numbers)	Govt Secondary School (Numbers)	Private Secondary School (Numbers)	Govt Senior Secondary School (Numbers)	Private Senior Secondary School (Numbers)	Govt Arts and Science Degree College (Numbers)	Private Arts and Science Degree College (Numbers)	Govt Engineering College (Numbers)	Private Engineering College (Numbers)	Govt Medicine College (Numbers)	Private Medicine College (Numbers)	Govt Management Institute (Numbers)	Private Management Institute (Numbers)	Govt Polytechnic (Numbers)	Private Polytechnic (Numbers)	Govt Vocational Training School/ITI (Numbers)	Private Vocational Training School/ITI (Numbers)	Government School For Disabled (Numbers)	Private School For Disabled (Numbers)
0-3 kms Panvel tehsil, Raighar district, Maharashtra																							
1	Vaghivali	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Pargaon Dungi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Kopar	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Karanjade	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Dapoli	2	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Pargaon	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Ulawe	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Targhar	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Wahal	4	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Kharkopar	3	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Sonkhar	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Padeghar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	Bambavi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	Kundevahal	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub Total	**26**	**1**	**11**	**1**	**4**	**1**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
3-7 kms Panvel tehsil, Raighar district, Maharashtra																							
15	Pale Bk.	3	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Harigram	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Koproli	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Chipale	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Bonshet	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	Nevali	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Adai	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Akurli	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Shilottar Raichur	5	0	3	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	Devad	3	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	Moho	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	Shivkar	3	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Vichumbe	4	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	Usarli Kh	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Chikhale	2	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	Nhave	2	1	2	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	Gavhan	6	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	Manghar	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Mosare	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Patnoli	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	Nanoshi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	Chirvat	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	Turmale	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	Vadavali	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	Nandgaon	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	Kudave	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	Palaspe	4	1	2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	Kolkhe	2	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	Kon	3	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	Derawali	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uran tehsil, Raighar district, Maharashtra																							
45	Chirle	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	Veshvi	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	Belondakhar	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	Paundkhar	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	Dhutum	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub Total	**78**	**5**	**31**	**4**	**9**	**3**	**7**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
7-10 kms Panvel tehsil, Raighar district, Maharashtra																							
50	Adivali	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	Ghot	3	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	Koyana Velhe	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	Taloje Majkur	2	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	Pisarve	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	Rohinjan	3	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	Bid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	Owe	8	0	4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	Valap	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	Devichapada	4	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	Kanpoli	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	Chindharan	3	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	Hedutane	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	Kevale	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	Khanav	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	Chinchavali Tarf Waje	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	Umroli	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	Vakadi	2	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	Vihighar	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	Nere	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNEXURE-XVI(1)
INFRASTRUCTURE
(Rural Educational Facilities)

Sr. No	Village Name	Govt Primary School (Numbers)	Private Primary School (Numbers)	Govt Middle School (Numbers)	Private Middle School (Numbers)	Govt Secondary School (Numbers)	Private Secondary School (Numbers)	Govt Senior Secondary School (Numbers)	Private Senior Secondary School (Numbers)	Govt Arts and Science Degree College (Numbers)	Private Arts and Science Degree College (Numbers)	Govt Engineering College (Numbers)	Private Engineering College (Numbers)	Govt Medicine College (Numbers)	Private Medicine College (Numbers)	Govt Management Institute (Numbers)	Private Management Institute (Numbers)	Govt Polytechnic (Numbers)	Private Polytechnic (Numbers)	Govt Vocational Training School/ITI (Numbers)	Private Vocational Training School/ITI (Numbers)	Government School For Disabled (Numbers)	Private School For Disabled (Numbers)
70	Ambivali	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	Sangatoli	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	Wangani Tarf Waje	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	Loniwadi	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	Pali Kh	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	Bherle	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	Sangade	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	Belavali	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	Borle	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	Bhingar	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	Ajivali	2	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	Shedung	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	Ariwali	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	Ashte	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	Kasal Khand	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	Bhatan	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	Somtane	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	Giravale	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	Shirdhon	2	0	3	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	Sangurli	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	Chinchavan	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	Narpoli	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92	Dahivali	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uran tehsil, Raighar district, Maharashtra																							
93	Dighode	3	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	Kanthavali	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	Pohi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	Ransai	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	Vindhane	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	Taki	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99	Harishchandra Pimpale	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	Bori Bk.	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	Boricha Kotha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	Juna Sheva	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103	Sonari	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104	Sawarkhar	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105	Pagote	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	Karal	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub Total	**89**	**1**	**34**	**2**	**10**	**7**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Grand Total	**193**	**7**	**76**	**7**	**23**	**11**	**16**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Source: Census of India 2011.																							

ANNEXURE-XVI
INFRACTURE DETAILS
(Rural Health Facilities)

Sr. No	Village Name	Community Health Centre (Numbers)	Community Health Centre Doctors Total Strength (Numbers)	Primary Health Centre (Numbers)	Primary Health Centre Doctors Total Strength (Numbers)	Primary Heallth Sub Centre (Numbers)	Primary Heallth Sub Centre Doctors Total Strength (Numbers)	Maternity And Child Welfare Centre (Numbers)	Maternity And Child Welfare Centre Doctors Total Strength	Maternity And Child Welfare Centre Para Medical Staff Total Strength	Maternity And Child Welfare Centre Para Medical Staff In Position	TB Clinic (Numbers)	TB Clinic Doctors Total Strength (Numbers)	Hospital Allopathic (Numbers)	Hospital Allopathic Doctors Total Strength (Numbers)	Dispensary (Numbers)	Dispensary Doctors Total Strength (Numbers)	Veterinary Hospital (Numbers)	Veterinary Hospital Doctors Total Strength (Numbers)	Mobile Health Clinic (Numbers)	Mobile Health Clinic Doctors Total Strength (Numbers)	Family Welfare Centre (Numbers)	Family Welfare Centre Doctors Total Strength (Numbers)
il, Raighar district, Maharashtra																							
1	Vaghivali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Pargaon Dungi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Kopar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Karanjade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Dapoli	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Pargaon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
7	Ulawe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Targhar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Wahal	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Kharkopar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Sonkhar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Padeghar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	Bambavi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	Kundevahal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub Total	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**
il, Raighar district, Maharashtra																							
15	Pale Bk.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Harigram	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Koproli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Chipale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Bonshet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	Nevali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Adai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Akurli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Shilottar Raichur	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	Devad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	Moho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	Shivkar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Vichumbe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	Usarli Kh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Chikhale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	Nhave	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	Gavhan	0	0	1	2	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
32	Manghar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Mosare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Patnoli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	Nanoshi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	Chirvat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	Turmale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	Vadavali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	Nandgaon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	Kudave	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	Palaspe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	Kolkhe	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	Kon	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	Derawali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
aighar district, Maharashtra																							
45	Chirle	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNEXURE-XVI
INFRACTURE DETAILS
(Rural Health Facilities)

Sr. No	Village Name	Community Health Centre (Numbers)	Community Health Centre Doctors Total Strength (Numbers)	Primary Health Centre (Numbers)	Primary Health Centre Doctors Total Strength (Numbers)	Primary Heallth Sub Centre (Numbers)	Primary Heallth Sub Centre Doctors Total Strength (Numbers)	Maternity And Child Welfare Centre (Numbers)	Maternity And Child Welfare Centre Doctors Total Strength	Maternity And Child Welfare Centre Para Medical Staff Total Strength	Maternity And Child Welfare Centre Para Medical Staff In Position	TB Clinic (Numbers)	TB Clinic Doctors Total Strength (Numbers)	Hospital Allopathic (Numbers)	Hospital Allopathic Doctors Total Strength (Numbers)	Dispensary (Numbers)	Dispensary Doctors Total Strength (Numbers)	Veterinary Hospital (Numbers)	Veterinary Hospital Doctors Total Strength (Numbers)	Mobile Health Clinic (Numbers)	Mobile Health Clinic Doctors Total Strength (Numbers)	Family Welfare Centre (Numbers)	Family Welfare Centre Doctors Total Strength (Numbers)
46	Veshvi	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	Belondakhar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	Paundkhar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	Dhutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub Total	**0**	**0**	**1**	**2**	**8**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**
sil, Raighar district, Maharashtra																							
50	Adivali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	Ghot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
52	Koyana Velhe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	Taloje Majkur	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	Pisarve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	Rohinjan	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	Bid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	Owe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	Valap	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	Devichapada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	Kanpoli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	Chindharan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	Hedutane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	Kevale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	Khanav	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	Chinchavali Tarf Waje	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	Umroli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	Vakadi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	Vihighar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	Nere	0	0	1	2	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
70	Ambivali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	Sangatoli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	Wangani Tarf Waje	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	Loniwadi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	Pali Kh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	Bherle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	Sangade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	Belavali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	Borle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	Bhingar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	Ajivali	0	0	1	2	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
81	Shedung	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	Ariwali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	Ashte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	Kasal Khand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	Bhatan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	Somtane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	Giravale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	Shirdhon	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	Sangurli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	Chinchavan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	Narpoli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92	Dahivali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNEXURE-XVI
INFRACTURE DETAILS
(Rural Health Facilities)

Sr. No	Village Name	Community Health Centre (Numbers)	Community Health Centre Doctors Total Strength (Numbers)	Primary Health Centre (Numbers)	Primary Health Centre Doctors Total Strength (Numbers)	Primary Heallth Sub Centre (Numbers)	Primary Heallth Sub Centre Doctors Total Strength (Numbers)	Maternity And Child Welfare Centre (Numbers)	Maternity And Child Welfare Centre Doctors Total Strength	Maternity And Child Welfare Centre Para Medical Staff Total Strength	Maternity And Child Welfare Centre Para Medical Staff In Position	TB Clinic (Numbers)	TB Clinic Doctors Total Strength (Numbers)	Hospital Allopathic (Numbers)	Hospital Allopathic Doctors Total Strength (Numbers)	Dispensary (Numbers)	Dispensary Doctors Total Strength (Numbers)	Veterinary Hospital (Numbers)	Veterinary Hospital Doctors Total Strength (Numbers)	Mobile Health Clinic (Numbers)	Mobile Health Clinic Doctors Total Strength (Numbers)	Family Welfare Centre (Numbers)	Family Welfare Centre Doctors Total Strength (Numbers)
aighar district, Maharashtra																							
93	Dighode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	Kanthavali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	Pohi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	Ransai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	Vindhane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	Taki	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99	Harishchandra Pimpale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	Bori Bk.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	Boricha Kotha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	Juna Sheva	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103	Sonari	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104	Sawarkhar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105	Pagote	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	Karal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub Total	**0**	**0**	**2**	**4**	**6**	**0**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**0**	**0**	**1**	**1**	**2**	**2**
	Grand Total	**0**	**0**	**3**	**6**	**16**	**0**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**1**	**1**	**3**	**3**
ensus of India 2011.																							

ANNEXURE-XVI(3)
INFRASTRUCTURE
(Drinking Water Facilities)

Sr. No	Village Name	Tap Water-Treated (Status A(1)/NA(0)	Tap Water Untreated (Status A(1)/NA(0)	Covered Well (Status A(1)/NA(0)	Uncovered Well (Status A(1)/NA(0)	Hand Pump (Status A(1)/NA(0)	Tube Wells/Borehole (Status A(1)/NA(0)	Spring (Status A(1)/NA(0)	River/Canal (Status A(1)/NA(0)	Tank/Pond/Lake (Status A(1)/NA(0)	Others (Status A(1)/NA(0)
0-3 kms Panvel tehsil, Raighar district, Maharashtra											
1	Vaghivali	1	0	0	1	1	0	0	0	1	0
2	Pargaon Dungi	1	0	0	1	1	0	0	1	0	0
3	Kopar	1	0	1	1	0	0	0	0	1	0
4	Karanjade	1	0	1	1	1	0	0	1	1	0
5	Dapoli	1	0	0	1	1	0	0	0	1	0
6	Pargaon	1	0	0	1	1	0	0	1	1	0
7	Ulawe	1	0	0	1	0	0	0	0	1	0
8	Targhar	1	0	1	1	1	0	0	0	1	0
9	Wahal	1	0	1	1	1	1	0	0	0	0
10	Kharkopar	0	0	0	1	1	0	0	0	0	0
11	Sonkhar	0	0	0	0	0	0	0	0	0	0
12	Padeghar	0	0	0	1	0	0	0	0	0	0
13	Bambavi	1	0	0	1	1	0	0	0	0	0
14	Kundevahal	1	0	0	1	1	0	0	0	1	0
	Sub Total	**11**	**0**	**4**	**13**	**10**	**1**	**0**	**3**	**8**	**0**
3-7 kms Panvel tehsil, Raighar district, Maharashtra											
15	Pale Bk.	1	0	0	1	1	1	0	1	0	0
16	Harigram	0	1	0	1	1	1	0	0	0	0
17	Koproli	1	0	0	1	1	1	1	1	1	0
18	Chipale	0	1	0	1	1	1	0	1	0	0
19	Bonshet	0	1	1	1	1	1	0	0	0	0
20	Nevali	1	1	1	1	0	1	0	0	1	0
21	Adai	0	1	0	1	1	1	0	0	1	0
22	Akurli	0	1	0	1	1	1	0	1	0	0
23	Shilottar Raichur	1	0	0	1	1	1	0	1	0	0
24	Devad	1	0	1	1	1	1	0	1	0	0
25	Moho	0	1	0	1	1	1	0	0	1	0
26	Shivkar	0	1	1	1	0	1	1	0	1	0
27	Vichumbe	1	1	1	1	1	1	0	1	0	0
28	Usarli Kh	0	0	1	1	1	1	0	1	0	0
29	Chikhale	1	0	0	1	0	1	0	1	1	0
30	Nhave	1	0	0	1	1	0	0	0	1	0
31	Gavhan	1	0	0	1	1	0	0	0	1	0
32	Manghar	1	0	0	1	0	0	0	0	1	0
33	Mosare	1	0	0	1	1	0	0	0	1	0
34	Patnoli	1	0	0	1	1	0	0	0	0	0
35	Nanoshi	1	0	0	1	1	0	0	0	1	0
36	Chirvat	0	1	0	1	0	1	0	1	1	0
37	Turmale	0	1	0	1	0	1	0	1	0	0
38	Vadavali	1	0	0	0	0	0	0	0	0	0
39	Nandgaon	1	0	0	1	1	0	0	1	1	0
40	Kudave	1	0	0	1	0	1	0	1	0	0
41	Palaspe	1	0	0	1	1	1	0	1	1	0
42	Kolkhe	1	0	0	1	1	1	0	1	0	0
43	Kon	1	0	0	1	0	1	0	0	1	0
44	Derawali	0	1	0	1	0	1	0	0	0	0
Uran tehsil, Raighar district, Maharashtra											
45	Chirle	0	1	0	1	1	1	0	0	1	0
46	Veshvi	0	1	0	1	0	0	0	0	0	0
47	Belondakhar	0	1	0	1	0	0	0	0	0	0
48	Paundkhar	1	0	0	1	0	0	0	0	0	0
49	Dhutum	1	0	0	1	0	0	0	0	1	0
	Sub Total	**21**	**15**	**6**	**34**	**21**	**23**	**2**	**15**	**17**	**0**
7-10 kms Panvel tehsil, Raighar district, Maharashtra											
50	Adivali	0	0	1	1	0	1	0	0	1	0
51	Ghot	1	0	0	1	1	1	0	1	1	0
52	Koyana Velhe	1	0	0	1	0	1	0	1	0	0
53	Taloje Majkur	0	0	0	1	0	0	0	1	0	0
54	Pisarve	0	1	0	1	0	1	0	0	1	0
55	Rohinjan	1	0	0	1	1	0	0	0	0	0
56	Bid	1	0	0	0	0	0	0	0	0	0
57	Owe	1	0	0	1	1	0	0	0	0	0
58	Valap	1	0	0	1	1	1	0	0	0	0
59	Devichapada	1	0	0	1	1	1	0	1	0	0
60	Kanpoli	0	0	1	1	1	0	0	1	0	0
61	Chindharan	1	0	0	1	1	1	0	1	1	0
62	Hedutane	0	0	0	1	1	0	0	0	0	0
63	Kevale	0	1	0	1	1	1	1	1	1	0
64	Khanav	0	0	0	1	1	1	0	1	0	0
65	Chinchavali Tarf W	0	1	1	1	0	1	0	0	0	0
66	Umroli	0	0	0	1	0	1	0	1	0	0
67	Vakadi	1	1	0	1	1	0	0	1	0	0

ANNEXURE-XVI(3)
INFRASTRUCTURE
(Drinking Water Facilities)

Sr. No	Village Name	Tap Water-Treated (Status A(1)/NA(0)	Tap Water Untreated (Status A(1)/NA(0)	Covered Well (Status A(1)/NA(0)	Uncovered Well (Status A(1)/NA(0))	Hand Pump (Status A(1)/NA(0)	Tube Wells/Borehole (Status A(1)/NA(0)	Spring (Status A(1)/NA(0)	River/Canal (Status A(1)/NA(0)	Tank/Pond/Lake (Status A(1)/NA(0)	Others (Status A(1)/NA(0)
68	Vihighar	0	0	1	1	1	1	0	0	0	0
69	Nere	1	0	1	1	1	1	0	1	0	0
70	Ambivali	1	1	1	1	1	1	0	0	0	0
71	Sangatoli	0	0	0	1	0	0	0	0	0	0
72	Wangani Tarf Waje	0	1	0	1	1	1	0	0	1	0
73	Loniwadi	0	0	0	1	1	1	1	0	0	0
74	Pali Kh	0	1	0	1	1	1	0	0	0	0
75	Bherle	1	0	0	1	0	0	0	0	0	0
76	Sangade	1	0	0	1	0	1	1	1	1	0
77	Belavali	0	0	0	1	0	1	0	1	0	0
78	Borle	1	0	0	1	0	1	0	1	1	0
79	Bhingar	1	0	0	1	0	1	0	0	0	0
80	Ajivali	1	0	0	1	0	1	0	0	0	0
81	Shedung	1	0	0	0	0	0	0	0	1	0
82	Ariwali	0	0	0	1	1	0	0	0	0	0
83	Ashte	0	0	0	1	0	1	0	0	0	0
84	Kasal Khand	0	0	0	1	0	1	0	0	0	0
85	Bhatan	0	0	0	1	1	1	0	0	0	0
86	Somtane	1	0	0	1	0	0	0	0	0	0
87	Giravale	1	0	0	1	0	0	0	0	0	0
88	Shirdhon	1	0	1	1	1	0	0	0	1	0
89	Sangurli	1	0	0	1	0	0	0	0	0	0
90	Chinchavan	1	0	0	1	1	0	0	0	0	0
91	Narpoli	0	0	0	1	0	1	0	0	0	0
92	Dahivali	1	0	0	0	0	0	0	0	0	0
Uran tehsil, Raighar district, Maharashtra											
93	Dighode	0	1	0	1	0	0	0	0	0	0
94	Kanthavali	1	0	0	1	0	0	0	1	0	0
95	Pohi	0	0	0	0	0	0	0	0	0	0
96	Ransai	0	0	0	1	0	0	0	0	0	0
97	Vindhane	1	1	0	1	0	1	1	1	1	0
98	Taki	0	1	0	1	0	0	1	0	0	0
99	Harishchandra Pim	1	0	0	1	0	0	0	0	0	0
100	Bori Bk.	1	0	0	1	0	0	0	0	1	0
101	Boricha Kotha	0	0	0	1	0	0	0	0	0	0
102	Juna Sheva	0	0	0	0	0	0	0	0	0	0
103	Sonari	1	0	0	1	0	0	0	0	0	0
104	Sawarkhar	1	0	0	1	0	0	0	0	0	0
105	Pagote	1	0	0	1	0	0	0	0	0	0
106	Karal	1	0	0	1	0	0	0	0	0	0
	Sub Total	**31**	**10**	**7**	**52**	**21**	**27**	**5**	**16**	**12**	**0**
	Grand Total	**63**	**25**	**17**	**99**	**52**	**51**	**7**	**34**	**37**	**0**
Source: Census of India 2011.											
***Note: 1= Available, 0= Not Available.**											

ANNEXURE-XVI(4)
INFRASTRUCTRE DETAILS
(Rural Communication Facilities)

Sr. No	Village Name	Post Office (Status A(1)/NA(0)	Sub Post Office (Status A(1)/NA(0)	Post And Telegraph Office (Status A(1)/NA(0)	Mobile Phone Coverage (Status A(1)/NA(0)	Private Courier Facility (Status A(1)/NA(0)	Public Bus Service (Status A(1)/NA(0)	Private Bus Service (Status A(1)/NA(0)	Railway Station (Status A(1)/NA(0)	Auto/Modified Autos (Status A(1)/NA(0)	Taxi (Status A(1)/NA(0)	Vans (Status A(1)/NA(0)	Tractors (Status A(1)/NA(0)
0-3 kms Panvel tehsil, Raighar district, Maharashtra													
1	Vaghivali	0	0	0	1	0	1	0	0	0	0	0	0
2	Pargaon Dungi	0	0	0	0	0	0	0	0	0	0	0	0
3	Kopar	0	0	0	1	0	1	0	0	0	0	0	0
4	Karanjade	1	0	1	1	0	1	0	0	1	1	1	0
5	Dapoli	0	1	0	1	0	1	0	0	1	1	1	0
6	Pargaon	1	0	1	1	0	1	0	0	1	1	1	0
7	Ulawe	0	1	0	1	0	1	0	0	1	1	1	0
8	Targhar	1	0	1	1	0	1	0	0	1	1	1	0
9	Wahal	1	0	1	1	1	1	0	1	1	1	1	0
10	Kharkopar	0	0	0	1	0	1	0	0	1	1	1	0
11	Sonkhar	0	0	0	0	0	0	0	0	0	0	0	0
12	Padeghar	0	0	0	0	0	0	0	0	0	0	0	0
13	Bambavi	0	0	0	1	0	1	0	0	0	0	0	0
14	Kundevahal	0	1	0	1	0	1	0	0	0	0	0	0
	Sub Total	**4**	**3**	**4**	**11**	**1**	**11**	**0**	**1**	**7**	**7**	**7**	**0**
3-7 kms Panvel tehsil, Raighar district, Maharashtra													
15	Pale Bk.	0	1	0	1	0	1	0	0	1	1	1	0
16	Harigram	0	1	0	1	0	1	0	0	0	0	0	0
17	Koproli	0	0	0	1	0	1	0	0	0	0	0	0
18	Chipale	0	0	0	1	0	1	0	0	0	0	0	0
19	Bonshet	0	0	0	1	0	1	0	0	0	0	0	0
20	Nevali	0	0	0	1	0	1	0	0	0	0	0	0
21	Adai	1	0	1	1	0	1	0	0	1	1	1	0
22	Akurli	1	0	1	1	0	1	0	0	1	1	1	0
23	Shilottar Raichur	1	0	1	1	1	1	0	0	1	1	1	0
24	Devad	1	0	1	1	0	1	0	0	1	1	1	0
25	Moho	0	0	0	1	0	1	0	0	0	0	0	0
26	Shivkar	0	0	0	1	0	1	0	0	1	1	1	0
27	Vichumbe	1	0	1	1	1	1	0	0	1	1	1	0
28	Usarli Kh	0	0	0	1	0	1	0	1	1	1	1	0
29	Chikhale	0	1	0	1	0	1	0	0	0	0	0	0
30	Nhave	1	0	1	1	0	1	0	0	1	1	1	0
31	Gavhan	1	0	1	1	1	1	0	0	1	1	1	0
32	Manghar	0	0	0	1	0	0	0	0	0	0	0	0
33	Mosare	0	0	0	1	0	1	0	0	0	0	0	0
34	Patnoli	0	0	0	0	0	0	0	0	0	0	0	0
35	Nanoshi	0	0	0	1	0	1	0	0	0	0	0	0
36	Chirvat	0	0	0	1	0	0	0	0	0	0	0	0
37	Turmale	0	0	0	1	0	1	0	0	0	0	0	0
38	Vadavali	0	0	0	1	0	0	0	0	0	0	0	0
39	Nandgaon	0	0	0	1	0	1	0	0	1	1	1	0
40	Kudave	0	0	0	1	0	1	0	0	0	0	0	0
41	Palaspe	1	0	1	1	1	1	0	0	1	1	1	0
42	Kolkhe	1	0	1	1	0	1	0	0	1	1	1	0
43	Kon	0	0	0	1	0	1	0	0	1	1	1	0
44	Derawali	0	0	0	1	0	1	0	0	0	0	0	0
Uran tehsil, Raighar district, Maharashtra													
45	Chirle	1	0	1	1	0	1	0	0	1	1	1	0
46	Veshvi	0	0	0	1	0	1	0	0	0	0	0	0
47	Belondakhar	0	0	0	1	0	1	0	0	0	0	0	0
48	Paundkhar	0	0	0	1	0	1	0	0	0	0	0	0
49	Dhutum	0	0	0	1	0	1	0	0	1	1	1	0
	Sub Total	**10**	**3**	**10**	**34**	**4**	**31**	**0**	**1**	**16**	**16**	**16**	**0**
7-10 kms Panvel tehsil, Raighar district, Maharashtra													
50	Adivali	0	0	0	1	0	1	0	0	0	0	0	0
51	Ghot	1	0	1	1	0	1	0	0	1	1	1	0
52	Koyana Velhe	0	1	0	1	0	1	0	0	0	0	0	0
53	Taloje Majkur	0	0	0	1	0	1	0	0	1	1	1	0
54	Pisarve	0	0	0	1	0	1	0	0	0	0	0	0
55	Rohinjan	1	0	1	1	0	1	0	0	1	1	1	0
56	Bid	0	0	0	1	0	0	0	0	0	0	0	0
57	Owe	1	0	1	1	1	1	0	0	1	1	1	0
58	Valap	0	0	0	1	0	1	0	0	1	1	1	0
59	Devichapada	1	0	1	1	1	1	0	0	1	1	1	0
60	Kanpoli	0	0	0	1	0	1	0	0	0	0	0	0
61	Chindharan	0	0	0	1	0	1	0	0	1	1	1	0
62	Hedutane	0	0	0	1	0	1	0	0	0	0	0	0
63	Kevale	0	0	0	1	0	1	0	0	0	0	0	0
64	Khanav	0	0	0	1	0	1	0	0	0	0	0	0
65	Chinchavali Tarf W	0	0	0	1	0	1	0	0	0	0	0	0
66	Umroli	0	0	0	1	0	1	0	0	0	0	0	0
67	Vakadi	0	0	0	1	0	1	0	0	0	0	0	0
68	Vihighar	0	0	0	1	0	1	0	0	0	0	0	0
69	Nere	1	0	1	1	0	1	0	0	1	1	1	0
70	Ambivali	0	0	0	1	0	0	0	0	0	0	0	0
71	Sangatoli	0	0	0	1	0	0	0	0	0	0	0	0
72	Wangani Tarf Waje	0	0	0	1	0	1	0	0	0	0	0	0

ANNEXURE-XVI(4)
INFRASTRUCTRE DETAILS
(Rural Communication Facilities)

Sr. No	Village Name	Post Office (Status A(1)/NA(0)	Sub Post Office (Status A(1)/NA(0)	Post And Telegraph Office (Status A(1)/NA(0)	Mobile Phone Coverage (Status A(1)/NA(0)	Private Courier Facility (Status A(1)/NA(0)	Public Bus Service (Status A(1)/NA(0))	Private Bus Service (Status A(1)/NA(0)	Railway Station (Status A(1)/NA(0)	Auto/Modified Autos (Status A(1)/NA(0)	Taxi (Status A(1)/NA(0)	Vans (Status A(1)/NA(0)	Tractors (Status A(1)/NA(0)
73	Loniwadi	0	0	0	1	0	1	0	0	0	0	0	0
74	Pali Kh	0	0	0	1	0	1	0	0	0	0	0	0
75	Bherle	0	0	0	1	0	1	0	0	0	0	0	0
76	Sangade	0	0	0	1	0	1	0	0	0	0	0	0
77	Belavali	0	0	0	1	0	1	0	0	0	0	0	0
78	Borle	0	0	0	1	0	1	0	0	0	0	0	0
79	Bhingar	0	0	0	1	0	1	0	0	0	0	0	0
80	Ajivali	0	1	0	1	0	1	0	0	0	0	0	0
81	Shedung	0	0	0	1	0	1	0	0	0	0	0	0
82	Ariwali	0	0	0	1	0	1	0	0	0	0	0	0
83	Ashte	0	0	0	0	0	0	0	0	0	0	0	0
84	Kasal Khand	0	0	0	1	0	1	0	0	0	0	0	0
85	Bhatan	0	0	0	1	0	1	0	0	0	0	0	0
86	Somtane	0	1	0	1	0	1	0	1	0	0	0	0
87	Giravale	0	0	0	1	0	1	0	0	0	0	0	0
88	Shirdhon	1	0	1	1	0	1	0	0	1	1	1	0
89	Sangurli	0	0	0	1	0	1	0	0	0	0	0	0
90	Chinchavan	0	0	0	1	0	1	0	0	0	0	0	0
91	Narpoli	0	0	0	1	0	1	0	0	0	0	0	0
92	Dahivali	0	0	0	1	0	0	0	0	0	0	0	0
Uran tehsil, Raighar district, Maharashtra													
93	Dighode	0	1	0	1	0	1	0	0	1	1	1	0
94	Kanthavali	0	0	0	0	0	0	0	0	0	0	0	0
95	Pohi	0	0	0	0	0	0	0	0	0	0	0	0
96	Ransai	0	0	0	1	0	1	0	0	0	0	0	0
97	Vindhane	0	0	0	1	0	1	0	0	1	1	1	0
98	Taki	0	0	0	1	0	1	0	0	0	0	0	0
99	Harishchandra Pim	0	0	0	1	0	1	0	0	0	0	0	0
100	Bori Bk.	0	0	0	1	0	1	0	0	0	0	0	0
101	Boricha Kotha	0	0	0	0	0	0	0	0	0	0	0	0
102	Juna Sheva	0	0	0	0	0	0	0	0	0	0	0	0
103	Sonari	0	0	0	1	0	1	0	0	1	1	1	0
104	Sawarkhar	0	0	0	1	0	1	0	0	0	0	0	0
105	Pagote	0	1	0	1	0	1	0	0	0	0	0	0
106	Karal	0	0	0	1	0	1	0	0	0	0	0	0
	Sub Total	**6**	**5**	**6**	**52**	**2**	**48**	**0**	**1**	**12**	**12**	**12**	**0**
	Grand Total	**20**	**11**	**20**	**97**	**7**	**90**	**0**	**3**	**35**	**35**	**35**	**0**
Source: Census of India 2011.													
***Note: 1= Available, 0= Not Available.**													

ANNEXURE-XVI(5)
INFRASTRUCTURE DETAILS
(Rural Electrification Facilities)

Sr. No	Village Name	Power Supply For Domestic Use (Status A(1)/NA(0)	Power Supply For Agriculture Use (Status A(1)/NA(0)	Power Supply For Commercial Use (Status A(1)/NA(0)	Power Supply For All Users (Status A(1)/NA(0)
, Raighar district, Maharashtra					
1	Vaghivali	1	1	0	0
2	Pargaon Dungi	1	1	0	0
3	Kopar	1	1	1	1
4	Karanjade	1	1	1	1
5	Dapoli	1	1	1	1
6	Pargaon	1	1	1	1
7	Ulawe	1	1	1	1
8	Targhar	1	1	1	1
9	Wahal	1	1	1	1
10	Kharkopar	1	1	1	1
11	Sonkhar	0	0	0	0
12	Padeghar	0	0	0	0
13	Bambavi	1	1	0	0
14	Kundevahal	1	1	1	1
	Sub Total	**12**	**12**	**9**	**9**
, Raighar district, Maharashtra					
15	Pale Bk.	1	1	1	1
16	Harigram	1	1	1	1
17	Koproli	1	1	1	1
18	Chipale	1	1	1	1
19	Bonshet	1	1	0	0
20	Nevali	1	1	1	1
21	Adai	1	1	1	1
22	Akurli	1	1	1	1
23	Shilottar Raichur	1	1	1	1
24	Devad	1	1	1	1
25	Moho	1	1	1	1
26	Shivkar	1	1	1	1
27	Vichumbe	1	1	1	1
28	Usarli Kh	1	1	1	1
29	Chikhale	1	1	1	1
30	Nhave	1	1	1	1
31	Gavhan	1	1	1	1
32	Manghar	1	1	0	0
33	Mosare	1	1	0	0
34	Patnoli	1	1	0	0
35	Nanoshi	1	1	0	0
36	Chirvat	1	1	0	0
37	Turmale	1	1	1	1
38	Vadavali	1	1	0	0
39	Nandgaon	1	1	1	1
40	Kudave	1	1	1	1
41	Palaspe	1	1	1	1
42	Kolkhe	1	1	1	1
43	Kon	1	1	1	1

ANNEXURE-XVI(5)
INFRASTRUCTURE DETAILS
(Rural Electrification Facilities)

Sr. No	Village Name	Power Supply For Domestic Use (Status A(1)/NA(0)	Power Supply For Agriculture Use (Status A(1)/NA(0)	Power Supply For Commercial Use (Status A(1)/NA(0)	Power Supply For All Users (Status A(1)/NA(0)
44	Derawali	1	1	1	1
ghar district, Maharashtra					
45	Chirle	1	1	1	1
46	Veshvi	1	1	1	1
47	Belondakhar	1	1	1	1
48	Paundkhar	1	1	1	1
49	Dhutum	1	1	1	1
	Sub Total	**35**	**35**	**28**	**28**
l, Raighar district, Maharashtra					
50	Adivali	1	1	1	1
51	Ghot	1	1	1	1
52	Koyana Velhe	1	1	1	1
53	Taloje Majkur	1	1	1	1
54	Pisarve	1	1	1	1
55	Rohinjan	1	1	1	1
56	Bid	1	1	0	0
57	Owe	1	1	1	1
58	Valap	1	1	1	1
59	Devichapada	1	1	1	1
60	Kanpoli	1	1	1	1
61	Chindharan	1	1	1	1
62	Hedutane	1	1	1	1
63	Kevale	1	1	1	1
64	Khanav	1	1	1	1
65	Chinchavali Tarf Wa	1	1	0	0
66	Umroli	1	1	1	1
67	Vakadi	1	1	1	1
68	Vihighar	1	1	1	1
69	Nere	1	1	1	1
70	Ambivali	1	1	0	0
71	Sangatoli	1	1	0	0
72	Wangani Tarf Waje	1	1	0	0
73	Loniwadi	1	1	1	1
74	Pali Kh	1	1	0	0
75	Bherle	1	1	1	1
76	Sangade	1	1	1	1
77	Belavali	1	1	1	1
78	Borle	1	1	1	1
79	Bhingar	1	1	1	1
80	Ajivali	1	1	1	1
81	Shedung	1	1	0	0
82	Ariwali	1	1	1	1
83	Ashte	1	1	0	0
84	Kasal Khand	1	1	1	1
85	Bhatan	1	1	1	1
86	Somtane	1	1	1	1

ANNEXURE-XVI(5)
INFRASTRUCTURE DETAILS
(Rural Electrification Facilities)

Sr. No	Village Name	Power Supply For Domestic Use (Status A(1)/NA(0)	Power Supply For Agriculture Use (Status A(1)/NA(0)	Power Supply For Commercial Use (Status A(1)/NA(0)	Power Supply For All Users (Status A(1)/NA(0)
87	Giravale	1	1	1	1
88	Shirdhon	1	1	1	1
89	Sangurli	1	1	1	1
90	Chinchavan	1	1	1	1
91	Narpoli	1	1	1	1
92	Dahivali	1	1	0	0
ghar district, Maharashtra					
93	Dighode	1	1	1	1
94	Kanthavali	1	1	0	0
95	Pohi	1	1	0	0
96	Ransai	1	1	1	1
97	Vindhane	1	1	1	1
98	Taki	1	1	1	1
99	Harishchandra Pim	1	1	1	1
100	Bori Bk.	1	1	1	1
101	Boricha Kotha	0	0	0	0
102	Juna Sheva	1	1	0	0
103	Sonari	1	1	1	1
104	Sawarkhar	1	1	1	1
105	Pagote	1	1	1	1
106	Karal	1	1	1	1
	Sub Total	**56**	**56**	**44**	**44**
	Grand Total	**103**	**103**	**81**	**81**
nsus of India 2011.					
ilable, 0= Not Available.					

ANNEXURE-XVI(6)
INFRASTRUCTURE FACILITIES
(Road Network Facilities)

Sr. No	Village Name	Sea/River/Ferry Service (Status A(1)/NA(0)	National Highway (Status A(1)/NA(0)	State Highway (Status A(1)/NA(0)	Major District Road (Status A(1)/NA(0)	Other District Road (Status A(1)/NA(0)	Black Topped (pucca) Road (Status A(1)/NA(0)	Gravel (kuchha) Roads (Status A(1)/NA(0)	Water Bounded Macadam (Status A(1)/NA(0)	All Weather Road (Status A(1)/NA(0)	Navigable Waterways (River/Canal) (Status A(1)/NA(0)	Footpath (Status A(1)/NA (0)
0-3 kms Panvel tehsil, Raighar district, Maharashtra												
1	Vaghivali	0	0	0	0	0	1	1	0	1	0	1
2	Pargaon Dungi	0	0	0	0	0	1	0	0	1	0	1
3	Kopar	0	0	1	1	1	1	1	1	1	0	1
4	Karanjade	0	1	0	1	1	1	0	0	1	0	1
5	Dapoli	0	1	1	1	1	1	0	0	1	0	1
6	Pargaon	0	0	0	0	1	1	1	0	1	0	1
7	Ulawe	0	1	1	1	1	1	0	1	1	0	1
8	Targhar	0	1	1	1	1	1	0	0	1	0	1
9	Wahal	0	1	1	1	1	1	0	0	1	0	1
10	Kharkopar	0	0	0	0	1	0	0	1	1	0	1
11	Sonkhar	0	0	0	0	0	0	0	0	0	0	0
12	Padeghar	0	0	0	0	0	0	1	0	0	0	1
13	Bambavi	0	1	0	0	1	1	0	0	1	0	1
14	Kundevahal	0	1	1	1	1	1	1	1	1	0	1
	Sub Total	**0**	**7**	**6**	**7**	**10**	**11**	**5**	**4**	**12**	**0**	**13**
3-7 kms Panvel tehsil, Raighar district, Maharashtra												
15	Pale Bk.	0	0	0	0	1	1	0	0	1	0	1
16	Harigram	0	0	0	0	0	1	1	1	1	0	1
17	Koproli	0	0	0	0	1	1	0	0	1	0	1
18	Chipale	0	0	0	0	0	1	1	1	1	0	1
19	Bonshet	0	0	0	0	0	1	1	1	1	0	1
20	Nevali	0	0	0	0	0	1	1	1	1	0	1
21	Adai	0	0	0	0	1	0	1	0	1	0	1
22	Akurli	0	0	0	0	1	0	1	0	1	0	1
23	Shilottar Raichur	0	0	0	1	1	1	0	0	1	0	1
24	Devad	0	0	0	1	0	1	0	0	1	0	1
25	Moho	0	0	0	0	1	1	0	0	1	0	1
26	Shivkar	0	0	0	0	0	1	0	0	1	0	1
27	Vichumbe	0	0	0	0	1	1	0	0	1	0	1
28	Usarli Kh	1	0	0	0	0	1	0	1	1	0	1
29	Chikhale	0	0	1	1	1	1	0	0	1	0	1
30	Nhave	0	1	1	1	1	1	1	1	1	0	1
31	Gavhan	0	1	1	1	1	1	1	1	1	0	1
32	Manghar	0	0	0	0	0	1	1	0	1	0	1
33	Mosare	0	0	0	0	1	1	1	1	1	0	1
34	Patnoli	0	0	0	0	0	1	1	0	1	0	1
35	Nanoshi	0	0	0	0	0	1	1	1	1	0	1
36	Chirvat	0	0	0	0	0	1	0	0	1	0	1
37	Turmale	0	0	0	0	0	1	0	0	1	0	1
38	Vadavali	0	0	0	0	1	1	0	0	1	0	1
39	Nandgaon	0	1	1	1	1	1	1	1	1	0	1
40	Kudave	0	0	0	0	0	1	0	0	1	0	1
41	Palaspe	0	1	1	1	0	1	0	1	1	0	1
42	Kolkhe	0	1	1	1	0	1	0	0	1	0	1
43	Kon	0	1	1	1	1	1	0	0	1	0	1
44	Derawali	0	0	0	0	0	1	0	0	1	0	1
Uran tehsil, Raighar district, Maharashtra												

ANNEXURE-XVI(6)
INFRASTRUCTURE FACILITIES
(Road Network Facilities)

Sr. No	Village Name	Sea/River/Ferry Service (Status A(1)/NA(0)	National Highway (Status A(1)/NA(0)	State Highway (Status A(1)/NA(0)	Major District Road (Status A(1)/NA(0)	Other District Road (Status A(1)/NA(0)	Black Topped (pucca) Road (Status A(1)/NA(0)	Gravel (kuchha) Roads (Status A(1)/NA(0)	Water Bounded Macadam (Status A(1)/NA(0)	All Weather Road (Status A(1)/NA(0)	Navigable Waterways (River/Canal) (Status A(1)/NA(0)	Footpath (Status A(1)/NA (0)
45	Chirle	0	1	1	1	1	1	0	0	1	0	1
46	Veshvi	0	0	0	0	1	1	0	0	1	0	1
47	Belondakhar	0	0	0	0	1	1	0	0	1	0	1
48	Paundkhar	0	0	1	1	1	1	1	1	1	0	1
49	Dhutum	0	0	1	1	1	1	1	1	1	0	1
	Sub Total	**1**	**7**	**10**	**12**	**19**	**33**	**15**	**13**	**35**	**0**	**35**
7-10 kms Panvel tehsil, Raighar district, Maharashtra												
50	Adivali	0	1	1	1	0	1	0	0	1	0	1
51	Ghot	0	0	1	1	1	1	0	0	1	0	1
52	Koyana Velhe	0	0	0	1	1	1	1	1	1	0	1
53	Taloje Majkur	0	0	0	0	0	1	0	0	1	0	1
54	Pisarve	0	1	0	0	0	1	0	0	1	0	1
55	Rohinjan	0	0	1	1	1	1	1	1	1	0	1
56	Bid	0	0	0	0	0	1	1	1	1	0	1
57	Owe	0	0	0	0	1	1	1	1	1	0	1
58	Valap	0	0	0	1	1	1	0	0	1	0	1
59	Devichapada	0	0	0	0	1	1	0	0	1	0	1
60	Kanpoli	0	0	0	1	1	1	0	0	1	0	1
61	Chindharan	0	0	0	0	0	1	0	0	1	0	1
62	Hedutane	0	0	0	0	0	0	1	0	1	0	1
63	Kevale	0	0	0	0	1	1	1	0	1	0	1
64	Khanav	0	0	0	0	1	1	1	1	1	0	1
65	Chinchavali Tarf W	0	0	0	0	1	1	1	1	1	0	1
66	Umroli	0	0	0	1	0	1	0	0	1	0	1
67	Vakadi	0	0	0	0	1	1	1	1	1	0	1
68	Vihighar	0	0	0	0	0	1	1	1	1	0	1
69	Nere	0	0	0	0	1	0	1	1	1	0	1
70	Ambivali	0	0	0	0	0	1	1	1	1	0	1
71	Sangatoli	0	0	0	0	0	1	1	1	1	0	1
72	Wangani Tarf Waje	0	0	0	0	0	1	0	0	1	0	1
73	Loniwadi	0	0	0	0	1	1	1	0	1	0	1
74	Pali Kh	0	0	0	0	0	1	0	0	1	0	1
75	Bherle	0	0	0	1	0	1	1	0	1	0	1
76	Sangade	0	0	1	1	1	1	0	0	1	0	1
77	Belavali	0	0	0	1	0	1	0	0	1	0	1
78	Borle	0	0	1	1	1	1	0	0	1	0	1
79	Bhingar	0	0	0	1	0	1	1	0	1	0	1
80	Ajivali	0	1	1	1	0	1	0	0	1	0	1
81	Shedung	0	1	0	1	0	1	0	0	1	0	1
82	Ariwali	0	0	0	1	0	1	1	0	1	0	1
83	Ashte	0	0	0	1	1	1	1	0	1	0	1
84	Kasal Khand	0	0	0	1	0	1	1	0	1	0	1
85	Bhatan	0	0	1	1	0	1	1	0	1	0	1
86	Somtane	0	0	0	0	0	1	0	0	1	0	1
87	Giravale	0	1	1	1	1	1	0	0	1	0	1
88	Shirdhon	0	1	1	1	1	1	0	0	1	0	1
89	Sangurli	0	1	1	1	1	1	0	0	1	0	1
90	Chinchavan	0	1	1	1	1	1	0	0	1	0	1

ANNEXURE-XVI(6)
INFRASTRUCTURE FACILITIES
(Road Network Facilities)

Sr. No	Village Name	Sea/River/Ferry Service (Status A(1)/NA(0)	National Highway (Status A(1)/NA(0)	State Highway (Status A(1)/NA(0)	Major District Road (Status A(1)/NA(0)	Other District Road (Status A(1)/NA(0)	Black Topped (pucca) Road (Status A(1)/NA(0)	Gravel (kuchha) Roads (Status A(1)/NA(0)	Water Bounded Macadam (Status A(1)/NA(0)	All Weather Road (Status A(1)/NA(0)	Navigable Waterways (River/Canal) (Status A(1)/NA(0)	Foothpath (Status A(1)/NA (0)
91	Narpoli	0	0	0	1	0	1	1	0	1	0	1
92	Dahivali	0	0	0	0	0	1	0	0	1	0	1
Uran tehsil, Raighar district, Maharashtra												
93	Dighode	0	0	0	0	1	1	0	0	1	0	1
94	Kanthavali	0	0	0	1	1	1	1	1	1	0	1
95	Pohi	0	0	0	0	1	1	0	0	1	0	1
96	Ransai	0	0	0	0	0	0	1	0	1	0	1
97	Vindhane	0	0	1	1	1	1	1	1	1	0	1
98	Taki	0	0	0	0	0	1	1	1	1	0	1
99	Harishchandra Pim	0	0	0	0	0	1	1	1	1	0	1
100	Bori Bk.	1	0	0	0	1	1	1	1	1	0	1
101	Boricha Kotha	0	0	0	0	0	0	1	0	0	0	1
102	Juna Sheva	0	0	0	0	1	1	0	0	1	0	1
103	Sonari	0	0	1	1	1	1	1	1	1	0	1
104	Sawarkhar	0	0	1	1	1	1	1	1	1	0	1
105	Pagote	0	0	0	0	0	1	1	1	1	0	1
106	Karal	0	0	1	1	1	1	1	1	1	0	1
	Sub Total	**1**	**8**	**15**	**28**	**29**	**53**	**32**	**20**	**56**	**0**	**57**
	Grand Total	**2**	**22**	**31**	**47**	**58**	**97**	**52**	**37**	**103**	**0**	**105**
Source: Census of India 2011.												
***Note: 1= Available, 0= Not Available.**												

ANNEXURE-XVI(7)
INFRASTRUCTURE DETAILS
(Drainage Facilities)

Sr. No	Village Name	Closed Drainage (Status A(1)/NA(0)	Open Drainage (Status A(1)/NA(0)	No Drainage (Status A(1)/NA(0)	Open Pucca Drainage Covered with Tiles Slabs (Status A(1)/NA(0)	Open Pucca Drainage Uncovered (Status A(1)/NA(0)	Open Kuccha Drainage (Status A(1)/NA(0)	Whether Drain water is discharged directly into water bodies or to sewar plant (For Water Bodies-1/Sewar Plants-0)	Is the Area Covered under Total Sanitation Campaign (TSC)? (Status A(1)/NA(0)
0-3 kms Panvel tehsil, Raighar district, Maharashtra									
1	Vaghivali	0	0	1	0	0	0	0	1
2	Pargaon Dungi	0	0	1	0	0	0	0	1
3	Kopar	0	1	0	0	1	0	1	1
4	Karanjade	0	1	0	1	0	0	1	1
5	Dapoli	0	1	0	0	1	0	1	1
6	Pargaon	0	1	0	1	0	0	1	1
7	Ulawe	0	1	0	0	1	0	1	1
8	Targhar	0	1	0	1	0	0	1	1
9	Wahal	0	1	0	1	0	0	1	1
10	Kharkopar	0	1	0	0	1	0	1	1
11	Sonkhar	0	0	0	0	0	0	0	0
12	Padeghar	0	0	1	0	0	0	0	1
13	Bambavi	0	0	1	0	0	0	0	1
14	Kundevahal	0	1	0	0	1	0	1	1
	Sub Total	**0**	**9**	**4**	**4**	**5**	**0**	**9**	**13**
3-7 kms Panvel tehsil, Raighar district, Maharashtra									
15	Pale Bk.	0	1	0	0	1	0	1	1
16	Harigram	0	1	0	0	1	0	1	1
17	Koproli	0	1	0	0	1	0	1	1
18	Chipale	0	1	0	0	1	0	1	1
19	Bonshet	0	1	0	0	0	1	1	1
20	Nevali	0	1	0	0	1	0	1	1
21	Adai	0	1	0	1	0	0	1	1
22	Akurli	0	1	0	1	0	0	1	1
23	Shilottar Raichur	0	1	0	1	0	0	1	1

ANNEXURE-XVI(7)
INFRASTRUCTURE DETAILS
(Drainage Facilities)

Sr. No	Village Name	Closed Drainage (Status A(1)/NA(0)	Open Drainage (Status A(1)/NA(0)	No Drainage (Status A(1)/NA(0)	Open Pucca Drainage Covered with Tiles Slabs (Status A(1)/NA(0)	Open Pucca Drainage Uncovered (Status A(1)/NA(0)	Open Kuccha Drainage (Status A(1)/NA(0)	Whether Drain water is discharged directly into water bodies or to sewar plant (For Water Bodies-1/Sewar Plants-0)	Is the Area Covered under Total Sanitation Campaign (TSC)? (Status A(1)/NA(0)
24	Devad	0	1	0	1	0	0	1	1
25	Moho	0	1	0	0	1	0	1	1
26	Shivkar	0	1	0	0	1	0	1	1
27	Vichumbe	0	1	0	1	0	0	1	1
28	Usarli Kh	0	1	0	0	1	0	1	1
29	Chikhale	0	1	0	0	1	0	1	1
30	Nhave	0	1	0	1	0	0	1	1
31	Gavhan	0	1	0	1	0	0	1	1
32	Manghar	0	0	1	0	0	0	0	1
33	Mosare	0	0	1	0	0	0	0	1
34	Patnoli	0	0	1	0	0	0	0	1
35	Nanoshi	0	0	1	0	0	0	0	1
36	Chirvat	0	0	1	0	0	0	0	1
37	Turmale	0	1	0	0	1	0	1	1
38	Vadavali	0	0	1	0	0	0	0	1
39	Nandgaon	0	1	0	0	1	0	1	1
40	Kudave	0	1	0	0	1	0	1	1
41	Palaspe	0	1	0	1	0	0	1	1
42	Kolkhe	0	1	0	1	0	0	1	1
43	Kon	0	1	0	0	1	0	1	1
44	Derawali	0	1	0	0	1	0	1	1
Uran tehsil, Raighar district, Maharashtra									
45	Chirle	0	1	0	1	0	0	1	1
46	Veshvi	0	1	0	0	1	0	1	1
47	Belondakhar	0	0	1	0	0	0	0	1
48	Paundkhar	0	1	0	0	1	0	1	1

ANNEXURE-XVI(7)
INFRASTRUCTURE DETAILS
(Drainage Facilities)

Sr. No	Village Name	Closed Drainage (Status A(1)/NA(0)	Open Drainage (Status A(1)/NA(0)	No Drainage (Status A(1)/NA(0)	Open Pucca Drainage Covered with Tiles Slabs (Status A(1)/NA(0)	Open Pucca Drainage Uncovered (Status A(1)/NA(0)	Open Kuccha Drainage (Status A(1)/NA(0)	Whether Drain water is discharged directly into water bodies or to sewar plant (For Water Bodies-1/Sewar Plants-0)	Is the Area Covered under Total Sanitation Campaign (TSC)? (Status A(1)/NA(0)
49	Dhutum	0	1	0	0	1	0	1	1
	Sub Total	**0**	**28**	**7**	**10**	**17**	**1**	**28**	**35**
7-10 kms Panvel tehsil, Raighar district, Maharashtra									
50	Adivali	0	0	1	0	0	0	0	1
51	Ghot	0	1	0	1	0	0	1	1
52	Koyana Velhe	0	1	0	0	1	0	1	1
53	Taloje Majkur	0	1	0	0	1	0	1	1
54	Pisarve	0	1	0	0	1	0	1	1
55	Rohinjan	0	1	0	1	0	0	1	1
56	Bid	0	0	1	0	0	0	0	1
57	Owe	0	1	0	1	0	0	1	1
58	Valap	0	1	0	0	1	0	1	1
59	Devichapada	0	1	0	1	0	0	1	1
60	Kanpoli	0	1	0	0	0	1	1	1
61	Chindharan	0	1	0	0	1	0	1	1
62	Hedutane	0	0	1	0	0	0	0	1
63	Kevale	0	1	0	0	1	0	1	1
64	Khanav	0	1	0	0	0	1	1	1
65	Chinchavali Tarf W	0	1	0	0	0	1	1	1
66	Umroli	0	0	1	0	0	0	0	1
67	Vakadi	0	1	0	0	1	0	1	1
68	Vihighar	0	1	0	0	1	0	1	1
69	Nere	0	1	0	1	0	0	1	1
70	Ambivali	0	0	1	0	0	0	0	1
71	Sangatoli	0	0	1	0	0	0	0	1
72	Wangani Tarf Waje	0	0	1	0	0	0	0	1
73	Loniwadi	0	0	1	0	0	0	0	1

ANNEXURE-XVI(7)
INFRASTRUCTURE DETAILS
(Drainage Facilities)

Sr. No	Village Name	Closed Drainage (Status A(1)/NA(0)	Open Drainage (Status A(1)/NA(0)	No Drainage (Status A(1)/NA(0)	Open Pucca Drainage Covered with Tiles Slabs (Status A(1)/NA(0)	Open Pucca Drainage Uncovered (Status A(1)/NA(0)	Open Kuccha Drainage (Status A(1)/NA(0)	Whether Drain water is discharged directly into water bodies or to sewar plant (For Water Bodies-1/Sewar Plants-0)	Is the Area Covered under Total Sanitation Campaign (TSC)? (Status A(1)/NA(0)
74	Pali Kh	0	0	1	0	0	0	0	1
75	Bherle	0	0	1	0	0	0	0	1
76	Sangade	0	0	1	0	0	0	0	1
77	Belavali	0	1	0	0	1	0	1	1
78	Borle	0	0	1	0	0	0	0	1
79	Bhingar	0	1	0	0	1	0	1	1
80	Ajivali	0	1	0	0	1	0	1	1
81	Shedung	0	0	1	0	0	0	0	1
82	Ariwali	0	0	1	0	0	0	0	1
83	Ashte	0	0	1	0	0	0	0	1
84	Kasal Khand	0	1	0	0	1	0	1	1
85	Bhatan	0	1	0	0	1	0	1	1
86	Somtane	0	1	0	0	1	0	1	1
87	Giravale	0	1	0	0	0	1	1	1
88	Shirdhon	0	1	0	1	0	0	1	1
89	Sangurli	0	1	0	0	0	1	1	1
90	Chinchavan	0	1	0	0	1	0	1	1
91	Narpoli	0	0	1	0	0	0	0	1
92	Dahivali	0	0	1	0	0	0	0	1
Uran tehsil, Raighar district, Maharashtra									
93	Dighode	0	1	0	0	1	0	1	1
94	Kanthavali	0	0	1	0	0	0	0	1
95	Pohi	0	0	1	0	0	0	0	1
96	Ransai	0	1	0	0	1	0	1	1
97	Vindhane	0	1	0	0	1	0	1	1
98	Taki	0	0	1	0	0	0	0	1

ANNEXURE-XVI(7)
INFRASTRUCTURE DETAILS
(Drainage Facilities)

Sr. No	Village Name	Closed Drainage (Status A(1)/NA(0)	Open Drainage (Status A(1)/NA(0)	No Drainage (Status A(1)/NA(0)	Open Pucca Drainage Covered with Tiles Slabs (Status A(1)/NA(0)	Open Pucca Drainage Uncovered (Status A(1)/NA(0)	Open Kuccha Drainage (Status A(1)/NA(0)	Whether Drain water is discharged directly into water bodies or to sewar plant (For Water Bodies-1/Sewar Plants-0)	Is the Area Covered under Total Sanitation Campaign (TSC)? (Status A(1)/NA(0)
99	Harishchandra Pim	0	0	1	0	0	0	0	1
100	Bori Bk.	0	0	1	0	0	0	0	1
101	Boricha Kotha	0	0	1	0	0	0	0	1
102	Juna Sheva	0	0	1	0	0	0	0	1
103	Sonari	0	1	0	0	1	0	1	1
104	Sawarkhar	0	1	0	0	1	0	1	1
105	Pagote	0	1	0	0	1	0	1	1
106	Karal	0	1	0	0	1	0	1	1
	Sub Total	**0**	**33**	**24**	**6**	**22**	**5**	**33**	**57**
	Grand Total	**0**	**70**	**35**	**20**	**44**	**6**	**70**	**105**
Source: Census of India 2011.									
***Note: 1= Available, 0= Not Available.**									

ANNEXURE-XVI(8)
INFRASTRUCTURE FACILITIES
(Banking Facilities)

Sr. No	Village Name	ATM (Status A(1)/NA(0)	Commercial Bank (Status A(1)/NA(0)	Cooperative Bank (Status A(1)/NA(0)	Agricultural Credit Societies (Status A(1)/NA(0)	Self - Help Group (SHG) (Status A(1)/NA(0)	Agricultural Marketing Society (Status A(1)/NA(0)
, Raighar district, Maharashtra							
1	Vaghivali	0	0	0	0	1	0
2	Pargaon Dungi	0	0	0	0	0	0
3	Kopar	0	0	0	1	1	0
4	Karanjade	0	0	0	1	1	0
5	Dapoli	0	0	0	1	1	0
6	Pargaon	0	0	0	1	1	0
7	Ulawe	0	0	0	1	1	0
8	Targhar	0	0	1	1	1	0
9	Wahal	0	1	1	1	1	0
10	Kharkopar	0	0	0	1	1	0
11	Sonkhar	0	0	0	0	0	0
12	Padeghar	0	0	0	0	0	0
13	Bambavi	0	0	0	0	1	0
14	Kundevahal	0	0	0	1	1	0
	Sub Total	**0**	**1**	**2**	**9**	**11**	**0**
, Raighar district, Maharashtra							
15	Pale Bk.	0	0	0	1	1	0
16	Harigram	0	0	0	1	1	0
17	Koproli	0	0	0	1	1	0
18	Chipale	0	0	0	1	1	0
19	Bonshet	0	0	0	0	1	0
20	Nevali	0	0	0	1	1	0
21	Adai	0	0	0	1	1	0
22	Akurli	0	0	0	1	1	0
23	Shilottar Raichur	0	1	1	1	1	0
24	Devad	0	0	0	1	1	0
25	Moho	0	0	0	1	1	0
26	Shivkar	0	0	0	1	1	0
27	Vichumbe	0	1	1	1	1	0
28	Usarli Kh	0	0	0	1	1	0
29	Chikhale	0	0	0	1	1	0
30	Nhave	0	1	0	1	1	0

ANNEXURE-XVI(8)
INFRASTRUCTURE FACILITIES
(Banking Facilities)

Sr. No	Village Name	ATM (Status A(1)/NA(0)	Commercial Bank (Status A(1)/NA(0)	Cooperative Bank (Status A(1)/NA(0)	Agricultural Credit Societies (Status A(1)/NA(0)	Self - Help Group (SHG) (Status A(1)/NA(0)	Agricultural Marketing Society (Status A(1)/NA(0)
31	Gavhan	0	1	1	1	1	0
32	Manghar	0	0	0	0	0	0
33	Mosare	0	0	0	0	1	0
34	Patnoli	0	0	0	0	0	0
35	Nanoshi	0	0	0	0	1	0
36	Chirvat	0	0	0	0	0	0
37	Turmale	0	0	0	1	1	0
38	Vadavali	0	0	0	0	0	0
39	Nandgaon	0	0	0	1	1	0
40	Kudave	0	0	0	1	1	0
41	Palaspe	0	1	1	1	1	0
42	Kolkhe	0	1	1	1	1	0
43	Kon	0	0	0	1	1	0
44	Derawali	0	0	0	1	1	0
ghar district, Maharashtra							
45	Chirle	0	0	0	1	1	0
46	Veshvi	0	0	0	1	1	0
47	Belondakhar	0	0	0	0	1	0
48	Paundkhar	0	0	0	1	1	0
49	Dhutum	0	0	0	1	1	0
	Sub Total	**0**	**6**	**5**	**27**	**31**	**0**
l, Raighar district, Maharashtra							
50	Adivali	0	0	0	0	1	0
51	Ghot	0	0	0	1	1	0
52	Koyana Velhe	0	0	0	1	1	0
53	Taloje Majkur	0	0	0	1	1	0
54	Pisarve	0	0	0	1	1	0
55	Rohinjan	0	0	1	1	1	0
56	Bid	0	0	0	0	0	0
57	Owe	0	1	1	1	1	0
58	Valap	0	0	0	1	1	0
59	Devichapada	0	1	1	1	1	0
60	Kanpoli	0	0	0	0	1	0

ANNEXURE-XVI(8)
INFRASTRUCTURE FACILITIES
(Banking Facilities)

Sr. No	Village Name	ATM (Status A(1)/NA(0)	Commercial Bank (Status A(1)/NA(0)	Cooperative Bank (Status A(1)/NA(0)	Agricultural Credit Societies (Status A(1)/NA(0)	Self - Help Group (SHG) (Status A(1)/NA(0)	Agricultural Marketing Society (Status A(1)/NA(0)
61	Chindharan	0	0	0	1	1	0
62	Hedutane	0	0	0	0	1	0
63	Kevale	0	0	0	1	1	0
64	Khanav	0	0	0	0	1	0
65	Chinchavali Tarf Wa	0	0	0	0	1	0
66	Umroli	0	0	0	0	1	0
67	Vakadi	0	0	0	1	1	0
68	Vihighar	0	0	0	1	1	0
69	Nere	0	1	0	1	1	0
70	Ambivali	0	0	0	0	0	0
71	Sangatoli	0	0	0	0	0	0
72	Wangani Tarf Waje	0	0	0	0	1	0
73	Loniwadi	0	0	0	0	1	0
74	Pali Kh	0	0	0	0	1	0
75	Bherle	0	0	0	0	1	0
76	Sangade	0	0	0	0	1	0
77	Belavali	0	0	0	1	1	0
78	Borle	0	0	0	0	1	0
79	Bhingar	0	0	0	1	1	0
80	Ajivali	0	0	0	1	1	0
81	Shedung	0	0	0	0	0	0
82	Ariwali	0	0	0	0	1	0
83	Ashte	0	0	0	0	0	0
84	Kasal Khand	0	0	0	1	1	0
85	Bhatan	0	0	0	1	1	0
86	Somtane	0	0	0	1	1	0
87	Giravale	0	0	0	0	1	0
88	Shirdhon	0	0	0	1	1	0
89	Sangurli	0	0	0	0	1	0
90	Chinchavan	0	0	0	1	1	0
91	Narpoli	0	0	0	0	1	0
92	Dahivali	0	0	0	0	0	0
ghar district, Maharashtra							

ANNEXURE-XVI(8)
INFRASTRUCTURE FACILITIES
(Banking Facilities)

Sr. No	Village Name	ATM (Status A(1)/NA(0)	Commercial Bank (Status A(1)/NA(0)	Cooperative Bank (Status A(1)/NA(0)	Agricultural Credit Societies (Status A(1)/NA(0)	Self - Help Group (SHG) (Status A(1)/NA(0)	Agricultural Marketing Society (Status A(1)/NA(0)
93	Dighode	0	0	0	1	1	0
94	Kanthavali	0	0	0	0	0	0
95	Pohi	0	0	0	0	0	0
96	Ransai	0	0	0	1	1	0
97	Vindhane	0	0	0	1	1	0
98	Taki	0	0	0	0	1	0
99	Harishchandra Pim	0	0	0	1	1	0
100	Bori Bk.	0	0	0	0	1	0
101	Boricha Kotha	0	0	0	0	0	0
102	Juna Sheva	0	0	0	0	0	0
103	Sonari	0	0	0	1	1	0
104	Sawarkhar	0	0	0	1	1	0
105	Pagote	0	0	0	1	1	0
106	Karal	0	0	0	1	1	0
	Sub Total	**0**	**3**	**3**	**29**	**47**	**0**
	Grand Total	**0**	**10**	**10**	**65**	**89**	**0**

nsus of India 2011.
ilable, 0= Not Available.

ANNEXURE-XVI(9)
INFRASTRUCTURE FACILITIES
(Educational Facilities in Urban Area)

Sr. No	Town Name	Govt. Primary School (Numbers)	Private Primary School (Numbers)	Govt. Middle School (Numbers)	Private Middle School (Numbers)	Govt. Secondary School (Numbers)	Private Secondary School (Numbers)	Govt. Senior Secondary School (Numbers)	Private Senior Secondary School (Numbers)	Govt. Degree College-Art,Science and Commerce (Numbers))	Private Degree College-Art,Science and Commerce (Numbers)	Govt. Degree College-Law (Numbers))	Private Degree College-Law (Numbers)	Govt. Degree College-University (Numbers))	Private Degree College-University (Numbers)	Govt.-Medical College (Numbers))	Private-Medical College (Numbers)	Govt.-Engineering College (Numbers))	Private-Engineering College (Numbers)	Govt.-Management Institute (Numbers))	Private-Management Institute (Numbers)	Govt.-Polytechnic (Numbers))	Private-Polytechnic (Numbers)	Govt.-Special School for Disabled (Numbers))	Private-Special School for Disabled (Numbers)
, Raighar district, Maharashtra																									
1	anvel (M (	18	20	21	11	9	17	7	4	0	3	0	0	0	0	0	0	0	2	0	1	1	1	0	2
2	i Panvel I	10	0	4	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
3	lidevad ((	2	5	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	adghar (C	4	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Owle (CT)	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	**37**	**25**	**31**	**14**	**14**	**18**	**8**	**4**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**1**	**2**	**0**	**2**
, Raighar district, Maharashtra																									
6	Panchna	6	2	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	arghar ((	4	20	3	20	1	18	0	9	1	1	0	0	0	0	4	0	4	0	1	0	0	0	0	0
8	lundre ((	2	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
hane district, Maharastra																									
9	umbai (M	104	139	101	131	55	104	16	20	0	37	0	2	0	2	0	4	0	10	0	1	0	4	1	12
ghar district, Maharashtra																									
10	Jasai (CT)	2	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	**118**	**162**	**110**	**152**	**59**	**122**	**18**	**29**	**1**	**38**	**0**	**2**	**0**	**2**	**4**	**4**	**4**	**10**	**1**	**1**	**0**	**4**	**1**	**12**
	0	**155**	**187**	**141**	**166**	**73**	**140**	**26**	**33**	**1**	**41**	**0**	**2**	**0**	**2**	**4**	**4**	**4**	**12**	**1**	**2**	**1**	**6**	**1**	**14**
nsus of India 2011.																									

ANNEXURE-XVI(10)
INFRASTRUCTURE FACILITIES
(Urban Healthcare Facilities)

Sr. No	Town Name	Hospital Allopathic (Numbers)	Hospital Allopathic Beds (Numbers)	Hospital Allopathic Doctors-Total Strength (Numbers)	Hospital Alternative Medicine (Numbers)	Hospital Alternative Medicine Beds (Numbers)	Hospital Alternative Medicine Doctors-Total Strength (Numbers)	Dispensary/ Health Centre (Numbers)	Dispensary/ Health Centre Beds (Numbers)	Dispensary/ Health Centre Doctors-Total Strength (Numbers)	Family Welfare Centre (Numbers)	Family Welfare Centre Beds (Numbers)	Family Welfare Centre Doctors-Total Strength (Numbers)	Maternity and Child Welfare Centre (Numbers)
0-3 kms Panvel tehsil, Raighar district, Maharashtra														
1	Panvel (M Cl)	1	30	2	0	0	0	0	0	0	0	0	0	1
2	Navi Mumbai Panvel Raigarh (CT)	0	0	0	0	0	0	1	0	1	1	10	1	0
3	Palidevad (CT)	1	10	1	1	5	1	1	9	2	1	2	1	1
4	Vadghar (CT)	0	0	0	0	0	0	0	0	0	0	0	0	1
5	Owle (CT)	0	0	0	0	0	0	0	0	0	1	5	1	0
	Sub Total	**2**	**40**	**3**	**1**	**5**	**1**	**2**	**9**	**3**	**3**	**17**	**3**	**3**
3-7 kms Panvel tehsil, Raighar district, Maharashtra														
6	Talode Panchnad (CT)	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Kharghar (CT)	0	0	0	0	0	0	1	0	1	1	10	1	0
8	Kalundre (CT)	1	10	1	0	0	0	0	0	0	0	0	0	0
Thane tehsil, Thane district, Maharastra														
9	Navi Mumbai (M Corp.)	2	300	184	1	10	1	20	0	20	0	0	0	4
Uran tehsil, Raighar district, Maharashtra														
10	Jasai (CT)	0	0	0	0	0	0	1	20	2	0	0	0	0
	Sub Total	**3**	**310**	**185**	**1**	**10**	**1**	**22**	**20**	**23**	**1**	**10**	**1**	**4**
	Grand Total	**5**	**350**	**188**	**2**	**15**	**2**	**24**	**29**	**26**	**4**	**27**	**4**	**7**
Source: Census of India 2011.														

Sr. No	Town Name	Maternity and Child Welfare Centre Beds (Numbers)	Maternity and Child Welfare Centre Doctors-Total Strength	Maternity Home (Numbers)	Maternity Home Beds (Numbers)	Maternity Home Doctors-Total Strength (Numbers)	T.B. Hospital/ Clinic (Numbers)	T.B. Hospital/ Clinic Beds (Numbers)	T.B. Hospital/ Clinic Doctors-Total Strength (Numbers)	Nursing Home (Numbers)	Nursing Home Beds (Numbers)	Nursing Home Doctors-Total Strength (Numbers)	Veterinary Hospital (Numbers)	Veterinary Hospital Beds (Numbers)	Veterinary Hospital Doctors-Total Strength (Numbers)	Mobile Health Clinic (Numbers)	Mobile Health Clinic Beds (Numbers)	Mobile Health Clinic Doctors-Total Strength (Numbers)
0-3 kms Panvel tehsil, Raighar district, Maharashtra																		
1	Panvel (M Cl)	30	1	1	30	1	0	0	0	0	0	0	1	0	1	0	0	0
2	Navi Mumbai Panvel Raigarh (CT)	0	0	0	0	0	0	0	0	1	5	1	0	0	0	1	1	1
3	Palidevad (CT)	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Vadghar (CT)	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Owle (CT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub Total	**50**	**3**	**1**	**30**	**1**	**0**	**0**	**0**	**1**	**5**	**1**	**1**	**0**	**1**	**1**	**1**	**1**
3-7 kms Panvel tehsil, Raighar district, Maharashtra																		
6	Talode Panchnad (CT)	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1
7	Kharghar (CT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Kalundre (CT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thane tehsil, Thane district, Maharastra																		
9	Navi Mumbai (M Corp.)	200	48	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Uran tehsil, Raighar district, Maharashtra																		
10	Jasai (CT)	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
	Sub Total	**200**	**48**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**	**3**	**0**	**3**
	Grand Total	**250**	**51**	**1**	**30**	**1**	**0**	**0**	**0**	**1**	**5**	**1**	**3**	**0**	**3**	**4**	**1**	**4**
Source: Census of India 2011.																		

ANNEXURE-XVI(11)
INFRASTRUCTURE DETAILS
(Urban Drinkng Water Facilities)

Sr. No	Area Name	Main Source of Drinking Water									
		Tapwater from	Tapwater from	Covered well	Un-covered	Handpu mp	Tubewel l/Boreh	Spring	River/ Canal	Tank/ Pond/	Other sources
0-3 kms Panvel tehsil, Raighar district, Maharashtra											
1	Panvel (M Cl)	96.7	1.8	0.1	0	0	0.1	0.1	0	0.1	1.2
2	Navi Mumbai Panvel Raigarh	90.7	2.6	0.2	0.2	1.1	3.6	0.3	0.1	0.2	0.9
3	Palidevad (CT)	91.5	1.6	0.1	0	0.2	3.6	0	0.2	0.2	2.6
4	Vadghar (CT)	97.4	2.2	0	0	0	0	0	0.1	0	0.3
5	Owle (CT)	99.2	0.1	0	0	0	0	0.1	0.2	0	0.3
	% of Facilities	**475.5**	**8.3**	**0.4**	**0.2**	**1.3**	**7.3**	**0.5**	**0.6**	**0.5**	**5.3**
	Sub Total	**499.9**	**499.9**	**499.9**	**499.9**	**499.9**	**499.9**	**499.9**	**499.9**	**499.9**	**499.9**
	Average	**95.1**	**1.7**	**0.1**	**0.0**	**0.3**	**1.5**	**0.1**	**0.1**	**0.1**	**1.1**
3-7 kms Panvel tehsil, Raighar district, Maharashtra											
6	Talode Panchnad (CT)	90.2	1.8	0.2	5.9	0	1.6	0.1	0	0.1	0
7	Kharghar (CT)	97.7	1.3	0.1	0.1	0.5	0	0.1	0	0.1	0.1
8	Kalundre (CT)	88	10.4	0.3	0	0.1	0	0.3	0.3	0.3	0.3
Thane tehsil, Thane district, Maharastra											
9	Navi Mumbai (M Corp.)	97.5	1.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
Uran tehsil, Raighar district, Maharashtra											
10	Jasai (CT)	82.8	12.6	0	4.2	0.1	0.1	0.2	0.1	0	0.1
	% of Facilities	**456.2**	**27.6**	**0.7**	**10.3**	**0.8**	**1.8**	**0.8**	**0.5**	**0.6**	**0.9**
	Sub Total	**500.2**	**500.2**	**500.2**	**500.2**	**500.2**	**500.2**	**500.2**	**500.2**	**500.2**	**500.2**
	Average	**91.2**	**5.5**	**0.1**	**2.1**	**0.2**	**0.4**	**0.2**	**0.1**	**0.1**	**0.2**
	0- 07 km Grand total % of facilities	**931.7**	**35.9**	**1.1**	**10.5**	**2.1**	**9.1**	**1.3**	**1.1**	**1.1**	**6.2**
	0- 07 km Grand Total	**1000.1**	**1000.1**	**1000.1**	**1000.1**	**1000.1**	**1000.1**	**1000.1**	**1000.1**	**1000.1**	**1000.1**
	0- 07 km Total Average	**93.2**	**3.6**	**0.1**	**1.0**	**0.2**	**0.9**	**0.1**	**0.1**	**0.1**	**0.6**
Source: Census of India 2011											

ANNEXURE-XVII

MAHARASHTRA REGIONAL AND TOWN PLANNING ACT, 1966

(Under Section 37 of Maharashtra Regional and Town Planning Act, 1966)

NAVI MUMBAI MUNICIPAL CORPORATION

(Under section 37 of Maharashtra Regional and Town Planning Act, 1966)

NOTICE

Whereas, the Government of Maharashtra in exercise of the powers conferred by Sub Section (1) of the Section 113 of the Maharashtra Regional & Town Planning Act, 1966 (Maharashtra XXXVII of 1966) (hereinafter referred to as "the said Act") has designated site for New town of Navi Mumbai vide Urban Development & Public Health Department Notification No.RPB-1171/18124/I.W, dated 20th March 1971 and City Industrial Development Corporation Limited (CIDCO), has been appointed as a "New Town Development Authority" for New Town of Navi Mumbai;

And whereas, the Government of Maharashtra vide urban Development and Public Health Department Notification No.RPB-1175/635/UD-5, dated 18th January 1980 has sanctioned the draft Development Plan in the form of structure plan, submitted by CIDCO for the area comprised in the New Town of Navi Mumbai and the same has come into force with effect from 1st March 1980;

And whereas, Navi Mumbai Municipal Corporation has been constituted under Government Notification No.NBC/1091/140/CR-14/91/UD-20, dated 17th December 1991 under Section 3 of the Bombay provincial Municipal Corporation Act,1949 (hereinafter referred to as the "said Municipal Corporation") for the local areas of the revenue villages specified therein. Out of 44 villages included in Navi Mumbai Municipal Corporation's limit 29 revenue villages are comprising of the sanctioned Development Plan of Navi Mumbai Project Area while remaining 15 villages are comprising of sanctioned Regional Plan of Mumbai Metropolitan Region.

And whereas, the limits of the city of Navi Mumbai Municipal Corporation has been altered thereby excluding the areas of 14 revenue villages of the sanctioned Regional Plan of Mumbai Metropolitan Region retaining only village Adivali- Bhutavli to be in the Corporation limit with effect from the date 08/06/2007 vide Govt. GR No.NMC-112000/CR54/04/UD-28 .

And whereas, Navi Mumbai Corporation has all the powers of the Planning Authority under Chapter 3 & 4 (Section 21 to 58) of the Maharashtra Regional and Town Planning Act,1966 (hereinafter referred to as the 'Said Act') within its area from the date specified by the State Government in this behalf in respect of the developed nodes of Vashi, sanpada, Nerul, Belapur-CBD, Koperkhairane and Airoli in accordance with the provisions of Section 2(15) (a) and Section 2(19) of "the said Act". This has been specifically mentioned by the Government. in its Order No. NMMC/1692/1187/CR-138/94/UD-24, dated 15th December 1994;

And whereas, Government in Urban Development Department vide its order beraring No. TPB/4306/2964/CR-176/08/UD-11, dt. 29th July 2008 as per the powers vested under section 154 of the said Act issued the directions that the Navi Mumbai Municipal Corporation shall act as Planning Authority in respect of developed node of Ghansoli comprising of revenue villages of Ghansoli (pt), Rabale (pt), Gothivali (pt), Talvali (pt) (parts which are not included in MIDC Area) in accordance with the provision of Section 2 (15) (a) and Section 2(19) by the said Act.

And whereas, Govt. of Maharashtra, in Urban Development Department vide its Notification, no TPB – 4306/564/CR-55/06/UD-11 dated 12th Dec. 2007, sanctioned the proposal of modification under Sub Section (2) of Section 37 of the Maharashtra Regional & Town Planning Act, 1966 to the Development Control Regulations 1994 (hereinafter referred to as “The Said Regulation”) as submitted by Navi Mumbai Municipal Corporation for its area by keeping some of the Regulations in abeyance. The said Regulations are made applicable from 27th Dec. 2007.

And whereas, the Government in Urban Development Department vide its Notification No. TPB/4306/564/CR-55/06/UD-11, dt. 21st July, 2008 has sanctioned the regulations which were kept in abeyance vide its earlier Notification dt. 12th Dec. 2007 and that the said Regulation have came into force with effect from 23rd July 2008.

And whereas, if observed the area from Belapur to Digha within the jurisdiction of the NMMC, it is seen that, on east of Thane-Belapur road the area of MIDC/area occupied by slum along with Parsik Hill, on west Thane Creek, on north area of Thane Municipal Corporation and on south area of Kharghar within jurisdiction of CIDCO. Due to such Geographical location there are constraints for the expansion of NMMC’s jurisdiction.

And whereas, in all the nodes included in NMMC area mainly includes the buildings constructed by CIDCO, the residential./commercial buildings constructed by all section of the people on the plots allotted by CIDCO to the private developers/CHS, Economically weaker section & LIG Houses, original congested area also extended congested area & the houses of project affected therein.

And whereas, the population as per 1991 census was 3.07 Lakhs at the time of constitution of NMMC. It was 7.04 Lakhs as per 2001 census. The population of NMMC as in 2011 reached more than 12 Lakhs. The trend of population increase in NMMC is seen to be increasing twice in a decade. The present population is about 50% more than that what is projected by CIDCO. Considering the International Airport/SEZ/Metro Railway/ Mono Railway along the NMMC boundary, the population of NMMC is expected to reach up to 25 Lakhs in 2031.

And whereas, as mentioned above considering the geographical location of NMMC, the NMMC limit cannot be extended and considering the projected population, the future population will have to be accommodate on the already developed land.

And whereas, the existing population in NMMC jurisdiction and considering the projected population of 25Lakhs in 2031 as mentioned above, the NMMC has appointed M/s. Crisil as a consultant to prepare an Impact Assessment Report by studying the public amenities & infrastructures. The said consultant has studied existing infrastructures and proposed works and after actual survey has submitted its report. The said report was submitted to G.B. on 06.03.2012 for information.

And whereas, M/s. Crisil in its report has mentioned that considering the present population, existing basic infrastructures available in NMMC jurisdictions are capable to cop up the load of projected population of 25 Lakhs and to sustain the load of 2.5 FSI. However, certain public amenities are deficit for the projected population. Considering the above, and to made available the public amenities & wider roads, it is necessary to enhance the FSI for reconstruction/ redevelopment, so as remove the deficiency in public amenity spaces.

And whereas, due to humidity being the NMMC is adjacent to the creak and the residents using the buildings have not repaired & maintained the buildings from time to time such buildings becomes dilapidated and unsafe. The reconstruction/ redevelopment of such buildings is thus necessary.

And whereas, in CIDCO developed sectors the 6.00 M to 15.00 M wide roads are provided. These roads becomes inadequate for the increased vehicles for the present population. It is also observed that there is deficiency of public amenity spaces in CIDCO sectors. Considering the aforesaid facts if the additional FSI for dilapidated and unsafe buildings is granted then it is possible to reconstruction/ redevelopment the said building with a view of planning.

And whereas, CIDCO has constructed EWS & LIG houses to accommodate EWS & LIG in NMMC area. The planning of such houses is of congested type and having 3.0m to 4.5m wide access road and due to lack of parking spaces traffic is the problem. Further there is deficiency of public amenity spaces too.

And whereas, CIDCO has made available houses of special design for the artists in various field in sector-8, CBD in NMMC. These houses are constructed as ground, ground+1 upper floor. In this area except few roads, the houses are accessible by pathways. While constructing these houses, parking spaces are not provided. Therefore, the households are parking their vehicles elsewhere. Further, the plinth of these houses is very low and in rainy season, there is flooding around these houses. In short more or less is same situation like EWS & LIG as stated above.

And whereas, in views of the facts in both the aforesaid location and considering the need of future it becomes necessary to redevelop these areas together in the form of cluster with proper planning. To achieve this it is necessary to give incentive for the redevelopment of such houses with proper planning.

And whereas, CIDCO has acquired the lands held by the original residents of the Navi Mumbai and developed the city. Firstly the compensation was paid in terms of money and thereafter under 12.5% scheme developed plots are allotted to the project affected persons due to need of their increased family size have themself constructed houses in congested area and also in extended congested area. While constricting the said houses unknowingly they have violated the permissible FSI norms. The characteristic of the original congested area and extended congested area, it is observed that without proper planning haphazard constructions, narrows roads / path way, deficiency of marginal spaces around building for light & ventilation, deficiency in parking, public amenity & other vacant plots. In these areas even the fire brigade vehicles & ambulance cannot reach in some parts in case of emergency and due to such situation in case of any accident there are chances of casualty & wealth loss can not be overruled.

And whereas, considering the above in depth & being a need of the future the redevelopment of such original congested areas and extended congested areas together with proper planning by way of cluster under urban renewal schemes can be undertaken to remove the deficiency in such areas.

And whereas, in view of above it is necessary to modify the existing regulation and to incorporate certain new regulations in the sanctioned Development Control Regulations.

And whereas, the Navi Mumbai Municipal Corporation being the Planning Authority has empowered to modify the Regulations in the Development Control Regulations – 1994 prepared by it, as per provision of Section 37 of the Maharashtra Regional and Town Planning Act, 1966;

And now therefore, in exercise of the powers conferred under Sub-Section (1) of Section 37 of the Maharashtra Regional & Town Planning Act, and as per the resolution approved in General Body Meeting of the Navi Mumbai Municipal Corporation vide Resolution No. 1267 dated 11th May, 2012, the Navi Mumbai Municipal Corporation hereby proposes to modify the prevailing Development Control Regulations by modifying the existing regulation No. 46.3 and its Appendix-VI for allowing reconstruction/ redevelopment of dilapidated/unsafe declared buildings in

NMMC area; to incorporate a new regulation No. 46.(5) after proposed regulation No. 46. (4) for reconstruction/ redevelopment of existing residential units constructed/allotted by CIDCO under EWS, LIG and Artist Village of CBD by way of Cluster Development Plan to be prepared by the NMMC and to incorporate a new regulation No. 46(6) after newly inserted regulation No. 46(5) for reconstruction/ redevelopment of existing buildings/ structures in congested areas & extended congested areas under Urban Renewal Scheme on extensive area by way of cluster to be prepared by NMMC and hereby publishes the same (As attached herewith – Appendix 1,2 & 3)

In pursuance of Sub-Section (1) of Section 37 of the Maharashtra Regional & Town Planning Act, the Navi Mumbai Municipal Corporation hereby publishes the said proposed draft modification and invites objections and/ or suggestions from public in writing with respect to the said proposed draft modifications within the period not later than one month from the date of publication of this notice in Maharashtra Government Gazette. The objections and/or suggestions shall be sent to the Assistant Director of Town Planning, Town Planning Department, Navi Mumbai Municipal Corporation, Shopping Center Building, Opp. Bank of Maharashtra, Sector-1, C.B.D, Belapur, Navi Mumbai 400 614. The suggestion and/or objections will not be accepted after due date.

(Dr. Bhaskar Wankhede)
Commissioner
Navi Mumbai Municipal Corporation

Place : Navi Mumbai
Date : / /2012

Appendix - 1

PROPOSED MODIFICATION TO REPLACE EXISTING REGULATION NO. 46(3) OF DEVELOPMENT CONTROL REGULATION

Regulation No.	Existing provision	Amended Proposed Modification
46.3	[1]**Reconstruction of buildings destroyed by fire or which have been collapsed or which have been demolished. Etc.** – Reconstruction in whole or in part of a building (not being a building wholly occupied by warehousing user and also not being a ground floor structure), which has been ceased to exist in consequence of an accidental fire, natural collapse, or demolition for the reason, of the same having been declared unsafe by or under a lawful order of the Corporation is likely to be demolished for the reason of the same having been declared unsafe by or under a lawful order of the said Corporation duly certified by them, shall be allowed as specified in Appendix – VI of this Regulation.	[1]**Reconstruction Redevelopment of buildings destroyed by fire or which have been collapsed or which have been demolished. Etc.** – Reconstruction Redevelopment in whole or in part of a building (not being a building wholly occupied by warehousing user and also not being a ground floor structure), which has been ceased to exist in consequence of an accidental fire, natural collapse, or demolished and or is likely to be demolished for the reason, of the same having been declared unsafe by or under a lawful order of the Municipal Commissioner duly certified by them, shall be allowed as specified in Appendix – VI of this Regulation.
APPENDIX -VI	**" REGULATIONS FOR RECONSTRUCTION/ REDEVELOPMENT ".** **1. a)** These provision shall be applicable to following proposals: **I.** Reconstruction / redevelopment schemes undertaken by the Corporation / Owners for the existing residential developments. The FSI to be allowed for such proposal shall be FSI permissible under these regulation or the FSI consumed by the existing authorised building whichever is more. II Reconstruction / redevelopment of buildings destroyed by fires, collapsed, demolished etc. Reconstruction in whole or in part of a building (not being a building wholly occupied by warehousing user) which has ceased to exist in consequence of accidental fire, natural collapse or demolition for the reason of the same having been declared unsafe by or under a lawful order of the Municipal Commissioner. a) In case of reconstruction / redevelopment of buildings of CIDCO / NMMC having tenements size of less than 50 sq.mt. in outside congested areas, the total F.S.I shall be the authorizedly consumed F.S.I plus 50% incentive FSI, provided that total FSI of the new structure shall not exceed 1.5. In case of reconstruction / redevelopment of buildings	**APPENDIX- VI** **(Under Regulation No. 46.3)** **" REGULATIONS FOR RECONSTRUCTION/ REDEVELOPMENT ".** 1. **These provision shall be applicable to the following proposals:** **I.** Reconstruction / redevelopment schemes undertaken by the Corporation/CIDCO/Owners/ Association/CHS/ developer for the existing residential or residential cum commercial development. The FSI to be allowed for such proposal shall be FSI permissible under these regulation or the FSI consumed by the existing authorised building whichever is more. II Reconstruction/redevelopment schemes under-taken by corporation/CIDCO/Owners/Association/ CHS/Developer of the buildings destroyed by fires, collapsed, demolished etc. Reconstruction in whole or in part of a building (not being a building wholly occupied by warehousing user and also not being a ground floor structure) which has ceased to exist in consequence of accidental fire, natural collapse or demolished and or is likely to be demolished for the reason of the same having been declared unsafe by or under a lawful order of the Municipal Commissioner. A) In case of reconstruction / redevelopment of residential buildings irrespective of tenement size in outside congested areas, the total FSI shall be the authorisedly consumed FSI plus 50% incentive FSI. Provided that total FSI of the new structure shall not exceed 2.5

having tenements of size less than 50 sq.mt., in gaothan area the total F.S.I shall be the authorizedly consumed F.S.I plus 50% incentive F.S.I provided that total F.S.I of the new structure shall not exceed 1.8, provided that access road to the building shall not be less than 9 mt.

b) The Committee Comprises of Municipal Commissioner, Superintendent Engineer, Public Works Department Thane, Dy. Director, Town Planning, Konkan Division and Chief Architect & Planner of CIDCO shall be set up and the said Committee shall decide the building, which are dangerous and dilapidated

Note: -

i) For the purpose of deciding the authenticity of the structure if the approved plans of existing structure are not available, the Municipal commissioner shall consider other evidence such as Assessment Record of city survey record or sanad.

ii) In case where there are number of bldgs, on plot, in such cases, equivalent land component of the bldgs. which are declared unsafe shall be worked out and incentive F.S.I. shall be based on such land component.

2. Reconstruction of the new building on the plot should conform to the provisions of the development plan and these regulations. Reconstruction on the said plot not affected by the development plan proposal is permissible.

3. The new building may be permitted to be reconstructed in pursuance of an agreement to be executed on stamp paper by atleast 70 percent of the landlord / occupants (if any) in the original building within the meaning of the Bombay Rents, Hotel and lodging Houses Rent Control Act, 1947 and such agreement shall make a provision for accommodation for the said landlords / occupants in the new building on agreed terms and a copy of such agreement shall be deposited with the Corporation before commencement or undertaking reconstruction of the new buildings.

4. The carpet area of part or parts of the new building intended to be used as office premises shall not exceed the carpet area of part or parts of the original building so used as office premises or for commercial use or 0.5 F.S.I. whichever is more.

5. Building shall be reconstructed in accordance with these Regulations and all other Regulations and orders as applicable from time to time. The Municipal commissioner may exercise his powers

If the concern corporation / CIDCO/owners /Association /CHS/developer intent to avail the benefit of 2.5 FSI, then in that case on the over and above FSI upto 2.5 after excluding the FSI required for “rehabilitation + incentive” the concern CIDCO/owners/Association / CHS/ developer has to deposit premium to Navi Mumbai Municipal Corporation as per the regulation hereafter in this regulations.

Provided that :-

Sr. No.	Category	Permissible FSI
i	Plot having net area 1000 sq. m. or more and having access road of 15m wide and above.	2.50
ii	Plots having net area 1000 sq.m.or more and having access road of 9m . wide and above.	2.00
iii	All other plots having access road below 9m width.	Authorisedly consumed FSI + 50% Incentive

B) The Committee Under the Chairmanship of the Municipal Commissioner Comprises of City Engineer NMMC, Additional City Engineer, NMMC, Assistant Director of Town Planning, NMMC, and Structural Engineer registered with NMMC or Govt. (who is having at least 10 years experience in the said field) shall be appointed and set up and the said Committee shall decide the building, which are dangerous and dilapidated.

i) For the purpose of deciding the authenticity of the structure, if the approved plans of existing structure are not available, the Municipal commissioner shall consider other evidence such as Assessment Record of city survey record or sanad.

ii. In case where there are number of building on plot, in such cases, equivalent Land component of the building which are declared unsafe shall be worked out and incentive F.S.I. shall be based on such land component.

2. Reconstruction of the building on the plot should confirm the provisions of the development plan and these regulations. Reconstruction on the plot not affected by the development plan proposal is permissible.

3. The building may be permitted to be reconstructed in pursuance of an agreement to be executed on stamp paper by at least 70 percent of

under Regulation 14 for condensation of minor variations in respect of such reconstruction.

6. The maximum area of a residential tenement in the reconstructed building shall not exceed 70 sq.m or such larger area as may be decided by the Corporations in deserving cases.

7. The landlords ./ occupants of the original buildings shall furnish a duly stamped undertaking that he / they shall allot to all the occupants in the original building accommodation in the new building in accordance with these Regulations.

8. No construction or reconstruction shall be permitted on set back area or areas required for road widening and such area shall be handed over to the Municipal Corporation.

9. Reconstruction of partly collapsed / gutted / demolished buildings wherein the area of collapsed / gutted / demolished portion is not more than 25 percent of the total area of such building, will be permitted by the Corporation provided the FSI does not exceed the existing limit.

the landlord / occupants (if any) in the original building within the meaning of the Bombay Rents, Hotel and lodging Houses Rent Control Act, 1947 and such agreement shall make a provision for accommodation for the said landlords / occupants in the new building on agreed terms and copy of such agreement shall be deposited with the Corporation before commencement certificate.

4. The carpet area of part or parts of the new building intended to be used as office/or any other commercial premises shall not exceed the carpet area of part or parts of the original building so used as office premises or for commercial use.

5. Building shall be reconstructed in accordance with these Regulations and all other Regulation and orders as applicable from time to time.

6. The landlords/ Association/CHS/developer shall furnish a duly stamped undertaking that he / they shall allot to all the occupants in the original building accommodation in the new building in accordance with these Regulations.

7. Widening of existing roads as per the regular line of street prescribed by Navi Mumbai Municipal Corporation would be permissible for reconstruction/redevelopment of entire condominium/plot area so as to opt for category A (i) & A (ii) above, by handing over required stretch of land to Navi Mumbai Municipal Corporation free of cost, duly developed with storm water drain and footpath if any to the satisfaction of the Municipal Commissioner. In such cases the holder/Developer will be entitled to get additional built up area equivalent to the area so surrendered for road widening, on the abutting net plot area. After handing over of such land, the permissible F.S.I. shall be calculated on the net plot area, after deducting the area so surrendered for road widening to the Corporation.

8. It shall be mandatory to keep minimum 10% & 15% compulsory recreational open space on ground clearly open to sky other than podium garden in the proposed project of land area between 2500 sq. mtrs. to 4000 sq.mtrs. and for plot area more than 4000 sq.mtrs. respectively

9. It shall be mandatory to provide parking spaces as per Regulations of this DCR's .

10. The NOC from the Association / CHS / leaseholders or at least 70 % occupants of the condominium is mandatory as per the provisions of Maharashtra Ownership Flat Act, 1963 & Maharashtra Ownership Apartment Act-1970.

11. The Layout of entire condominium / residential /Residential cum commercial premises duly signed by the Association/CHS shall be submitted at the time of Commencement Certificate to ascertain the feasibility of the entire condominium

		for redevelopment, So that in future the proper redevelopment of other buildings in the condominium/residential premises shall be smoothly feasible. However, such redevelopment can be undertaken in a phase manner of one or two buildings likewise as per the approved layout of the entire condominium/ residential premises. In case of such partial redevelopment the premium shall also be deposited in proportion to the area under such partial redevelopment. 12. 20% tenements of 27.88 sqm to 45.00 sq.mtr. (affordable tenements) carpet area in size shall be constructed for Economically Weaker Section of the Society (EWS) in plot area more than 2000 sqm other than the rehabilitation component (i.e. in sale component). 13. The existing residential premises (other then R+C premises) shall be permitted to redeveloped for residential user only. No change of Use from Residential to Residential cum Commercial shall be permitted. However, in such premises if area of such plot is more than 1000sqm and fronting on 20 mtr and above wide road shall be permitted to construct convenient shopping to the extent of 5% of the plot area and if the plot area is more than 1000 sqmtr and fronting on 30 mtrs and above wide road then this limit will be upto 10 %. 14. The normal permissible tenement density per net hectare shall be allowed to be exceeded in multiple of FSI permissible in each category. 15. Reconstruction/Redevelopment under these Regulations will be permitted only after obtaining NOC from all the concern appropriate authorities. 16. The plot holder / developer of the original buildings shall furnish a duly stamped undertaking that he / they shall allot accommodation to the every occupant of the existing buildings. at least equivalent to the respective existing carpet area in his possession subject to the minimum carpet area of 33.44 sqm (360 sq.ft) . While calculating the carpet area for rehab tenements the balcony area permissible under DCR shall be included. 17. The list of all occupants and area occupied by each of them in the old dilapidated building shall be certified by the concern Association / CHS.with necessary proof of ownership. 18. Each occupant shall be rehabilitated and given the equivalent carpet area occupied by him for residential purpose in the old building subject to the minimum carpet area of 33.44 sqm (360 sq.ft)..The copies of such agreement shall be deposited with the corporation before occupation certificate. 19. In case of any discrepancy, the Municipal Commissioner's decision will be final and binding

		on the plot holders / developers. 20. 5% of the Plot area under reconstruction / redevelopment project shall be surrender to the Municipal corporation free of cost for essential amenity area for the plot area more than 2500 sq.m. The FSI of such amenity area shall be permissible on the balance plot area and the entire area of such amenity space will be considered for computation of FSI without deducting this area from the gross plot area. However, 1.0 FSI out of amenity space FSI will be deducted from the total permissible FSI. 21. Amalgamation of more than one Apartment owners association / Co. op. Hsg Societies / Residential Associations shall be permissible and after such amalgamation the amalgamated plot should be in the name of the applicant CHS with legal ownership title. without considering the provision made in the Regulation on no. 6.3.4 of this DCR. However consent of at least 70% leaseholders / occupants who intent to amalgamate of all such condominium shall be necessary. Further, the society those are registered with any sub registerar of co-operative society shall be considered eligible. 22. Premium : Reconstruction /Redevelopment under these regulations shall be allowed only after the deposition of additional premium for the additional FSI over and above authorisedly consumed FSI under existing building to be redeveloped Plus 50% incentive FSI. The rate of premium shall be 25% of the land rate as per the Ready Recknor of the concern Location and year. The NMMC shall revise the rate of such premium. 23. Reconstruction / Redevelopment shall be permissible for the premises where Co- Operative Housing Society is not form so far, only if at least 70% leaseholders / occupants given their written consent for such reconstruction / redevelopment of their dilapidated buildings. 24. A corpus fund is to be created by the developer for the rehab component which will take care of the maintenance of the building for a period of 10 years. In case of any dispute, the Municipal Commissioners decision will be final and binding on the concern society and developers. 25. The distance between any two rehabilitation buildings shall not be less than 6.0 mtrs.

Commissioner
Navi Mumbai Municipal Corporation

APPENDIX – 2

Proposed Modification to insert New Regulation No. 46 (5) after Proposed Regulation No. 46 (4) in Development Control Regulations.

Regulation No.46(5) : Reconstruction or Redevelopment of existing residential units constructed / allotted by CIDCO under EWS, LIG and Artist Village of CBD by way of Clusters.

Reconstruction or Redevelopment of existing Residential Units Constructed / allotted by CIDCO Under EWS, LIG and Artist Village of CBD (except residential plots allotted by CIDCO as Row House and Bungalow plots but including row houses along with high rise building in the condominium) if such unit holders come together as per the cluster shown in the plan to be prepared for all the existing residential Units Constructed by CIDCO under EWS, LIG & Artist Village of C.B.D. in Navi Mumbai Municipal Corporation Jurisdiction Shall be allowed to reconstruct or redevelop their units together as a Cluster development with 2.50 FSI subject to the Regulations as given in Appendix – XI.

Appendix – XI

Regulations for Reconstruction or Redevelopment of existing residential units constructed / allotted by CIDCO under EWS, LIG and Artist Village of CBD by way of Clusters.

Cluster Development :-

The reconstruction or redevelopment undertaken together by the no. of existing Residential unit holders under ESW, LIG and Artist Village of CBD as per the Cluster shown in the plan to be prepared for redevelopment of such Residential units by forming well defined Clusters with necessary amenities,

1) Reconstruction or Redevelopment of existing residential units constructed/allotted by CIDCO under EWS, LIG and Artist Village of CBD to the individual, if such unit holders come together and intent to reconstruct or redevelop such units together in the form of a single or more buildings under cluster development as per the clusters defined by Navi Mumbai Municipal Corporation by existing Association / CHS or by forming a Association/CHS of all such unit holders under Cluster with legal ownership title. The Amalgamation / Subdivision of such units or plots will be permitted without considering the provision made in Regulation No. 6.3.4 of this DCR and will be allowed to reconstruct or Redevelop such amalgamated / subdivided units or plots as per cluster defined by Navi Mumbai Municipal Corporation. The FSI for such Cluster development will be maximum upto 2.5.

2) All the necessary legal formalities as regards the ownership title shall be completed by the concern Association / CHS / leaseholders / occupants before applying for Commencement Certificate.

3) The Reconstruction or Redevelopment of such units shall be carried out as per the Cluster development plan to be prepared by the NMMC for redevelopment of such areas in the NMMC's Jurisdiction.

4) NMMC shall approve the necessary Layout of the proposed Cluster development in accordance with the Cluster Development Plan to be prepared by NMMC.

2/-

5) The area under road or road widening as proposed in the Cluster Development Plan to be prepared by the NMMC shall be handed over to the NMMC free of cost. The FSI of such area affected by road or road widening shall be eligible to consume on the residual Net plot area to the extent of 100% of the area affected by the road or road widening over and above the permissible FSI under these Regulations.

6) If the Net Plot area under such Cluster Development after deducting the area under proposed road or road widening handed over to the NMMC is more than 2500 sq. mtrs then 10% amenity space out of the total Net Plot area shall be handed over to the Navi Mumbai Municipal Corporation free of cost without any encumbrance for the amenity needed in that Vicinity for the use as would be decided by the Municipal Commissioner.

7) The FSI calculations shall be worked out on the net plot area after deducting the area under proposed road or road widening but including 10% amenity space handed over to the Navi Mumbai Municipal Corporation free of cost.

8) Parking Facilities shall be provided by the concern Association / CHS as per the regulations in respect of Parking as per this DCR.

9) Reconstruction or Redevelopment shall be permitted in pursuance of an agreement to be executed on stamp paper by all the original unit holders with the developer or the concern Association / CHS and such agreement shall make a provision for accommodation for the original unit holders in the new building on agreed terms and conditions and copy of such agreement shall be deposited with the Navi Mumbai Municipal Corporation before Commencement Certificate.

10) The built up area of part or parts of the new building intended to be used as office / or any other commercial premises shall not exceed the built up area of part or parts of the original building so used as office premises or for commercial use.

11) The list of all unit holders and area authorisedly occupied by each of them in the old units shall be certified by the concern Association / CHS along with the relevant documents in that support.

12) The Concern Association / CHS / Developer shall furnish a duly stamped undertaking that they shall allot accommodation to the every original unit holder of the existing units.

13) Each unit holder shall be rehabilitated and given the equivalent built up area authorisedly consumed by him for residential purpose in the old unit plus additional 50% built up area of such unit subject to the minimum carpet area of 33.44 sq. mtrs (360 sq.ft.)

14) The normal permissible tenement density per net hectare shall be allowed to be exceeded in multiple of FSI permissible for such Cluster development.

15) Building shall be constructed in accordance with these Regulations and all other Regulations of the Development Control Regulation.

16) Partial reconstruction or redevelopment of such units is not allowed.

17) The Municipal roads / pathways passing through such cluster will be handed over to such Association / CHS / Developers for proper development of cluster free of cost.

18) In case of any discrepancy, the Municipal Commissioner's decision will be final and binding on the Association/ CHS / Developers.

19) Premium: Reconstruction or Redevelopment under these Regulation shall be allowed only after the deposition of additional premium for the additional FSI over and above authorisedly consumed FSI and FSI required for additional 50% built up area to be given to the existing unit holder under redevelopment. The rate of premium shall be 20% of the land rate as per the Ready Recknor of the concern location and year. The NMMC shall revise the rate of such premium.

20) Navi Mumbai Municipal Corporation has to develop such handed over 10% amenity space for the amenities needed in that vicinity, if it is of open use such as Totlot, Garden, P.G. etc. or for such other open user as per the cluster Development Plan to be prepared by the Navi Mumbai Municipal Corporation.

21) If the 10% amenity space handed over to the Navi Mumbai Municipal Corporation and if it is decided to use it as built up amenity as per the Cluster Development Plan to be prepared by the Navi Mumbai Municipal Corporation then the FSI permissible for such amenity will be 1.0. Such amenity space is to be developed by the NMMC.

22) The existing units under EWS, LIG and Artist village in CBD included in the cluster and which are affected by the proposed road or road widening and amenity space shall also be rehabilitated in the same newly formed cluster.

23) For Smooth implementation of the cluster development undertaken by the Association/CHS of the occupiers the temporary transit camps may be permitted on the same land at their own cost. Such transit camps shall be permitted to utilized for other projects with prior permission of Municipal Commissioner.

24) A corpus fund is to be created by the developer for the rehab component which will take care of the maintenance of the building for a period of 10 years. In Case of any dispute, the Municipal Commissioner's decision will be final and binding on the concern society and developers.

25) The distance between any two rehabilitation buildings shall not be less than 6.0 mtrs.

Commissioner
Navi Mumbai Municipal Corporation

APPENDIX – 3

Proposed Modification to insert New Regulation No. 46 (6) after newly inserted Regulation No. 46 (5) in Development Control Regulations.

Regulation No. 46(6) :- **Reconstruction or Redevelopment of existing buildings / Structures in congested areas under Urban Renewal Schemes on extensive area.**

For Reconstruction or Redevelopment of existing buildings/structures under Urban Renewal Schemes in congested areas as shown by the Revenue Department as Gaothan areas and extended congested areas (extended Gaothan areas upto CIDCO developed sectors) and also including the congested area in Digha Administrative ward which is not recognized as congested area in Revenue record, (but excluding the area already considered under SRA) undertaken by (a) Co-op Housing Societies of tenants / occupiers therein of buildings/structures or Developer (b) Independently by the Landowners and / or Co-op Housing Societies of tenents/ occupiers of buildings/structures jointly or Developer, as per the cluster formed in the urban Renewal Plan to be prepared by Navi Mumbai Municipal Corporation the FSI shall be 4.00 or the FSI required for rehabilitation of existing tenants / occupiers plus incentive FSI as given in Appendix-XII, whichever is more.

Appendix- XII

Regulations for Reconstruction or Redevelopment of existing buildings structures in congested areas under Urban Renewal Schemes on extensive area.

1. "Urban Renewal Scheme" means a scheme in congested areas and extended congested areas upto CIDCO developed sectors in any congested areas of Navi Mumbai Municipal Corporation as per the cluster formed in the urban Renewal plan to be prepared by Navi Mumbai Municipal Corporation and such cluster consists of a mix structures / lands of different characteristics such as.

i) unsafe and dilapidated buildings liable to be demolish for the reason of the same having been declared unsafe by or under a Lawful order of the Municipal Commissioner. Other than this all other existing buildings which are not declared unsafe.

ii) All Lands including vacant and Land with buildings belonging to the Government, semi- Government, Navi Mumbai Municipal Corporation & CIDCO including Institutional buildings, office buildings, tenanted municipal buildings and building constructed by CIDCO.

iii) Other buildings which are, by reason of disrepair or have structural / sanitary defects, unfit for human habitation or by reasons of their bad configuration or the inhabitation of the area as may be certified by the Municipal Commissioner.

iv) All buildings affected by the proposed roads or widening of existing roads and proposed reservation sites shall also be included in the cluster form in the urban renewal plan on priority basis.

v) If some areas are previously developed / are in the process of development, under the different provisions of the DCR, such areas can also be included in Urban Renewal Scheme for the calculation of area of the cluster under Urban Renewal Scheme.

2. Eligibility for Urban Renewal Scheme.

i) In original congested areas as per Revenue Record,and In extended congested areas upto CIDCO developed sectors, and for area under Digha Administrative ward the buildings of any kind irrespective of its user and age and which are assessed for the property tax as on 11.05.2012 by property tax assessor and collector department shall be eligible.

ii) The list of all Occupants and area occupied by each of them in municipal buildings/or in the bldgs of other authorities shall be certified by Navi Mumbai Municipal Corporation. The list of occupants and area occupied by each of them in other buildings shall be certified by the concern ward officer of the Navi Mumbai Municipal Corporation.

3) Any vacant land belonging to the Government, Semi Government, Navi Mumbai Municipal Corporation and CIDCO which have been given on lease or owned by the of aforesaid Authority, which falls within the proposed cluster formed in the Urban Renewal plan shall be made available for the project subject to payment of Land rate as per the Ready Reckoner rate of that Location and year. In case of lands held by private individual the said rate shall be as per the rate of residential construction for 1.5 FSI.

4) Any built upon area belonging to the Government, Semi Government, Navi Mumbai Municipal Corporation and CIDCO which have been given on lease or owned by the of aforesaid Authority, or by private individual. which falls within the proposed cluster formed in the Urban Renewal plan shall be Rehabilitated and given equivalent occupied built up area in the old building / structure.

5) Development of more than one clusters which is defined as per urban Renewal plan to be prepared by Navi Mumbai Municipal corporation may be permitted.

6) a) Reconstruction or Redevelopment under Urban Renewal Scheme may be permitted in pursuance of an irrevocable written consent by not less than 70 percent of the tenants/ occupiers of each plot / Building / Structures involved in the Urban Renewal Scheme.

b) All the occupants/ tenants of the building shall be rehabilitated in the redeveloped building.

7) Each occupants / tenants shall be rehabilitated and given the carpet area occupied by him for residential purpose in the old building, subject to the minimum fixed carpet area of 33.44 sqmt. (360 sqft.) and maximum area equivalent to the area occupied in the old building. In case of non-residential occupier, the area to be given in the reconstructed building will be equivalent to the area occupied in the old building.

8) The total permissible FSI shall be on gross plot area including reservations/ designations, as per cluster formed in the Urban Renewal plan.

3/-

9) The incentive FSI admissible against the FSI required for rehabilitation shall be as under :-

i) Where the total area of amalgamated holdings (inclusive of proposed roads & Reservations) is upto 4000 sq.mtrs., then the incentive FSI admissible will be 50 %.

ii) Where the total area of amalgamated holdings (inclusive of proposed roads & Reservations) is between 4001 - 8000 sqmts., then the incentive FSI admissible will be 55%

iii) Where the total area of amalgamated holdings (inclusive of proposed roads & Reservations) is between 8001-12000 sqmts., then the incentive FSI admissible will be 65%

iv) Where the total area of amalgamated holdings (inclusive of proposed roads & Reservations) is between 12001 – 16000 sqmts., then the incentive FSI admissible will be 70%

v) Where the total area of amalgamated holdings (inclusive of proposed roads & Reservations) is between 16001 - 20000 sqmts., then the incentive FSI admissible will be 75%

vi) Where the total area of amalgamated holdings (inclusive of proposed roads & Reservations) is more than 20000 sq. mtrs., then the incentive FSI admissible will be 80%.

If any new area is added and if there is change in the slab prescribed above, the incentive FSI for the additional area in changed slab shall be determined as per the area falling the next slab. However augmentation of area of Urban Renewal scheme is not allowed after completion of the scheme.

Provided that, amalgamation of the different holdings from Revenue Department shall be insisted before the issue of occupation Certificate.

10) The List of all holdings along with ownership title and area of each holding included under Urban Renewal scheme shall be submitted along with the application seeking permission for reconstruction or redevelopment of cluster under Urban Renewal scheme.

11) The area under proposed roads shall be developed with all necessary underground infrastructure such as, sewerage Line, water supply pipe line, & also storm water drain and street lights by the owners/ developers at their own cost and handed over to the Navi Mumbai Municipal Corporation free of cost without any encumbrance, after demolition of the existing structures in the alignment of the said proposed roads to the satisfaction of the Municipal Commissioner.

The FSI of such area under proposed road shall be eligible to consume on the residual net plot area to the extent of 100 % of the area under proposed road over and above the permissible FSI under these Regulations.

4/-

12) The area under proposed reservation shall be handed over to the Navi Mumbai Municipal Corporation free of cost without any encumbrance after demolition of the existing structure in the reservation plot by leveling the site of such reservation to the satisfaction of the Municipal Commissioner.

The FSI of 1.00 equivalents to the area under reservation will be deducted from the total permissible FSI of the Gross plot area which will be utilized by the NMMC for the development of such reservations as per the use specified in the Urban Renewal plan.

13) For smooth implementation of the urban Renewal scheme undertaken by owners and / or co-op-Housing society of the tenants / occupiers the temporary transit camps may be permitted on the same land or land situated elsewhere belonging to the same owner / developer at their own cost. Such transit camps shall be permitted to utilized for other projects with prior permission of the High Power Committee set up under the chairmanship of the Municipal Commissioner.

14) Non Conforming activities- All activities which are existing shall be allowed to be reaccomodated regardless of non - conforming nature of the activities except those which are hazardous and highly polluting and except in cases where the alternative accommodation have already been provided elsewhere by the owner/ developer.

15) If the net plot area under urban Renewal scheme is more than 2500 sq. mts. the owner/ developer has to keep 15% of the Net plot area as Recreational open space physically on site open to sky.

16) **<u>Relaxation in Building and other requirements.</u>**

16.1 The calculation of FSI for all purposes shall be on gross plot area ie without deducting any percentage for recreational open space and area under reservations. This shall not affect the requirement of physical open space keeping aside the said recreational open space on site as per 16 above.

16.2 The balcony shall not reduce marginal open space to less than 3.00 meters. However, at ground level minimum 4.5 mtrs. clear margin shall be maintained. For calculation of carpet area of 33.44 sq.m. (360 sq. ft) the area of the enclosed balcony shall be included.

16.3 Area of common passages not exceeding 2.00 mtrs. in width, provided in rehabilitation component to give access shall not be counted towards FSI.

16.4 Front and marginal open spaces, for a building having height upto 24.0 mtrs. in the rehab component or composite building shall be 4.5 mts. for these buildings.

16.5 Where the Location of the plot abuts a trained nallah, the marginal open space along the nallah shall not be insisted upon beyond 4.5 mtrs, from the edge of the trained nallah.

16.6 The distance between any two rehabilitation buildings shall not be less than 6.0 mtrs.

5/-

16.7 If the height of the building is more than 24 mtrs, 6 mtrs wide marginal open space or as per the requirement of chief fire officer whichever is greater shall be considered.

16.8 A composite building shall contain at least 50 percent of the built up area as rehabilitation component.

16.9 The means of access shall be normally governed by provisions of this DCR. However, in the urban Renewal scheme, wherever the design of the building upto 24 mtrs height in the same land requires relaxation, it may be given.

16.10 Premium shall only be charged for the built up area other than rehab component as covered under the provisions of DCR.

16.11 Order to make the urban renewal scheme viable, the Municipal Commissioner shall be competent to sanction any relaxation in marginal open spaces except front marginal open spaces and parking requirement wherever necessary due to bonafide hardship, for reasons to be recorded in writing which shall not affect general and fire safety requirements.

16.12 All relaxation outlined hereinabove shall be given in the rehabilitation component and also to the composite buildings in the project premium shall not be charged for all or any of the relaxation's given herein above .

16.13 The parking in the scheme shall be provided as per the DCR provisions.

17) The approving / Sanctioning authority for the Building plans under the scheme will be the Municipal Commissioner as per the BPMC Act, 1949 and MRTP Act, 1966.

18) Restriction on transfer of tenements shall be governed by provision of Rent control Act till co-op Housing society is formed and after that the same shall be governed by the provision of maharashtra co-op Housing society's Act.

19) A corpus fund is to be created by the developer for the rehab component which will take care of the maintenance of the building for a period of 10 years. In case of any dispute, the Municipal Commissioner's decision will be final and binding on the concern society and developers.

20) Those schemes for which approval has been given under Regulation No. 46.3 of DCR and for which work has not yet started can be considered for approval under these Regulations provided they satisfy all the conditions for approval under these Regulations.

21) A High power committee (HPC) shall be constituted by the Municipal Commissioner of the concern officers of the Navi Mumbai Municipal Corporation under his chairmanship which will approve the schemes under these Regulations.

22) The High Power committee constituted shall approve the necessary Layout of the proposed cluster in the Urban Renewal Scheme in accordance with the cluster shown in the Urban Renewal Plan to be prepared by the Navi Mumbai Municipal Corporation.

Commissioner
Navi Mumbai Municipal Corporation

ANNEXURE-XVIII
POST-R&R SURVEY FORMAT

ANNEXURE-XVIII
(POST R&R SURVEY)

Name of the Household head :

Name of the Respondent :

Religion & Caste :

Present Address :

Previous Address :

When shifted to new address (year):

Family details

Sr. No	Name	Relation with HoF	Age	Sex	Marital status	Education
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

ANNEXURE-XVIII
(POST R&R SURVEY)

Occupation/Pattern & Source of Family Earning:

Sr. No	**Name of the family members**	**Pre-displacement**		
		Primary occupation	**Secondary occupation**	**Earning Monthly**
1				
2				
3				
4				
5				
		Post-displacement		
1.				
2.				
3.				
4.				
5.				

Code: a. Agriculture b. Business c. Service d. Labour e. Fishing f. Any other

ANNEXURE-XVIII
(POST R&R SURVEY)

Details of affected land/assets/structure

S. No.	Type of Land	Area of Acquisition	Approximate Value	Received Compensation	Satisfaction level from received compensation			
					Very Satisfied	Generally Satisfied	Dissatisfied	Highly Dissatisfied
1	Irrigated Land							
2	Un- Irrigated Land							
3	Barren land							
4	Orchid Area							
5	Home/ Homestead Area							
6	Any other /structure							

ANNEXURE-XVIII
(POST R&R SURVEY)

Income Restoration after Resettlement

	Definitely Better Off	Better Than Before	Same as before	Worse off Than Before
Income				
Assets				

Livelihood Restoration after Resettlement

	Definitely Better Off	Better Than Before	Same as before	Worse off Than Before
Earning opportunities				

Status of Living standard after Resettlement

Definitely Better Off	Better Than Before	Same as before	Worse off Then Before

Do you/family member get any vocational/IT/Other training or job placement from project authority?

Yes ☐ No ☐

If yes, write down type of training or job placement

If no, what type of training/job placement you are looking for?

ANNEXURE-XVIII
(POST R&R SURVEY)

What type of infrastructure facilities you had in previous area & which type of facilities available in your new resettlement area?

Sr. No	Infrastructure facilities	Name of infrastructure facilities in your previous area before resettlement	Name of infrastructure facilities in your resettlement area
1	Education		
2	Medical/health		
3	Drinking water type		
4	Sanitation		
5	Drainage		
6	Communication		
7	Transportation		
8	Road		
9	Banking		
10	Power		
11	Recreation		
12	Market		
13	Social Securities		
14	Others		

What type of infrastructure facilities needed in your resettlement area?

ANNEXURE-XVIII
(POST R&R SURVEY)

Reason for selecting the present site of Resettlement & distance from previous address

Satisfaction level for resettlement area

Very Satisfied	Generally Satisfied	Dissatisfied	Highly Dissatisfied

If respondent is dissatisfied/highly dissatisfied, write down reason.

ANNEXURE-XVIII
(POST R&R SURVEY)

Attitudes towards Resettlement

	Very Satisfied	Generally Satisfied	Dissatisfied	Highly Dissatisfied
Project adequately consulted the community in planning and implementation process				
Adequate amount of compensation and assistance was provided to re-establish pre-project incomes/livelihoods				
Loss of business has been adequately Mitigated				
Other				

What type of issues you are facing in new resettlement area?

ANNEXURE-XVIII
(POST R&R SURVEY)

Write down any additional information/observation noticed by surveyor

Other Observation: (Investigators Note)

	Very Good	Good	Reasonable	Bad
Visual estimation of living condition				
Visual estimation of levels economic Well being				
Visual estimation of health				

	Cooperative	Reasonable	Non cooperative
4 Attitude towards the investigator			

Name of Surveyor :

Signature :

Date :

ANNEXURE-XIX
SURVEY FORMAT-QUESTIONNAIRE FOR PAP STILL NOT SHIFTED

ANNEXURE-XIX
(QUESTIONNAIRE FOR PAP STILL NOT SHIFTED)

Name of the household head :

Name of the respondent :

Religion & Caste :

Address :

Family details

Sr. No.	Name	Relation with HoF	Age	Sex	Marital Status	Education
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Occupation/Pattern & Source of Family Earning:

Sr. No	Name of the Family Members	Principal Occupation	Secondary Occupation	Earning Monthly
1				
2				
3				
4				

Code: a. Agriculture b. Business c. service d. Labour e. Any other

ANNEXURE-XIX
(QUESTIONNAIRE FOR PAP STILL NOT SHIFTED)

Details of affected land/assets/structure

Sr. No.	Type of Land	Area of Acquisition	Approximate Value	Monetary compensation proposed by developing agency	Satisfaction level from announced LA package/other package			
					Very Satisfied	Generally Satisfied	Dissatisfied	Highly Dissatisfied
1	Irrigated Land							
2	Un- Irrigated Land							
3	Barren land							
4	Orchid Area							
5	Home/ Homestead Area							
6	Any other /structure							

ANNEXURE-XIX
(QUESTIONNAIRE FOR PAP STILL NOT SHIFTED)

What type of infrastructure facilities are available in your village/ area?

Sr. No	Infrastructure facilities	Name of infrastructure facilities in your area
1	Education	
2	Medical/health	
3	Drinking water	
4	Sanitation	
5	Drainage	
6	Communication	
7	Transportation	
8	Road	
9	Banking	
10	Power	
11	Recreation	
12	Market	
13	Social Securities	
14	Others	

Reason for not accepting to resettle at new resettlement area provided by PP

1. R&R package is not fulfilling expectations
2. Fear of loss of employment opportunities
3. End of traditional occupation
4. Fear of Landlessness/homelessness
5. Social conflicts arising from displacement
6. Other

....
....

Do you have any demands/suggestion from PP? if Yes, please list out:

Did you/family member receive any vocational/IT/Other training or job placement from project authority?

Yes ☐ **No** ☐

ANNEXURE-XIX
(QUESTIONNAIRE FOR PAP STILL NOT SHIFTED)

If yes, write down type of training or job placement

If no, what type of training/job placement you are looking for?

Write down any additional information/observation noticed by surveyor

Other Observation: (Investigators Note)

	Very Good	Good	Reasonable	Bad
Visual estimation of living condition				
Visual estimation of levels economic Well being				
Visual estimation of health				

ANNEXURE-XIX
(QUESTIONNAIRE FOR PAP STILL NOT SHIFTED)

	Cooperative	Reasonable	Non cooperative
4 Attitude towards the investigator			

Name of Surveyor :

Signature :

Date :

ANNEXURE-XX
FOCUSSED GROUP DISCUSSION-MAIN
QUESTIONNAIRE FOR SOCIO ECONOMIC SURVEY

QUESTIONNAIRE FOR SOCIO ECONOMIC SURVEY

Date:

<table>
<tr><td colspan="8">Identification</td></tr>
<tr><td>1</td><td>Village/ Town:</td><td colspan="6"></td></tr>
<tr><td>2</td><td>Tehsil / District:</td><td colspan="6"></td></tr>
<tr><td>3</td><td>Population / Household</td><td colspan="6"></td></tr>
<tr><td>4</td><td>Dominant cast / religion in village</td><td colspan="6"></td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Population %
If city area, ask about ward details</td><td>General</td><td>OBC</td><td>SC</td><td>ST</td><td>NT</td><td>Other if any</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">Infrastructural Facilities</td></tr>
<tr><td rowspan="4">I</td><td colspan="7">Educational</td></tr>
<tr><td>Types of Educational Facilities available
If Yes specify</td><td colspan="6">PS / MS / SS / HS / College (Degree/ Technical) /
Others (Industrial School / Training School etc.)</td></tr>
<tr><td>If No., availed at nearest place (with distance)</td><td colspan="6"></td></tr>
<tr><td>Satisfaction about education facilities
Remark</td><td colspan="6">HS / SA / NE / NS / HU</td></tr>
<tr><td></td><td colspan="7">Note:- HS: Highly satisfied, SA: Satisfied, N: Neutral, NS: Not Satisfied, HS: Highly Satisfied (For QOL ranking purpose)</td></tr>
<tr><td rowspan="7">II</td><td colspan="7">Medical Institutions</td></tr>
<tr><td>Types of institutional medical facilities
Pvt. Clinics – Allopathic:
If Yes mention No. / if no availed at nearest place with distance)</td><td colspan="6">Yes / No</td></tr>
<tr><td>CHC / PHC / PHS
If No, periodically visit by ANM & types of services provided through PHS or PHC</td><td colspan="6">Yes / No</td></tr>
<tr><td>Hospitals – Govt. / Pvt. / Charitable
Drug shops-</td><td colspan="6"></td></tr>
<tr><td>Others (Dispensary / TB Clinic / Mobile Health Clinic / Family Welfare Centre & Maternity & Child Welfare Centre & Nursing Home / Others: Pvt. Clinics - Ayurvedic / Homeopathic / Unani etc. Industrial clinic or Hospital)</td><td colspan="6"></td></tr>
<tr><td>List of common ailments in the families over last one year</td><td colspan="6">Viral fever/ Malaria/ Dysentery/ Diarrhoea/ others</td></tr>
<tr><td>Satisfaction with available medical Facilities
Remark</td><td colspan="6">HS / SA / NE / NS / HU</td></tr>
</table>

III	**Drinking Water (Source of drinking water)**	
	Major source of Water	Tap / Well / Bore Well / Hand pump / River/Lake/Tank/ Others (Specify)
	From where	Over Head Tank / Service Reservoir / River Infiltration Gallery / Bore Well Pumping System / Pressure Tank / Other
	Supplied by	Gram Panchayat / Corporation / CIDCO / any Other specify
	Satisfaction about availability of drinking water (quality & quantity) Remark	HS / S / N / NS / HU
IV	**Sanitation (Toilets / Sewerage / Drainage / Garbage Disposal)**	
	Toilets	
	No. / % of houses have Personal toilets	
1	If toilet facility is not available in 100% HH then, alternative used- No. of Common toilets used by No. / % of households	
2	No. / % of households go for open defecation	
3	Method used by households for disposed of toilet waste.	Septic Tank / Pit System or Soak pit / Latrine with Sewerage / Open defecation / Others
	Sewerage	
4	Drains for sewage	Open / Closed / Open & Closed both / No Drains / Open & No Drains Both
5	Sewerage System of Drainage	Connected to Public Sewer / Open Surface Drains (Open Nalla) / Box Surface Drains /Open pit / Backyard / Others
6	Percentage (%) of household connected with sewer line	
7	Sewage Treatment Plant if available in Area / Village	Yes / No
8	Separate or Combined Sewer line for carrying household or industrial waste water	Separate / Combined
	Drainage (Storm Water Drains)	
9	Storm water drains from roofs, streets and other surfaces	Yes / No
	If Yes, please mention type	Open Surface Drains (Open Nalla) / Box Surface Drains / Closed / any other
10	Problems with drainage	No problem/ flooding occasionally/ flooding

		Perennially/ other specific
	Garbage Disposal (Solid Waste Management)	
11	Garbage (Solid Waste) Disposal Facility	House to house garbage collection facility / Common or public garbage bin / Other
	If No, where do people generally dump Garbage	
12	Garbage bin use by villagers If yes, percentage (%)/No of household	Yes / No
13	Any other in sanitary problems experienced.	Fly/ Mosquito/ Rodents/ Insects/ Others
14	Satisfaction with sanitation facility (toilets, drains & garbage disposal facilities)	HS / SA / NE / NS / HU
V	**Transportation & Communication & Approach Roads**	
1	Mode of transport with distance	Road/Railway/Waterway/ Airway
2	Type of public transport vehicles	Buses: Govt. or Pvt./ Auto / Taxi / Others
3	Frequency of availability of rented vehicles	
4	Nearest Bus Depot/ Railway Station (mention name & distance)	
4	Mode used for communication	Mobile / PCO / STD/ Internet Cafe/ Post office / Other
5	Availability of Approach Roads	Puccka (Paved Roads) / Kacchha (Gravel Roads) / Both (Puccka & Kacchha)
6	Condition of Roads	Good / Maintained / Unmaintained / Bad
7	Satisfaction about Transportation, Communication Facilities and Approach Road Facilities Remark	HS / SA / NE / NS / HU
VI	**Type of Saving Facility** Name of Bank or Credit Society	Bank / ATM Facility / Credit Societies / Self-help Groups / Others
VII	**Fuel & Electricity**	
1	Fuel used in the household for cooking	Wood/ Kerosene/ LPG/ Cow dung/ Electricity
2	Whole area is electrified	Yes ☐ / No ☐

3	Electricity is available for all purposes	Domestic use/ agriculture/ industrial/ other
4	Streetlights	Yes ☐ / No ☐
5	Load shedding	Daily: ___________hr, weekly: _________hr/days
6	Use of Renewable energy sources	Biogas/ Solar Energy/ Wind Energy
7	Satisfaction with Fuel & Electricity supply Remark	HS / SA / NE / NS / HU Adequate No. of streetlights not available / Power if frequently cut / Other
VIII	**Security, Market Facility & Recreation/ Entertainment**	
1	Police Station If no mention name & distance	Yes ☐ / No ☐
2	If No, mention the name with distance where the police station situated	
3	Market Facility	Yes ☐ / No ☐
	If Yes	Daily / weekly
	If No, availed at a nearest places with distance or major market area	
4	Recreation Centres If Yes, Names of recreational Centres	/ Cinema/ Mall / Club / Park (Garden)/ Beach / Lack / Other
5	Availability of recreation at home	Radio / TV / VCR / CD player/ News Paper / magazines /others.
6	Satisfaction with market & recreational facilities	HS / SA / NE / NS / HU
IX	**Other Public Utilities / Amenities**	
1	If Yes Specify	Playground /Garden / Community Hall / Temples / Samaj Mandir /Gym / Library / others
Occupation		
1	People are engaged mainly in which Occupation.	Cultivation /Fishery / Livestock (Dairy & animal rearing)/ Industrial Workers / Casual Labour work / Service (Govt., Pvt. & Semi Govt. Sectors)/ Business / Tourism based business / Forest Based Business / Others

2	If engaged in Cultivation, % of Cultivators- Types of crops, Only Single crop taken on Rainy Season- If double crop is taken, irrigation sources, type of second crop- Production in per acre agriculture land- Selling cost of per quintal crops- Income: Monthly / Annually	
3	If engaged in industrial Work: Type of industries- % of local population employed- Daily or monthly wages-	
4	If engaged in fishing (% of fishermen) Types of fishes- Per day or per trip Avg. catch of fishes- Income- per day / monthly-	
5	If engaged in livestock (% of families engaged in livestock rearing activity) Types of livestock Uses: home consumption / Agriculture / income generating If income: per day / monthly income	
6	If engaged in business or type of business If forest-based business types of herbs or shrubs or other medicinal plants	Shops / Restaurants/ Bars / Hotels (Lodging & Boarding) / taxi /Auto / Tempo / Vender / Hawkers / Tourist guide /others (specify)
7	If engaged in Service, type of Govt. or Pvt. or Semi-Private offices	
8	Avg. Income: Per Day/ Monthly/ Annually- Min – max of casual labour worker or industrial workers or agricultural laborer's	
Women Employment		
1	Majority of women are engaged in which occupation.	
2	If engaged in labouring activities, do they get the same remuneration as compared to male worker?	
Unemployment		
1	Percentage /Number/Number/Number of unemployed Youth	
2	Percentage/Number of Unemployed educated youth	

3	Specify qualifications of unemployed educated youth (Approximate No. of unemployed youth in different faculties)	10^{th} & 12^{th} pass / Graduate & PG in Arts, Science & Commerce / ITI / MBA / Engineering / Polytechnique
Shelter / Housing / Food & Nutrition		
1	Ownership	
2	Rented Family	
	If Yes, No. of Houses Living on Rent (%)	
	Monthly Rent (Rs.)	
3	Migrant Family (If Yes, No. Family (%) Major reason for migration	Yes/No Unemployment / education / others specify
4	Type, Structure and quality of houses.: a] Type b] Structure c] Quality	 Flat / Independent Pucca (Fully Concrete) / Semi Pucca / Kaccha Good / Liveable / Dilapidated
5	Major Staple food	Rice / Wheat / Bajra / Jowar / Others-
6	Items of food obtained from fair price shop Total BPL Families	Wheat / Rice / Sugar / Pulses/ Edible oil/Other please write………………………………………………………………………..
7	Satisfaction about food & Shelter	HS / SA / NE / NS / HU
Welfare /Developmental Activities		
1	Any Types of Govt. Schemes are presently active in the area / village	Yes ☐ / No ☐
2	If Yes, specify (Schemes names & types of beneficiaries)	
3	Any type of CSR Activities in the area / village If Yes, specify (Types of benefits)	Yes ☐ / No ☐
4	Satisfaction about functioning of Govt. Schemes or any other Schemes by local body Any Remark	HS / SA / NE / NS / HU
Tourist Place		
1	Tourist Place	Yes ☐ / No ☐
2	If yes, Type of tourist place Mention the names of Tourist Places	Fort / Cave / Beach / Park / Temple / Church/ Tomb / Other (specify)

3	Does any project/industry related activities affect any tourist place	Yes / No If yes, write down how
Natural resources in your vicinity		
1	Is there any forest in your village/town	Yes ☐ No ☐
2	If yes, write down type of forest- Reserved Forest, protected forest, Communal Forest, Sacred groves	
3	is there a presence of wildlife such as Leopard, Python, Peacock, Vultures, smooth coated Otters (especially close to rivers) or any others (information shall be noted separately for actual sighting and separately for hearsay) ? Have you ever seen them? Or found any evidences like call, scat, pellets, feathers, nails, pug marks, scratch marks, carcases, nests, sprint?	
4	Are animal harmful for you in any manner? e.g. attack on humans, attack on livestock, destroying crops, etc. If yes, frequency and magnitude	Yes ☐ No ☐
5	Use/ dependency of wildlife (including hunting) for food, medicine, cultural/ religious value, indicators, game etc.	
6	Use/ dependency of floral species for food, medicine, cultural/ religious value, indicators, household etc.	
7	Use/ dependency of forest patches (including grasslands and plateaus) for firewood, grazing, other daily needs, worshiping (Dev Rai) within and surrounding site	
8	Use/ dependency of natural water body (including lakes/ ponds/ creeks/ rivers) for fishing or other daily needs	
Perception Regarding Development Activities		
1	At present, are there any types of developmental activities proposed in the area or nearby areas	Yes ☐ / No ☐
2	Type of Activities	
3	Opinion	Positive/ Negative/ Neutral
4	Reasons behind positive opinions	

5	Reasons behind negative opinions	
6	Expectations	

Airport construction related questions

If respondents are aware about the project and its activities, ask them below questions.

1.Did you have any project-related, concerns or grievances? a. Yes b. No c. No response

If yes, write down what type of concerns or grievance.

2. What type of positive impacts may benefit for your community due to the airport construction?

3.What type of negative impacts may affect your community due to the airport construction?

4. Any suggestion/observation you want to address to project authority?

Sr. No	Respondents Name	Signature	Contact No. /Mobile No.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Name of Surveyor :

Signature :

Date :

ANNEXURE-XXI
DEMOGRAPHIC DATA (2001 & 2011 CENSUS REPORT)

ANNEXURE-XXI
DEMOGRAPHIC DETAILS
(2001 CENSUS)

Sl.No.	Name of Village	No.of House Holds	Total Male	Total Female	Total Population	Male Below 6 Agegroup	Female Below 6 Agegroup	Population Below 6 Age group	SC Population	ST Population	Male Literates	Female Literates	Total Literates	Total Workers	Main Workers	Marginal Workers	Non Workers	Non Workers Male	Non Workers Female
0-3 kms Panvel tehsil, Raighar district, Maharashtra																			
1	Vaghivali	62	216	202	418	35	33	68	0	0	159	108	267	143	141	2	275	99	176
2	Pargaon Dungi	62	154	142	296	21	18	39	0	0	117	86	203	96	95	1	200	73	127
3	Kopar	251	608	635	1243	96	89	185	12	118	434	362	796	464	371	93	779	301	478
4	Karanjade	631	1517	1304	2821	231	220	451	111	248	1126	704	1830	1042	949	93	1779	672	1107
5	Dapoli	441	1174	1078	2252	182	160	342	183	16	883	627	1510	974	528	446	1278	555	723
6	Pargaon	476	1221	1196	2417	187	185	372	29	284	949	677	1626	798	596	202	1619	611	1008
7	Ulawe	423	1033	995	2028	129	122	251	76	568	796	540	1336	684	513	171	1344	517	827
8	Targhar	620	1634	1360	2994	210	209	419	91	1419	1220	647	1867	1177	821	356	1817	718	1099
9	Wahal	878	2359	2221	4580	279	276	555	25	217	1890	1256	3146	1606	650	956	2974	1229	1745
10	Kharkopar	148	345	325	670	48	47	95	15	16	283	222	505	208	160	48	462	158	304
11	Bambavi	129	318	310	628	46	59	105	5	111	195	122	317	321	99	222	307	142	165
12	Kundevahal	245	665	679	1344	105	103	208	0	210	512	368	880	542	525	17	802	309	493
13	Navi Mumbai (Panvel, Raigarh) (CT)	18456	46219	35636	81855	6648	6047	12695	2766	2685	35570	22065	57635	29186	26148	3038	52669	20330	32339
14	Palidevad	1196	2703	2197	4900	406	335	741	250	64	2135	1467	3602	1912	1767	145	2988	1135	1853
15	Vadghar	1140	2713	2607	5320	481	507	988	196	292	1993	1446	3439	1819	1616	203	3501	1256	2245
16	Owle	807	2083	1946	4029	294	319	613	44	174	1509	1016	2525	1569	1079	490	2460	1023	1437
17	Panvel (M Cl)	23894	54963	49095	104058	7125	6593	13718	4924	2753	44433	36060	80493	36341	34121	2220	67717	24997	42720
	Sub Total	**49859**	**119925**	**101928**	**221853**	**16523**	**15322**	**31845**	**8727**	**9175**	**94204**	**67773**	**161977**	**78882**	**70179**	**8703**	**142971**	**54125**	**88846**
3-7 kms Panvel tehsil, Raighar district, Maharashtra											523.00								
18	Taloje Panchnad (CT)	1736	5905	4934	10839	1037	955	1992	95	76	4281	3002	7283	3595	3149	446	7244	2704	4540
19	Kharghar	1269	3173	2820	5993	451	422	873	108	278	2435	1730	4165	1625	1221	404	4368	1824	2544
20	Pale Bk.	150	379	372	751	60	42	102	68	70	276	203	479	236	174	62	515	179	336
21	Harigram	272	695	758	1453	127	127	254	7	198	443	348	791	464	203	261	989	343	646
22	Koproli	207	513	461	974	93	87	180	27	348	297	192	489	433	373	60	541	231	310
23	Chipale	208	515	473	988	68	51	119	45	15	419	339	758	425	326	99	563	217	346
24	Bonshet	83	204	217	421	29	25	54	0	0	157	127	284	185	144	41	236	94	142
25	Nevali	175	423	366	789	65	58	123	0	17	336	231	567	492	235	257	297	161	136
26	Adai	393	1001	975	1976	152	164	316	101	59	727	466	1193	958	679	279	1018	419	599
27	Akurli	268	744	647	1391	133	99	232	19	19	560	372	932	422	347	75	969	402	567
28	Shilottar Raichur	480	1144	884	2028	198	175	373	47	6	897	571	1468	731	703	28	1297	501	796
29	Devad	215	564	518	1082	75	70	145	29	60	444	285	729	342	150	192	740	287	453
30	Moho	301	780	755	1535	103	114	217	36	1	583	414	997	670	542	128	865	376	489
31	Shivkar	372	1030	916	1946	148	142	290	40	0	730	487	1217	892	599	293	1054	495	559
32	Vichumbe	486	1194	969	2163	178	187	365	23	39	922	548	1470	1033	957	76	1130	465	665
33	Usarli Kh	237	602	512	1114	110	87	197	3	49	435	299	734	480	297	183	634	290	344
34	Chikhale	298	1038	899	1937	144	129	273	0	354	841	579	1420	779	483	296	1158	612	546
35	Nhave	755	1918	1632	3550	284	237	521	47	37	1508	1053	2561	985	763	222	2565	1041	1524
36	Gavhan	1870	4699	4468	9167	597	572	1169	186	3417	3649	2538	6187	2734	1808	926	6433	2416	4017
37	Manghar	50	136	140	276	22	21	43	5	32	105	82	187	160	39	121	116	61	55
38	Mosare	79	183	160	343	32	25	57	0	185	114	71	185	226	221	5	117	62	55
39	Patnoli	82	214	213	427	33	38	71	0	86	138	87	225	241	181	60	186	78	108
40	Nanoshi	106	241	239	480	58	52	110	0	406	107	46	153	303	219	84	177	86	91
41	Chirvat	48	114	117	231	13	21	34	0	16	87	56	143	124	116	8	107	53	54
42	Turmale	231	576	600	1176	83	86	169	81	39	415	327	742	623	455	168	553	255	298
43	Vadavali	40	113	91	204	18	10	28	5	0	81	53	134	58	33	25	146	65	81
44	Nandgaon	422	986	987	1973	144	142	286	6	212	694	525	1219	560	408	152	1413	546	867
45	Kudave	215	516	492	1008	79	63	142	0	11	383	282	665	455	301	154	553	238	315
46	Palaspe	694	1595	1480	3075	257	221	478	89	140	1249	1009	2258	1093	924	169	1982	786	1196
47	Kolkhe	614	1670	1294	2964	247	215	462	27	62	1332	803	2135	1247	879	368	1717	712	1005
48	Kon	354	872	818	1690	130	127	257	8	0	651	480	1131	659	612	47	1031	390	641
49	Derawali	196	464	462	926	81	90	171	8	0	327	245	572	299	221	78	627	228	399
50	Kalundre (CT)	1784	3928	3656	7584	561	512	1073	318	184	3220	2729	5949	2343	2076	267	5241	1892	3349
Thane tehsil, Thane district, Maharastra																			
51	Navi Mumbai (M Corp.)	163738	395705	308297	704002	51489	47256	98745	44154	10976	311531	204536	516067	270692	253325	17367	433310	163783	269527
Uran tehsil, Raighar district, Maharashtra																			
52	Jasai	1479	3511	2966	6477	487	520	1007	224	118	2501	1489	3990	2473	2201	272	4004	1495	2509
53	Chirle	588	1530	1401	2931	211	177	388	45	245	1146	805	1951	1473	1015	458	1458	669	789
54	Veshvi	337	835	829	1664	125	111	236	0	199	647	467	1114	715	458	257	949	390	559
55	Belondakhar	115	305	333	638	46	48	94	23	16	248	214	462	342	171	171	296	141	155
56	Paundkhar	37	89	84	173	15	9	24	0	0	70	52	122	61	34	27	112	37	75
57	Dhutum	390	961	812	1773	110	93	203	0	0	827	528	1355	629	464	165	1144	429	715
	Sub Total	**181374**	**441065**	**349047**	**790112**	**58293**	**53580**	**111873**	**45874**	**17970**	**345813**	**228670**	**574483**	**302257**	**277506**	**24751**	**487855**	**185453**	**302402**
7-10 kms Panvel tehsil, Raighar district, Maharashtra																			
58	Adivali	131	438	330	768	78	68	146	5	92	291	159	450	305	247	58	463	181	282
59	Ghot	454	1128	815	1943	154	138	292	41	108	829	423	1252	784	706	78	1159	455	704
60	Koyana Velhe	287	650	592	1242	93	80	173	3	0	519	381	900	379	229	150	863	341	522
61	Taloje Majkur	321	897	866	1763	128	99	227	0	72	713	521	1234	773	544	229	990	409	581
62	Pisarve	247	584	636	1220	95	116	211	0	156	383	317	700	690	364	326	530	224	306
63	Rohinjan	450	1202	1106	2308	233	200	433	51	6	912	678	1590	698	659	39	1610	620	990
64	Bid	12	43	38	81	9	13	22	0	20	20	14	34	31	12	19	50	24	26
65	Owe	1076	3140	2944	6084	562	495	1057	31	654	2138	1569	3707	1938	1511	427	4146	1686	2460
66	Valap	310	841	646	1487	141	105	246	36	102	663	403	1066	566	514	52	921	345	576
67	Devichapada	754	1994	1135	3129	266	252	518	75	4	1492	503	1995	1653	1599	54	1476	570	906
68	Kanpoli	139	378	362	740	69	55	124	4	50	279	194	473	439	201	238	301	154	147

ANNEXURE-XXI
DEMOGRAPHIC DETAILS
(2001 CENSUS)

Sl.No.	Name of Village	No.of House Holds	Total Male	Total Female	Total Population	Male Below 6 Agegroup	Female Below 6 Agegroup	Population Below 6 Age group	SC Population	ST Population	Male Literates	Female Literates	Total Literates	Total Workers	Main Workers	Marginal Workers	Non Workers	Non Workers Male	Non Workers Female
69	Chindharan	364	1016	1030	2046	168	184	352	15	0	760	571	1331	651	535	116	1395	524	871
70	Hedutane	145	361	330	691	88	100	188	2	506	146	49	195	355	348	7	336	142	194
71	Kevale	215	570	598	1168	95	111	206	5	189	334	235	569	568	358	210	600	261	339
72	Khanav	143	435	411	846	71	86	157	0	7	266	185	451	284	191	93	562	205	357
73	Chinchavali Tarf Waje	86	284	254	538	52	48	100	2	28	199	121	320	258	240	18	280	133	147
74	Umroli	177	402	396	798	70	65	135	0	38	281	219	500	284	200	84	514	178	336
75	Vakadi	285	895	711	1606	149	144	293	33	481	577	328	905	651	485	166	955	470	485
76	Vihighar	192	548	547	1095	77	88	165	0	0	418	291	709	411	384	27	684	269	415
77	Nere	645	1678	1543	3221	287	271	558	60	353	1146	827	1973	1318	751	567	1903	763	1140
78	Ambivali	67	187	158	345	28	16	44	0	1	139	95	234	161	107	54	184	75	109
79	Sangatoli	97	226	238	464	42	50	92	0	257	93	66	159	269	232	37	195	83	112
80	Wangani Tarf Waje	75	205	207	412	28	29	57	0	125	143	109	252	204	194	10	208	84	124
81	Loniwadi	126	344	340	684	33	51	84	0	47	289	183	472	345	188	157	339	147	192
82	Pali Kh	111	275	257	532	38	31	69	0	46	199	133	332	284	75	209	248	128	120
83	Bherle	139	306	289	595	54	48	102	0	595	111	55	166	321	8	313	274	140	134
84	Sangade	157	358	366	724	35	52	87	0	0	302	218	520	201	100	101	523	186	337
85	Belavali	270	707	715	1422	93	103	196	0	0	524	371	895	1050	385	665	372	166	206
86	Borle	148	380	397	777	41	62	103	27	0	302	216	518	389	227	162	388	141	247
87	Bhingar	304	729	691	1420	96	85	181	0	0	544	378	922	572	327	245	848	361	487
88	Ajivali	285	671	577	1248	101	84	185	57	9	543	415	958	432	391	41	816	287	529
89	Shedung	123	320	233	553	42	48	90	0	0	244	124	368	234	202	32	319	110	209
90	Ariwali	132	328	294	622	47	34	81	0	4	264	196	460	279	275	4	343	129	214
91	Ashte	65	171	160	331	23	17	40	9	8	140	127	267	108	49	59	223	77	146
92	Kasal Khand	214	595	548	1143	99	74	173	11	131	457	378	835	499	258	241	644	273	371
93	Bhatan	258	651	641	1292	78	71	149	0	18	522	405	927	582	248	334	710	295	415
94	Somtane	170	417	437	854	62	56	118	94	17	326	294	620	276	149	127	578	206	372
95	Giravale	118	305	302	607	36	40	76	0	51	209	166	375	196	189	7	411	141	270
96	Shirdhon	765	1786	1737	3523	271	244	515	19	225	1279	990	2269	1261	874	387	2262	872	1390
97	Sangurli	133	337	327	664	57	45	102	0	146	221	170	391	224	193	31	440	156	284
98	Chinchavan	274	650	608	1258	103	92	195	0	297	492	302	794	662	232	430	596	281	315
99	Narpoli	151	378	373	751	55	58	113	0	0	294	260	554	346	289	57	405	164	241
100	Dahivali	83	200	187	387	27	25	52	0	0	146	103	249	198	118	80	189	94	95
Uran tehsil, Raighar district, Maharashtra																			
101	Dighode	460	1176	1147	2323	132	122	254	115	345	943	644	1587	905	781	124	1418	537	881
102	Kanthavali	76	171	149	320	28	23	51	24	48	117	71	188	143	76	67	177	84	93
103	Pohi	9	19	21	40	3	4	7	0	0	16	12	28	12	12	0	28	9	19
104	Ransai	230	429	475	904	84	100	184	0	894	181	97	278	601	422	179	303	138	165
105	Vindhane	499	1155	1149	2304	150	149	299	41	319	840	557	1397	1061	742	319	1243	538	705
106	Taki (N.V.)	98	234	226	460	26	28	54	0	8	194	135	329	151	42	109	309	121	188
107	Harishchandra Pimpale	171	387	411	798	56	65	121	0	0	313	218	531	453	116	337	345	158	187
108	Bori Bk.	154	370	348	718	58	47	105	0	0	293	195	488	319	54	265	399	184	215
109	Juna Sheva	192	426	265	691	66	55	121	12	0	353	203	556	297	296	1	394	132	262
110	Sonari	590	1409	1172	2581	187	153	340	5	0	1136	704	1840	854	820	34	1727	630	1097
111	Sawarkhar	213	430	386	816	64	61	125	0	3	324	229	553	219	218	1	597	218	379
112	Pagote	237	575	548	1123	82	77	159	4	15	473	337	810	303	286	17	820	308	512
113	Karal	185	390	401	791	69	70	139	0	0	283	239	522	221	221	0	570	178	392
	Sub Total	**13812**	**35181**	**32070**	**67251**	**5379**	**5087**	**10466**	**781**	**6475**	**25615**	**17383**	**42998**	**27668**	**19474**	**8194**	**39583**	**15785**	**23798**
	Grand Total	**245045**	**596171**	**483045**	**1079216**	**80195**	**73989**	**154184**	**55382**	**33620**	**465632**	**313826**	**779458**	**408807**	**367159**	**41648**	**670409**	**255363**	**415046**
Source: Census of India 2001.																			

ANNEXURE-XXI
DEMOGRAPHIC DATA
(2011 CENSUS)

Sl.No.	Name of Village	No.of House Holds	Total Male	Total Female	Total Population	Male Below 6 Agegroup	Female Below 6 Agegroup	Population Below 6 Age group	SC Population	ST Population	Male Literates	Female Literates	Total Literates	Total Workers	Main Workers	Marginal Workers	Non Workers	Non Workers Male	Non Workers Female
0-3 kms Panvel tehsil, Raighar district, Maharashtra																			
1	Vaghivali	99	264	239	503	49	33	82	0	0	206	174	380	138	123	15	365	141	224
2	Pargaon Dungi	70	165	170	335	17	16	33	0	5	142	137	279	120	113	7	215	65	150
3	Kopar	328	694	679	1373	109	104	213	48	132	509	400	909	408	345	63	965	329	636
4	Karanjade	857	1931	1711	3642	288	263	551	354	424	1433	1070	2503	1396	1360	36	2246	823	1423
5	Dapoli	588	1407	1255	2662	212	179	391	250	15	1087	880	1967	903	874	29	1759	683	1076
6	Pargaon	704	1619	1542	3161	229	216	445	216	340	1242	1018	2260	1053	883	170	2108	704	1404
7	Ulawe	583	1341	1295	2636	194	188	382	251	692	1013	823	1836	885	634	251	1751	609	1142
8	Targhar	959	2118	1917	4035	287	321	608	130	1683	1623	1125	2748	1534	1328	206	2501	846	1655
9	Wahal	1273	2907	2697	5604	389	367	756	126	202	2271	1664	3935	1732	1558	174	3872	1384	2488
10	Kharkopar	656	1464	1375	2839	185	195	380	81	39	1163	897	2060	992	922	70	1847	600	1247
11	Padeghar	28	50	41	91	10	10	20	0	0	20	4	24	65	64	1	26	13	13
12	Bambavi	183	366	331	697	58	51	109	38	89	214	142	356	343	326	17	354	143	211
13	Kundevahal	360	837	858	1695	129	143	272	0	283	624	511	1135	612	415	197	1083	398	685
14	Navi Mumbai Panvel Raigarh (CT)	46920	107342	88031	195373	14165	12708	26873	14989	4793	86155	63982	150137	75042	67522	7520	120331	44267	76064
15	Palidevad (CT)	2193	4913	4281	9194	572	552	1124	1142	297	4154	3363	7517	3223	3088	135	5971	2248	3723
16	Vadghar (CT)	1700	3873	3468	7341	645	571	1216	443	248	2828	2140	4968	2796	2042	754	4545	1753	2792
17	Owle (CT)	947	2202	2073	4275	336	293	629	229	156	1695	1349	3044	1357	1238	119	2918	990	1928
18	Panvel (M Cl)	43107	92484	87536	180020	9695	8764	18459	14464	4301	79450	72243	151693	67994	61532	6462	112026	41049	70977
	Sub Total	**101555**	**225977**	**199499**	**425476**	**27569**	**24974**	**52543**	**32761**	**13699**	**185829**	**151922**	**337751**	**160593**	**144367**	**16226**	**264883**	**97045**	**167838**
3-7 kms Panvel tehsil, Raighar district, Maharashtra																			
19	Talode Panchnad (CT) WARD NO.-00	2749	7668	6650	14318	1279	1291	2570	567	336	5832	4499	10331	4319	4030	289	9999	3703	6296
20	Kharghar (CT) WARD NO.-0001	20737	42001	38611	80612	4895	4593	9488	5750	1534	35342	31232	66574	31350	27643	3707	49262	18263	30999
21	Pale Bk.	667	1556	1076	2632	186	166	352	72	226	1168	680	1848	1437	1203	234	1195	479	716
22	Harigram	358	892	852	1744	115	97	212	24	313	638	478	1116	1007	688	319	737	362	375
23	Koproli	227	571	455	1026	73	63	136	65	93	444	312	756	387	347	40	639	238	401
24	Chipale	373	857	772	1629	83	86	169	96	380	707	572	1279	754	276	478	875	381	494
25	Bonshet	117	308	242	550	23	29	52	0	3	240	135	375	264	240	24	286	84	202
26	Nevali	330	807	653	1460	119	92	211	172	176	604	421	1025	511	478	33	949	366	583
27	Adai	804	1812	1546	3358	257	236	493	445	101	1329	922	2251	1465	1243	222	1893	707	1186
28	Akurli	813	1850	1494	3344	287	233	520	246	51	1443	1059	2502	1473	1346	127	1871	727	1144
29	Shilottar Raichur	1409	3178	2618	5796	464	346	810	961	95	2570	1980	4550	2330	2036	294	3466	1324	2142
30	Devad	803	1765	1445	3210	235	226	461	464	168	1388	900	2288	1413	1187	226	1797	624	1173
31	Moho	394	925	897	1822	95	104	199	90	22	734	577	1311	780	674	106	1042	387	655
32	Shivkar	527	1297	1167	2464	152	177	329	74	24	996	723	1719	812	763	49	1652	605	1047
33	Vichumbe	1624	3512	2820	6332	388	395	783	1012	152	2833	2023	4856	2615	2282	333	3717	1399	2318
34	Usarli Kh	628	1397	1211	2608	183	151	334	412	170	1138	901	2039	893	807	86	1715	650	1065
35	Chikhale	443	998	901	1899	109	91	200	4	36	809	652	1461	666	634	32	1233	458	775
36	Nhave	798	1884	1647	3531	162	156	318	53	24	1631	1218	2849	1309	1221	88	2222	795	1427
37	Gavhan	1894	4270	4141	8411	482	444	926	86	3283	3479	2853	6332	2775	2474	301	5636	1867	3769
38	Manghar	93	196	176	372	35	25	60	39	36	140	117	257	150	137	13	222	73	149
39	Mosare	125	308	277	585	69	56	125	0	371	210	155	365	180	17	163	405	154	251
40	Patnoli	91	223	230	453	36	33	69	1	65	146	130	276	165	95	70	288	85	203
41	Nanoshi	130	316	303	619	61	47	108	6	523	152	114	266	188	187	1	431	163	268
42	Chirvat	63	154	124	278	15	14	29	0	0	124	76	200	115	107	8	163	47	116
43	Turmale	256	602	646	1248	53	74	127	85	53	468	391	859	426	374	52	822	239	583
44	Vadavali	39	112	95	207	16	15	31	3	0	80	59	139	83	83	0	124	52	72
45	Nandgaon	529	1175	1130	2305	149	153	302	11	216	918	721	1639	731	576	155	1574	556	1018
46	Kudave	284	658	634	1292	76	75	151	27	21	525	382	907	491	458	33	801	283	518
47	Palaspe	1267	2644	2442	5086	313	320	633	423	202	2166	1798	3964	1958	1782	176	3128	1093	2035
48	Kolkhe	1113	2521	2136	4657	327	287	614	205	99	2019	1556	3575	1655	1448	207	3002	1070	1932
49	Kon	503	1182	1005	2187	156	108	264	44	61	901	684	1585	978	720	258	1209	517	692
50	Derawali	256	643	562	1205	93	69	162	18	12	479	370	849	432	353	79	773	304	469
51	Kalundre (CT)	1672	3515	3111	6626	436	405	841	372	218	2798	2276	5074	2419	2186	233	4207	1488	2719
Thane tehsil, Thane district, Maharastra																			
52	Navi Mumbai (M Corp.)	273626	610060	510487	1120547	68142	61449	129591	100067	18913	501797	386320	888117	455485	419469	36016	665062	248838	416224
Uran tehsil, Raighar district, Maharashtra																			
53	Jasai (CT)	2133	4520	3714	8234	715	665	1380	818	214	3315	2272	5587	3220	2982	238	5014	1702	3312
54	Chirle	821	1924	1790	3714	267	244	511	54	244	1447	1202	2649	1310	961	349	2404	866	1538
55	Veshvi	436	1000	977	1977	124	122	246	26	249	790	652	1442	643	405	238	1334	461	873
56	Belondakhar	175	381	414	795	48	51	99	12	0	302	292	594	210	209	1	585	197	388
57	Paundkhar	329	688	642	1330	76	58	134	5	0	578	528	1106	473	276	197	857	264	593
58	Dhutum	467	1039	1005	2044	125	135	260	7	1	839	684	1523	616	574	42	1428	487	941
	Sub Total	**320103**	**711409**	**601098**	**1312507**	**80919**	**73381**	**154300**	**112816**	**28685**	**583519**	**452916**	**1036435**	**528488**	**482971**	**45517**	**784019**	**292358**	**491661**
7-10 kms Panvel tehsil, Raighar district, Maharashtra																			
59	Adivali	161	440	331	771	48	40	88	25	35	348	212	560	290	271	19	481	194	287
60	Ghot	841	1951	1390	3341	271	241	512	274	185	1435	831	2266	1489	1250	239	1852	704	1148
61	Koyana Velhe	319	692	645	1337	77	72	149	328	6	581	511	1092	489	348	141	848	301	547
62	Taloje Majkur	384	1067	959	2026	154	132	286	167	87	819	623	1442	662	534	128	1364	507	857
63	Pisarve	240	571	608	1179	83	58	141	97	0	451	427	878	387	362	25	792	248	544
64	Rohinjan	901	2138	1882	4020	355	361	716	191	30	1658	1277	2935	1451	1348	103	2569	970	1599
65	Bid	24	57	61	118	8	13	21	0	16	41	36	77	35	26	9	83	28	55
66	Owe	1909	5371	4375	9746	740	706	1446	284	779	3959	2720	6679	3531	3090	441	6215	2503	3712
67	Valap	542	1298	938	2236	165	140	305	16	158	1001	593	1594	967	845	122	1269	476	793
68	Devichapada	1409	3487	2087	5574	363	328	691	291	27	2931	1469	4400	2907	2454	453	2667	968	1699
69	Kanpoli	142	370	357	727	37	56	93	3	18	291	225	516	336	148	188	391	140	251
70	Chindharan	474	1174	1076	2250	139	116	255	11	0	972	759	1731	777	734	43	1473	542	931
71	Hedutane	129	377	342	719	71	61	132	4	624	179	110	289	242	176	66	477	190	287
72	Kevale	237	607	573	1180	62	67	129	8	544	454	360	814	622	333	289	558	258	300
73	Khanav	176	421	392	813	52	37	89	0	2	319	254	573	370	196	174	443	190	253
74	Chinchavali Tarf Waje	119	300	283	583	37	37	74	2	35	221	186	407	219	181	38	364	115	249
75	Umroli	164	427	439	866	48	49	97	0	0	340	293	633	467	353	114	399	173	226

ANNEXURE-XXI
DEMOGRAPHIC DATA
(2011 CENSUS)

Sl.No.	Name of Village	No.of House Holds	Total Male	Total Female	Total Population	Male Below 6 Agegroup	Female Below 6 Agegroup	Population Below 6 Age group	SC Population	ST Population	Male Literates	Female Literates	Total Literates	Total Workers	Main Workers	Marginal Workers	Non Workers	Non Workers Male	Non Workers Female
76	Vakadi	356	800	769	1569	105	101	206	69	450	551	429	980	762	592	170	807	342	465
77	Vihighar	249	596	579	1175	55	49	104	22	0	479	376	855	507	385	122	668	235	433
78	Nere	768	1850	1719	3569	220	206	426	387	202	1440	1173	2613	1239	1158	81	2330	872	1458
79	Ambivali	92	219	179	398	21	24	45	0	0	154	111	265	133	133	0	265	105	160
80	Sangatoli	66	154	167	321	23	23	46	38	102	96	92	188	161	146	15	160	69	91
81	Wangani Tarf Waje	108	321	297	618	31	28	59	0	147	200	155	355	275	265	10	343	158	185
82	Loniwadi	171	427	429	856	55	59	114	25	89	339	259	598	546	495	51	310	136	174
83	Pali Kh	108	277	254	531	31	36	67	0	6	214	138	352	156	152	4	375	135	240
84	Bherle	172	354	382	736	54	71	125	0	731	209	156	365	331	228	103	405	140	265
85	Sangade	185	431	440	871	52	58	110	24	0	332	273	605	303	261	42	568	180	388
86	Belavali	367	816	844	1660	88	95	183	3	19	636	584	1220	686	657	29	974	339	635
87	Borle	189	437	453	890	59	50	109	35	19	313	278	591	361	328	33	529	172	357
88	Bhingar	354	810	753	1563	103	84	187	5	10	631	471	1102	798	644	154	765	256	509
89	Ajivali	317	739	678	1417	102	85	187	134	7	578	475	1053	453	405	48	964	357	607
90	Shedung	97	236	216	452	22	20	42	0	0	201	159	360	145	135	10	307	115	192
91	Ariwali	183	426	341	767	50	42	92	2	3	369	293	662	263	248	15	504	183	321
92	Ashte	78	185	161	346	12	19	31	21	0	168	142	310	106	101	5	240	86	154
93	Kasal Khand	249	589	577	1166	49	66	115	60	112	479	386	865	517	402	115	649	226	423
94	Bhatan	287	761	691	1452	88	82	170	23	11	618	503	1121	691	494	197	761	348	413
95	Somtane	246	775	495	1270	60	47	107	126	8	550	353	903	649	482	167	621	229	392
96	Giravale	161	381	359	740	48	48	96	0	62	302	230	532	316	296	20	424	168	256
97	Shirdhon	929	2046	1909	3955	231	228	459	57	192	1634	1281	2915	1530	1233	297	2425	869	1556
98	Sangurli	182	413	398	811	62	48	110	0	246	295	258	553	412	352	60	399	171	228
99	Chinchavan	306	661	632	1293	79	88	167	14	337	455	320	775	430	423	7	863	279	584
100	Narpoli	181	431	396	827	46	53	99	0	0	349	269	618	240	214	26	587	203	384
101	Dahivali	97	225	215	440	15	25	40	0	3	181	129	310	148	125	23	292	97	195
Uran tehsil, Raighar district, Maharashtra																			
102	Dighode	603	1355	1265	2620	160	146	306	119	8	1040	761	1801	1030	674	356	1590	615	975
103	Kanthavali	69	153	143	296	22	20	42	30	3	128	98	226	96	78	18	200	72	128
104	Pohi	9	19	21	40	0	0	0	0	0	19	19	38	11	10	1	29	9	20
105	Ransai	271	638	638	1276	112	123	235	4	1267	316	217	533	635	399	236	641	285	356
106	Vindhane	559	1148	1124	2272	162	125	287	55	315	808	712	1520	1006	341	665	1266	540	726
107	Taki	205	451	433	884	61	52	113	0	1	357	273	630	308	288	20	576	197	379
108	Harishchandra Pimpale	218	458	498	956	49	68	117	0	0	389	351	740	529	258	271	427	168	259
109	Bori Bk.	185	426	410	836	63	60	123	5	0	331	268	599	423	191	232	413	168	245
110	Boricha Kotha	2	3	4	7	0	0	0	0	0	3	4	7	7	0	7	0	0	0
111	Juna Sheva	1	3	4	7	0	1	1	0	0	3	3	6	4	2	2	3	1	2
112	Sonari	510	1130	1084	2214	124	128	252	13	0	953	828	1781	855	688	167	1359	486	873
113	Sawarkhar	396	818	663	1481	125	108	233	3	9	646	459	1105	522	502	20	959	340	619
114	Pagote	371	865	799	1664	112	88	200	38	23	699	595	1294	587	565	22	1077	387	690
115	Karal	393	747	627	1374	126	109	235	26	6	575	466	1041	462	454	8	912	316	596
	Sub Total	**18461**	**44322**	**38784**	**83106**	**5587**	**5277**	**10864**	**3039**	**6934**	**34040**	**25233**	**59273**	**33874**	**27453**	**6421**	**49232**	**18561**	**30671**
	Grand Total	**440119**	**981708**	**839381**	**1821089**	**114075**	**103632**	**217707**	**148616**	**49318**	**803388**	**630071**	**1433459**	**722955**	**654791**	**68164**	**1098134**	**407964**	**690170**
Source: Census of India 2011.																			

ANNEXURE-XX1
ECONOMIC PARTICIPATION
DEMOGRAPHIC DATA
(CENSUS-2011)

Sr. No	Name of The Village/Urban Area	Total workers	Main workers Total	Main workers Cultivators	Main workers Agricultural Laborers	Main workers Household Industry Workers	Main workers Other Workers	Marginal workers Total	Marginal workers Cultivators	Marginal workers Agricultural Laborers	Marginal workers Household Industry Workers	Marginal workers Other Workers	workers Other Workers 3 - 6 months Total	Marginal workers Cultivators 3 - 6 months	workers Agricultural Laborers 3 - 6	workers Household Industry Workers 3 - 6	Marginal workers Other Workers 3 to 6 months	workers Other Workers 0-3 months Total	Marginal workers Cultivators 0-3 months	workers Agricultural Laborers 0-3	workers Household Industry Workers	workers Other Workers 0-3 months
0-3 kms Panvel tehsil, Raighar district, Maharashtra																						
1	Vaghivali	138	123	5	0	1	117	15	0	0	0	15	13	0	0	0	13	2	0	0	0	2
2	Pargaon Dungi	120	113	76	3	12	22	7	1	1	1	4	3	1	0	0	2	4	0	1	1	2
3	Kopar	408	345	19	26	10	290	63	0	16	0	47	50	0	16	0	34	13	0	0	0	13
4	Karanjade	1396	1360	106	68	36	1150	36	3	0	0	33	28	2	0	0	26	8	1	0	0	7
5	Dapoli	903	874	192	11	12	659	29	10	4	2	13	27	10	4	2	11	2	0	0	0	2
6	Pargaon	1053	883	177	54	35	617	170	69	43	6	52	145	60	39	3	43	25	9	4	3	9
7	Ulawe	885	634	59	5	45	525	251	35	11	45	160	188	30	8	36	114	63	5	3	9	46
8	Targhar	1534	1328	69	4	23	1232	206	18	36	13	139	181	17	33	11	120	25	1	3	2	19
9	Wahal	1732	1558	173	25	62	1298	174	51	73	10	40	172	51	73	9	39	2	0	0	1	1
10	Kharkopar	992	922	49	54	26	793	70	10	3	0	57	56	7	1	0	48	14	3	2	0	9
11	Padeghar	65	64	1	0	0	63	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0
12	Bambavi	343	326	11	0	4	311	17	1	1	2	13	14	1	1	0	12	3	0	0	2	1
13	Kundevahal	612	415	129	110	7	169	197	100	25	0	72	193	99	25	0	69	4	1	0	0	3
14	Navi Mumbai Panvel Raigar	75042	67522	458	354	1263	65447	7520	231	154	293	6842	6873	221	144	237	6271	647	10	10	56	571
15	Palidevad (CT)	3223	3088	30	13	106	2939	135	4	4	11	116	124	3	4	9	108	11	1	0	2	8
16	Vadghar (CT)	2796	2042	221	21	41	1759	754	11	22	33	688	411	9	18	30	354	343	2	4	3	334
17	Owle (CT)	1357	1238	147	26	60	1005	119	4	10	12	93	115	4	10	11	90	4	0	0	1	3
18	Panvel (M Cl)	67994	61532	397	265	1192	59678	6462	222	56	210	5974	5891	214	51	152	5474	571	8	5	58	500
	Sub Total	**160593**	**144367**	**2319**	**1039**	**2935**	**138074**	**16226**	**770**	**459**	**638**	**14359**	**14485**	**729**	**427**	**500**	**12829**	**1741**	**41**	**32**	**138**	**1530**
3-7 kms Panvel tehsil, Raighar district, Maharashtra																						
19	Talode Panchnad (CT) WAR	4319	4030	74	23	120	3813	289	3	1	4	281	284	3	1	4	276	5	0	0	0	5
20	Kharghar (CT) WARD NO.-0	31350	27643	107	262	597	26677	3707	83	103	301	3220	3414	83	49	263	3019	293	0	54	38	201
21	Pale Bk.	1437	1203	189	69	46	899	234	28	32	1	173	228	25	32	1	170	6	3	0	0	3
22	Harigram	1007	688	372	25	7	284	319	92	20	8	199	221	84	17	8	112	98	8	3	0	87
23	Koproli	387	347	24	16	7	300	40	8	9	2	21	38	8	8	2	20	2	0	1	0	1
24	Chipale	754	276	79	10	5	182	478	20	2	8	448	478	20	2	8	448	0	0	0	0	0
25	Bonshet	264	240	22	1	7	210	24	1	1	1	21	24	1	1	1	21	0	0	0	0	0
26	Nevali	511	478	33	5	12	428	33	3	6	2	22	21	2	2	2	15	12	1	4	0	7
27	Adai	1465	1243	131	21	59	1032	222	53	18	10	141	169	50	6	8	105	53	3	12	2	36
28	Akurli	1473	1346	185	11	86	1064	127	39	11	20	57	100	27	4	19	50	27	12	7	1	7
29	Shilottar Raichur	2330	2036	83	87	150	1716	294	100	5	14	175	264	97	5	9	153	30	3	0	5	22
30	Devad	1413	1187	68	13	37	1069	226	9	7	2	208	185	8	6	0	171	41	1	1	2	37
31	Moho	780	674	151	88	1	434	106	77	16	0	13	103	76	15	0	12	3	1	1	0	1
32	Shivkar	812	763	224	12	16	511	49	11	4	2	32	45	11	4	2	28	4	0	0	0	4
33	Vichumbe	2615	2282	191	17	82	1992	333	56	7	16	254	280	55	5	15	205	53	1	2	1	49
34	Usarli Kh	893	807	62	21	15	709	86	22	10	1	53	63	19	10	1	33	23	3	0	0	20
35	Chikhale	666	634	127	81	43	383	32	9	2	0	21	30	9	2	0	19	2	0	0	0	2
36	Nhave	1309	1221	48	12	53	1108	88	9	3	1	75	82	8	0	1	73	6	1	3	0	2
37	Gavhan	2775	2474	137	59	57	2221	301	33	50	20	198	268	31	44	17	176	33	2	6	3	22
38	Manghar	150	137	35	13	0	89	13	10	0	1	2	13	10	0	1	2	0	0	0	0	0
39	Mosare	180	17	0	1	1	15	163	18	91	1	53	118	13	79	1	25	45	5	12	0	28
40	Patnoli	165	95	54	0	3	38	70	2	44	0	24	69	1	44	0	24	1	1	0	0	0
41	Nanoshi	188	187	60	89	0	38	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0
42	Chirvat	115	107	3	11	2	91	8	2	3	1	2	7	2	2	1	2	1	0	1	0	0
43	Turmale	426	374	192	28	7	147	52	15	3	1	33	49	14	3	1	31	3	1	0	0	2
44	Vadavali	83	83	43	4	1	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	Nandgaon	731	576	72	58	39	407	155	8	76	4	67	127	6	55	2	64	28	2	21	2	3
46	Kudave	491	458	127	42	9	280	33	3	4	0	26	32	2	4	0	26	1	1	0	0	0
47	Palaspe	1958	1782	104	31	55	1592	176	42	4	3	127	144	39	2	2	101	32	3	2	1	26
48	Kolkhe	1655	1448	54	25	72	1297	207	21	9	11	166	120	19	8	5	88	87	2	1	6	78
49	Kon	978	720	210	65	9	436	258	27	8	1	222	239	26	8	0	205	19	1	0	1	17
50	Derawali	432	353	77	4	24	248	79	4	3	0	72	55	3	1	0	51	24	1	2	0	21
51	Kalundre (CT)	2419	2186	12	7	51	2116	233	4	12	8	209	202	4	11	8	179	31	0	1	0	30
Thane tehsil, Thane district, Maharastra																						
52	Navi Mumbai (M Corp.)	455485	419469	1261	2723	9176	406309	36016	648	475	1549	33344	31847	632	413	1198	29604	4169	16	62	351	3740
Uran tehsil, Raighar district, Maharashtra																						
53	Jasai (CT)	3220	2982	17	49	113	2803	238	8	8	10	212	212	8	7	7	190	26	0	1	3	22
54	Chirle	1310	961	65	28	48	820	349	56	174	16	103	183	31	61	12	79	166	25	113	4	24
55	Veshvi	643	405	69	11	24	301	238	20	4	13	201	220	17	4	13	186	18	3	0	0	15
56	Belondakhar	210	209	114	4	1	90	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0
57	Paundkhar	473	276	9	0	5	262	197	60	50	2	85	136	33	34	1	68	61	27	16	1	17
58	Dhutum	616	574	18	2	13	541	42	11	4	4	23	40	11	4	2	23	2	0	0	2	0
	Sub Total	**528488**	**482971**	**4903**	**4028**	**11053**	**462987**	**45517**	**1615**	**1280**	**2038**	**40584**	**40112**	**1488**	**954**	**1615**	**36055**	**5405**	**127**	**326**	**423**	**4529**
7-10 kms Panvel tehsil, Raighar district, Maharashtra																						
59	Adivali	290	271	28	9	10	224	19	2	2	1	14	19	2	2	1	14	0	0	0	0	0
60	Ghot	1489	1250	139	12	17	1082	239	32	8	5	194	116	16	5	2	93	123	16	3	3	101
61	Koyana Velhe	489	348	49	1	10	288	141	16	15	4	106	101	12	11	4	74	40	4	4	0	32
62	Taloje Majkur	662	534	155	17	22	340	128	28	4	5	91	114	24	3	4	83	14	4	1	1	8
63	Pisarve	387	362	181	2	11	168	25	7	0	1	17	24	7	0	1	16	1	0	0	0	1
64	Rohinjan	1451	1348	222	39	41	1046	103	20	1	2	80	99	20	1	1	77	4	0	0	1	3
65	Bid	35	26	11	1	1	13	9	1	6	0	2	9	1	6	0	2	0	0	0	0	0
66	Owe	3531	3090	193	77	128	2692	441	40	20	15	366	347	29	17	6	295	94	11	3	9	71
67	Valap	967	845	36	24	14	771	122	37	3	2	80	107	29	3	2	73	15	8	0	0	7
68	Devichapada	2907	2454	133	9	42	2270	453	17	4	6	426	263	14	4	5	240	190	3	0	1	186
69	Kanpoli	336	148	4	0	0	144	188	133	10	3	42	175	131	6	1	37	13	2	4	2	5
70	Chindharan	777	734	304	25	20	385	43	14	7	3	19	42	13	7	3	19	1	1	0	0	0
71	Hedutane	242	176	38	87	2	49	66	5	50	1	10	39	4	29	0	6	27	1	21	1	4

ANNEXURE-XX1
ECONOMIC PARTICIPATION
DEMOGRAPHIC DATA
(CENSUS-2011)

Sr. No	Name of The Village/Urban Area	Total workers	Main workers Total	Main workers Cultivators	Main workers Agricultural Laborers	Main workers Household Industry Workers	Main workers Other Workers	Marginal workers Total	Marginal workers Cultivators	Marginal workers Agricultural Laborers	Marginal workers Household Industry Workers	Marginal workers Other Workers	workers Other Workers 3 - 6 months Total	Marginal workers Cultivators 3 - 6 months	workers Agricultural Laborers 3 - 6	workers Household Industry Workers 3 - 6	Marginal workers Other Workers 3 to 6 months	workers Other Workers 0-3 months Total	Marginal workers Cultivators 0-3 months	workers Agricultural Laborers 0-3	workers Household Industry Workers	workers Other Workers 0-3 months
72	Kevale	622	333	106	119	1	107	289	157	88	34	10	113	76	25	5	7	176	81	63	29	3
73	Khanav	370	196	123	2	9	62	174	78	15	10	71	162	78	12	10	62	12	0	3	0	9
74	Chinchavali Tarf Waje	219	181	79	3	1	98	38	4	1	0	33	37	3	1	0	33	1	1	0	0	0
75	Umroli	467	353	129	15	3	206	114	107	4	0	3	114	107	4	0	3	0	0	0	0	0
76	Vakadi	762	592	151	90	10	341	170	23	38	0	109	163	23	34	0	106	7	0	4	0	3
77	Vihighar	507	385	126	12	5	242	122	59	13	3	47	100	59	5	2	34	22	0	8	1	13
78	Nere	1239	1158	190	71	55	842	81	24	3	2	52	77	24	3	1	49	4	0	0	1	3
79	Ambivali	133	133	87	1	5	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	Sangatoli	161	146	53	41	11	41	15	5	8	2	0	15	5	8	2	0	0	0	0	0	0
81	Wangani Tarf Waje	275	265	132	109	3	21	10	2	6	0	2	10	2	6	0	2	0	0	0	0	0
82	Loniwadi	546	495	279	39	0	177	51	34	1	0	16	7	3	0	0	4	44	31	1	0	12
83	Pali Kh	156	152	91	50	0	11	4	0	3	0	1	4	0	3	0	1	0	0	0	0	0
84	Bherle	331	228	0	98	1	129	103	1	72	0	30	102	1	71	0	30	1	0	1	0	0
85	Sangade	303	261	43	66	5	147	42	20	8	1	13	42	20	8	1	13	0	0	0	0	0
86	Belavali	686	657	375	32	19	231	29	6	1	1	21	21	4	0	0	17	8	2	1	1	4
87	Borle	361	328	120	72	4	132	33	19	5	0	9	31	18	4	0	9	2	1	1	0	0
88	Bhingar	798	644	164	51	142	287	154	6	2	94	52	67	5	1	28	33	87	1	1	66	19
89	Ajivali	453	405	42	6	7	350	48	8	7	1	32	48	8	7	1	32	0	0	0	0	0
90	Shedung	145	135	23	4	52	56	10	0	0	1	9	9	0	0	0	9	1	0	0	1	0
91	Ariwali	263	248	44	0	1	203	15	2	1	0	12	13	0	1	0	12	2	2	0	0	0
92	Ashte	106	101	17	1	14	69	5	0	0	0	5	5	0	0	0	5	0	0	0	0	0
93	Kasal Khand	517	402	85	19	3	295	115	9	51	6	49	100	9	42	6	43	15	0	9	0	6
94	Bhatan	691	494	231	39	5	219	197	28	6	0	163	180	24	6	0	150	17	4	0	0	13
95	Somtane	649	482	45	9	18	410	167	5	6	9	147	158	5	5	6	142	9	0	1	3	5
96	Giravale	316	296	45	92	29	130	20	4	11	1	4	18	4	9	1	4	2	0	2	0	0
97	Shirdhon	1530	1233	145	44	95	949	297	70	44	17	166	271	66	39	12	154	26	4	5	5	12
98	Sangurli	412	352	187	79	12	74	60	26	29	4	1	53	26	24	3	0	7	0	5	1	1
99	Chinchavan	430	423	141	82	10	190	7	0	1	0	6	7	0	1	0	6	0	0	0	0	0
100	Narpoli	240	214	147	2	0	65	26	0	12	0	14	24	0	10	0	14	2	0	2	0	0
101	Dahivali	148	125	44	0	11	70	23	2	16	1	4	18	2	13	1	2	5	0	3	0	2
Uran tehsil, Raighar district, Maharashtra																						
102	Dighode	1030	674	75	13	24	562	356	57	59	129	111	155	25	20	11	99	201	32	39	118	12
103	Kanthavali	96	78	8	1	5	64	18	5	0	1	12	18	5	0	1	12	0	0	0	0	0
104	Pohi	11	10	0	0	0	10	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0
105	Ransai	635	399	288	15	3	93	236	94	114	7	21	236	94	114	7	21	0	0	0	0	0
106	Vindhane	1006	341	140	56	17	128	665	65	483	6	111	361	52	202	3	104	304	13	281	3	7
107	Taki	308	288	128	4	1	155	20	2	16	0	2	19	2	16	0	1	1	0	0	0	1
108	Harishchandra Pimpale	529	258	90	61	23	84	271	76	61	97	37	181	63	56	29	33	90	13	5	68	4
109	Bori Bk.	423	191	154	7	6	24	232	34	64	105	29	112	21	57	7	27	120	13	7	98	2
110	Boricha Kotha	7	0	0	0	0	0	7	0	7	0	0	7	0	7	0	0	0	0	0	0	0
111	Juna Sheva	4	2	0	0	0	2	2	0	1	0	1	1	0	1	0	0	1	0	0	0	1
112	Sonari	855	688	16	14	41	617	167	14	5	15	133	44	5	3	3	33	123	9	2	12	100
113	Sawarkhar	522	502	11	2	5	484	20	2	0	0	18	20	2	0	0	18	0	0	0	0	0
114	Pagote	587	565	31	5	49	480	22	4	0	1	17	22	4	0	1	17	0	0	0	0	0
115	Karal	462	454	4	2	2	446	8	3	0	0	5	8	3	0	0	5	0	0	0	0	0
	Sub Total	**33874**	**27453**	**5882**	**1731**	**1025**	**18815**	**6421**	**1407**	**1392**	**596**	**3026**	**4609**	**1150**	**912**	**171**	**2376**	**1812**	**257**	**480**	**425**	**650**
	Grand Total	**722955**	**654791**	**13104**	**6798**	**15013**	**619876**	**68164**	**3792**	**3131**	**3272**	**57969**	**59206**	**3367**	**2293**	**2286**	**51260**	**8958**	**425**	**838**	**986**	**6709**
Source: Census of India 2011.																						

ANNEXURE-XXII
AIR DISPERSION MODELING RESULTS (ISOPLETHS)

NAVI MUMBAI INTERNATIONAL AIRPORT

AIR DISPERSION MODELLING RESULTS

PHASE II & PHASE III

PARTICULARS	PAGES
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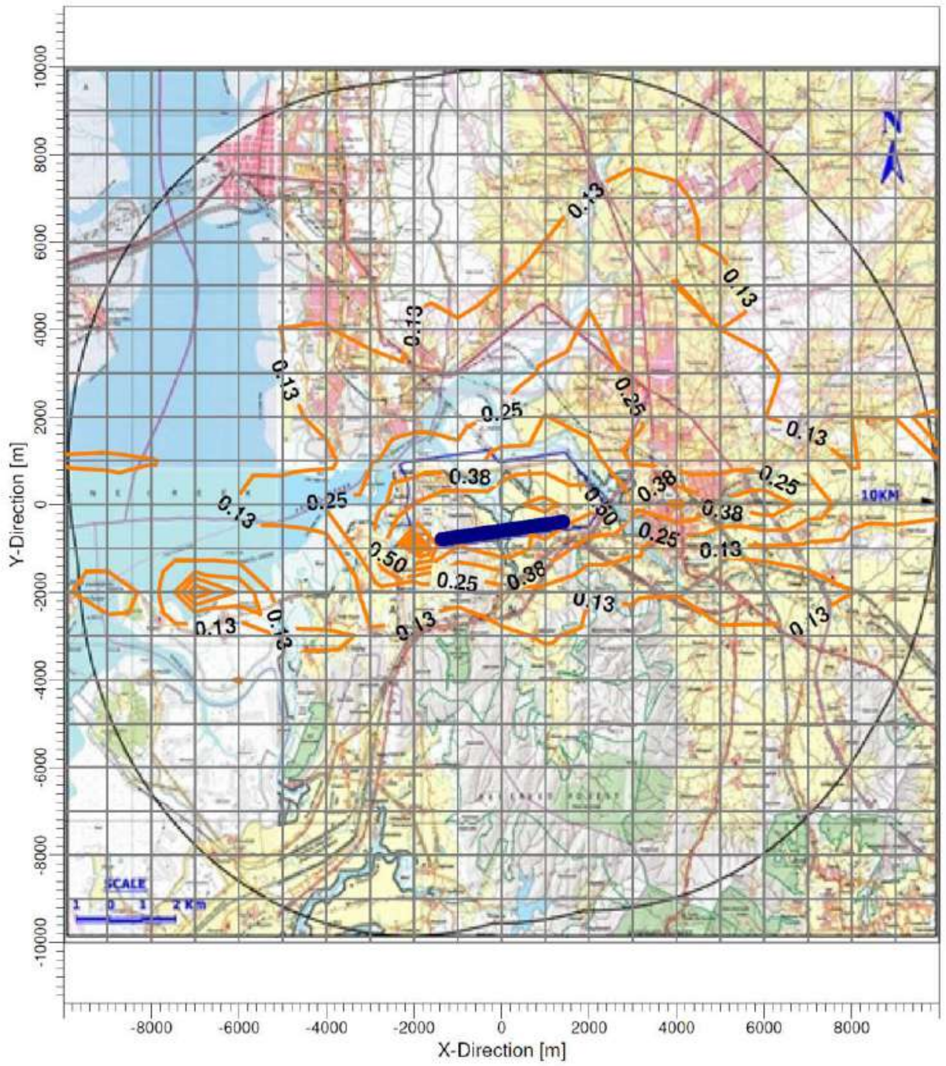
• *Air Dispersion Modelling Results of Aircraft Landing and Take-off Cycles-Phase III*	*7 to 12*
• *Air Dispersion Modelling Results of Land Traffic Assessment-Phase II*	*13 to 16*
• *Air Dispersion Modelling Results of Land Traffic Assessment-Phase III*	*17 to 20*

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -II)

PROJECT TITLE:

Navi Mumbai International Airport
Phase-II (20 MPPA)



COMMENTS:	SOURCES:	COMPANY NAME:	
Predicted GLCs - SO2	1	Vimta Labs Limited	
	RECEPTORS: 441	MODELER: M.Janardhan Bh.Durga Bhavani	
	OUTPUT TYPE: Concentration	SCALE: 1:129,374 (0 – 5 km)	
	MAX: 1.13162 ug/m^3		PROJECT NO.:

FIGURE-4.14 : PHASE-II
ISOPLETHS SHOWING INCREMENTAL CONCENTRATION FOR SO_2
RUNWAY TOWARDS SOUTH

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -II)

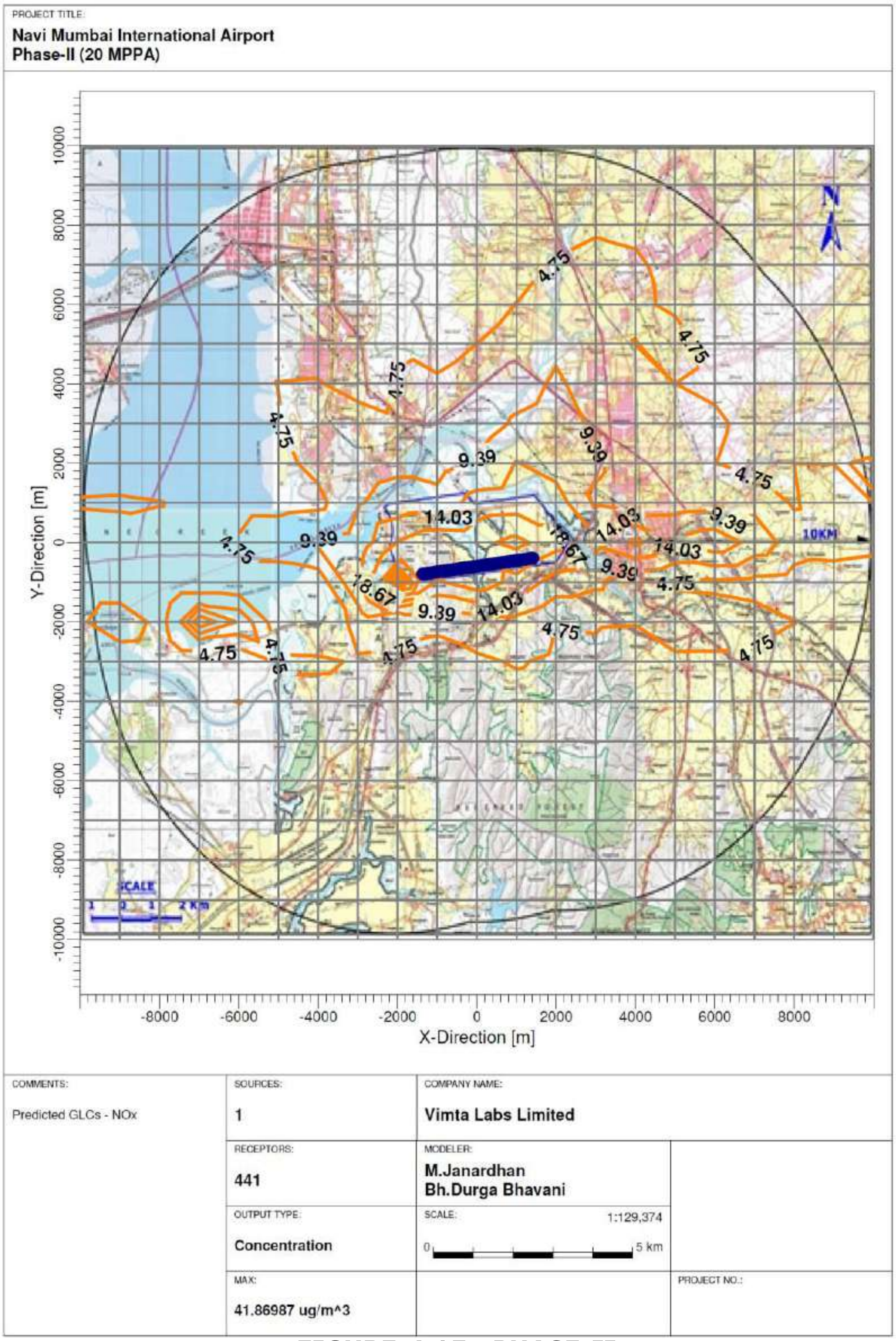


FIGURE-4.15 : PHASE-II
ISOPLETHS SHOWING INCREMENTAL CONCENTRATION FOR NO2
RUNWAY TOWARDS SOUTH

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -II)

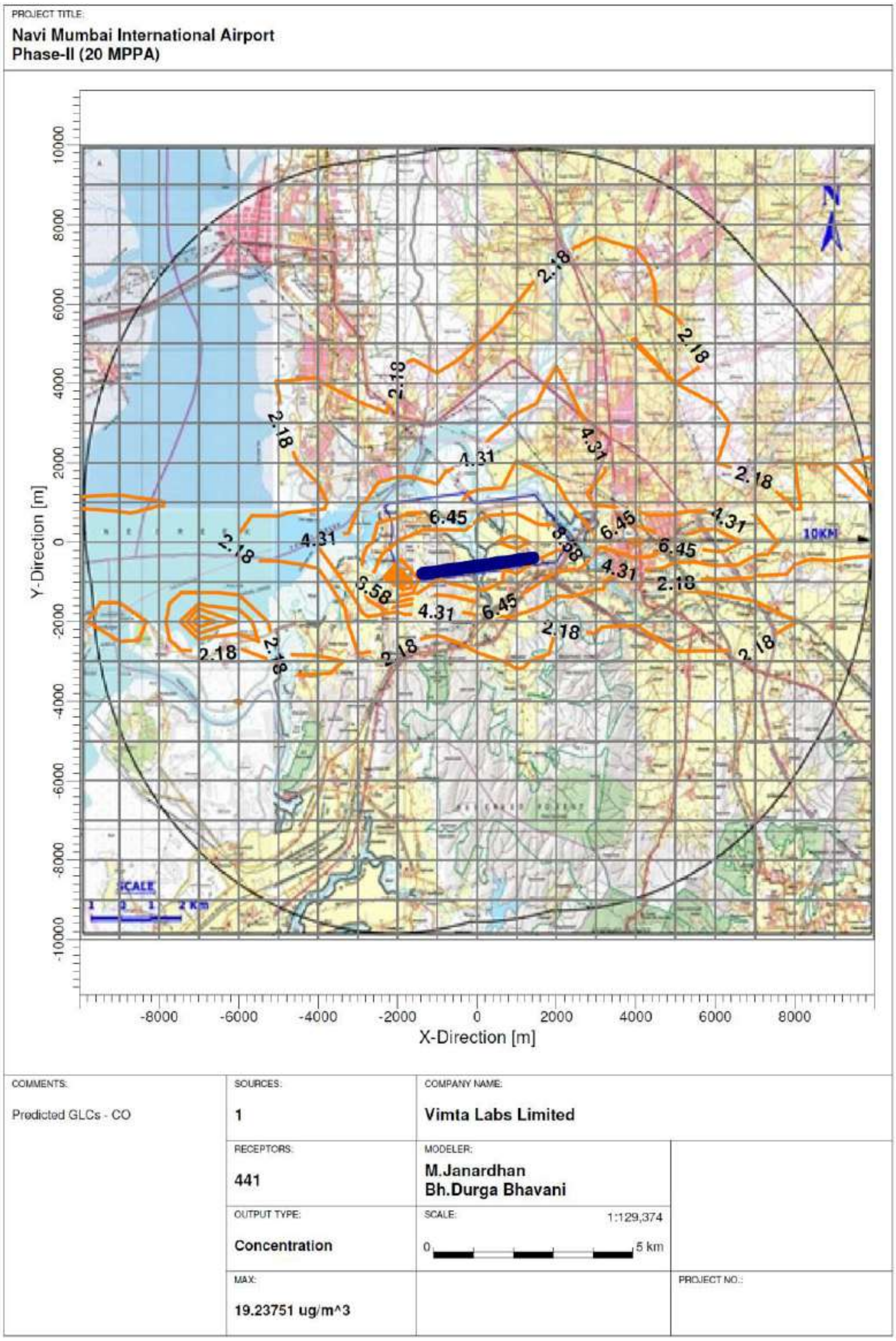
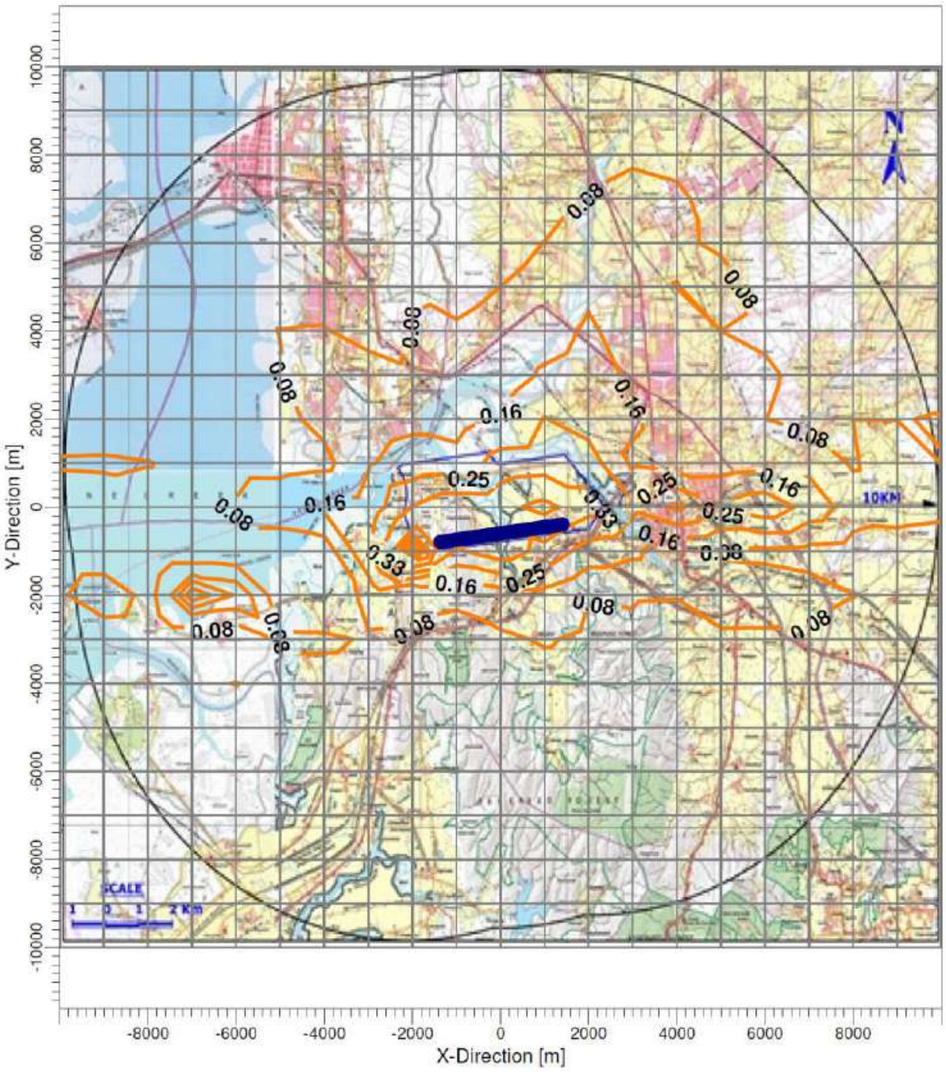


FIGURE-4.16 : PHASE-II
ISOPLETHS SHOWING INCREMENTAL CONCENTRATION FOR CO RUNWAY TOWARDS SOUTH

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -II)

PROJECT TITLE:
Navi Mumbai International Airport
Phase-II (20 MPPA)



COMMENTS:	SOURCES:	COMPANY NAME:	
Predicted GLCs - HC	1	Vimta Labs Limited	
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	OUTPUT TYPE: Concentration	SCALE: 1:129,374 0 5 km	
	MAX: 0.73555 ug/m^3		PROJECT NO.:

FIGURE-4.17 : PHASE-II
ISOPLETHS SHOWING INCREMENTAL CONCENTRATION FOR HC RUNWAY TOWARDS SOUTH

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -II)

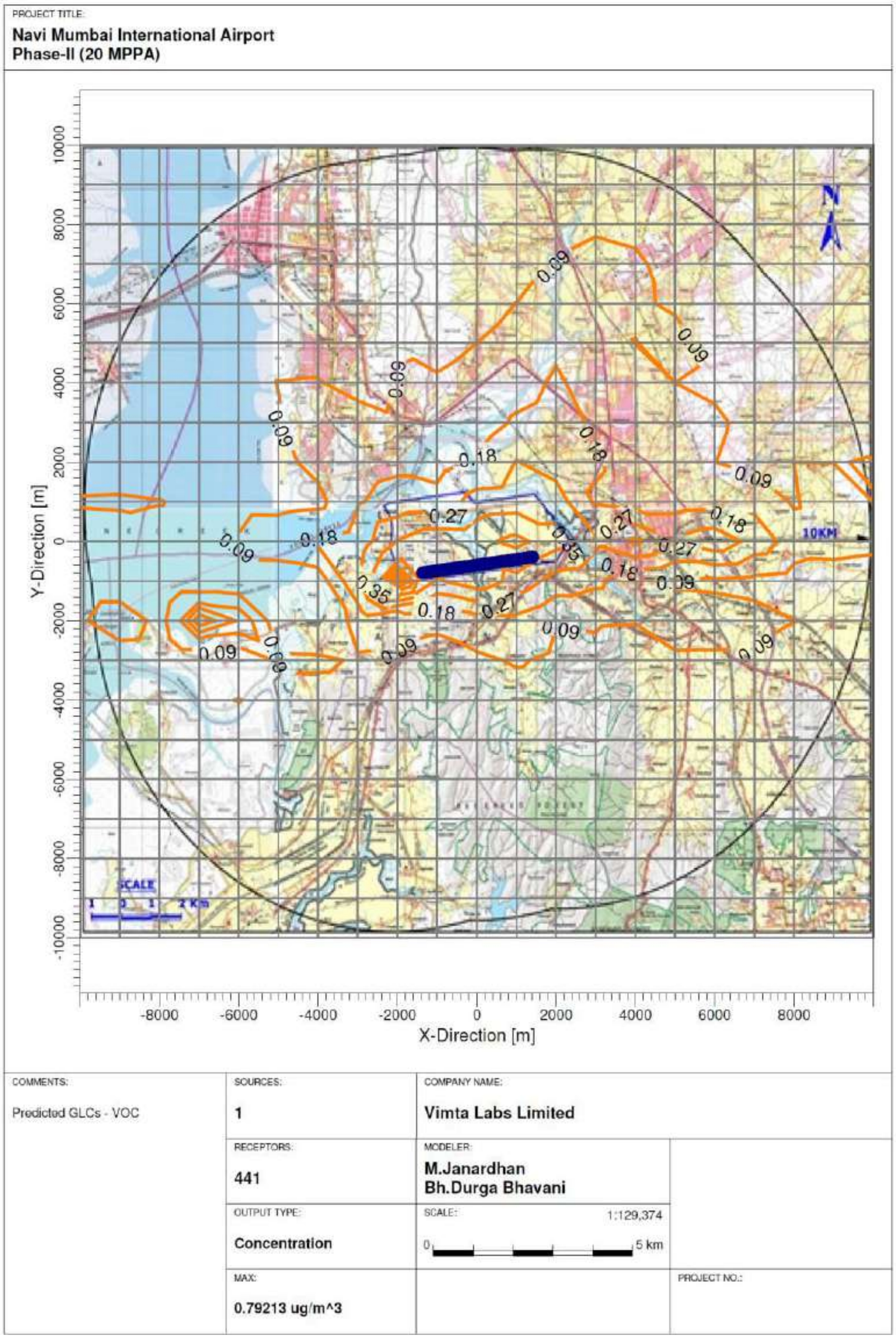


FIGURE-4.18 : PHASE-II
ISOPLETHS SHOWING INCREMENTAL CONCENTRATION FOR VOC
RUNWAY TOWARDS SOUTH

ANNEXURE-XXII: AIR DISPERSION MODELLING RESULTS

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -II)

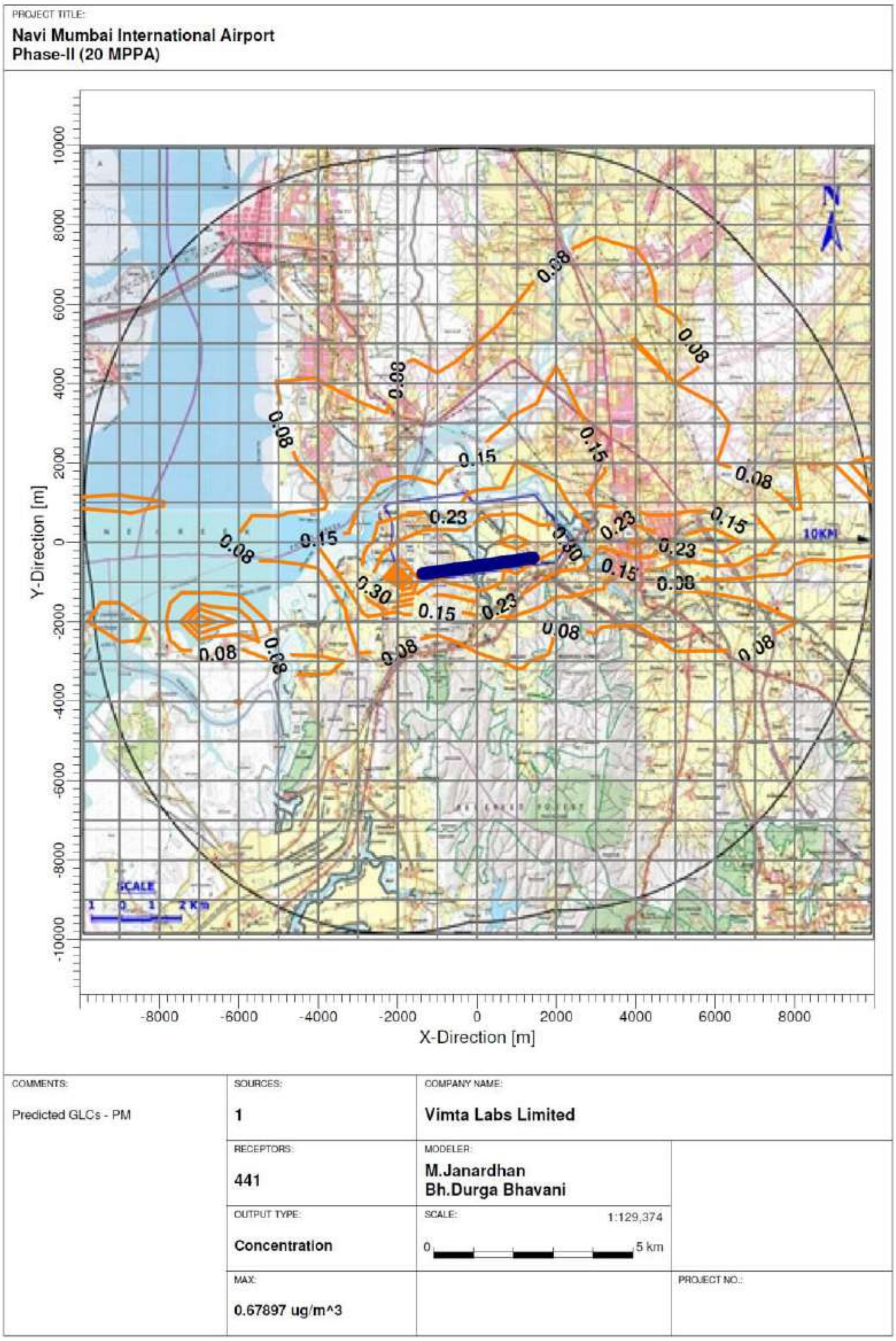


FIGURE-4.19: PHASE-II
ISOPLETHS SHOWING INCREMENTAL CONCENTRATION FOR PM10
RUNWAY TOWARDS SOUTH

ANNEXURE-XXII: AIR DISPERSION MODELLING RESULTS

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -III)

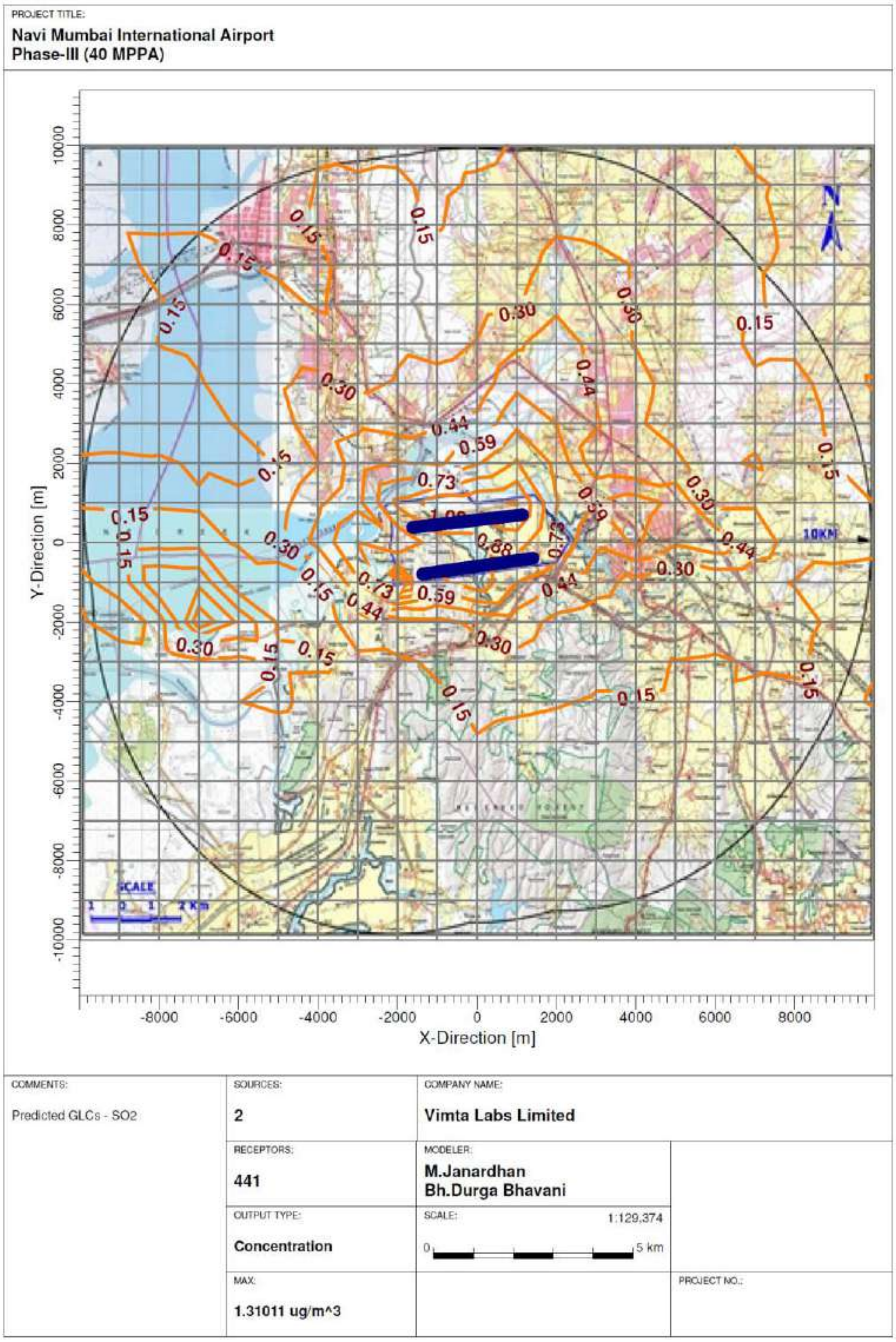


FIGURE-4.20 : PHASE-III
ISOPLETHS SHOWING GLC'S INCREMENTAL CONCENTRATION FOR SO2
RUNWAY TOWARDS SOUTH & NORTH

ANNEXURE-XXII: AIR DISPERSION MODELLING RESULTS

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -III)

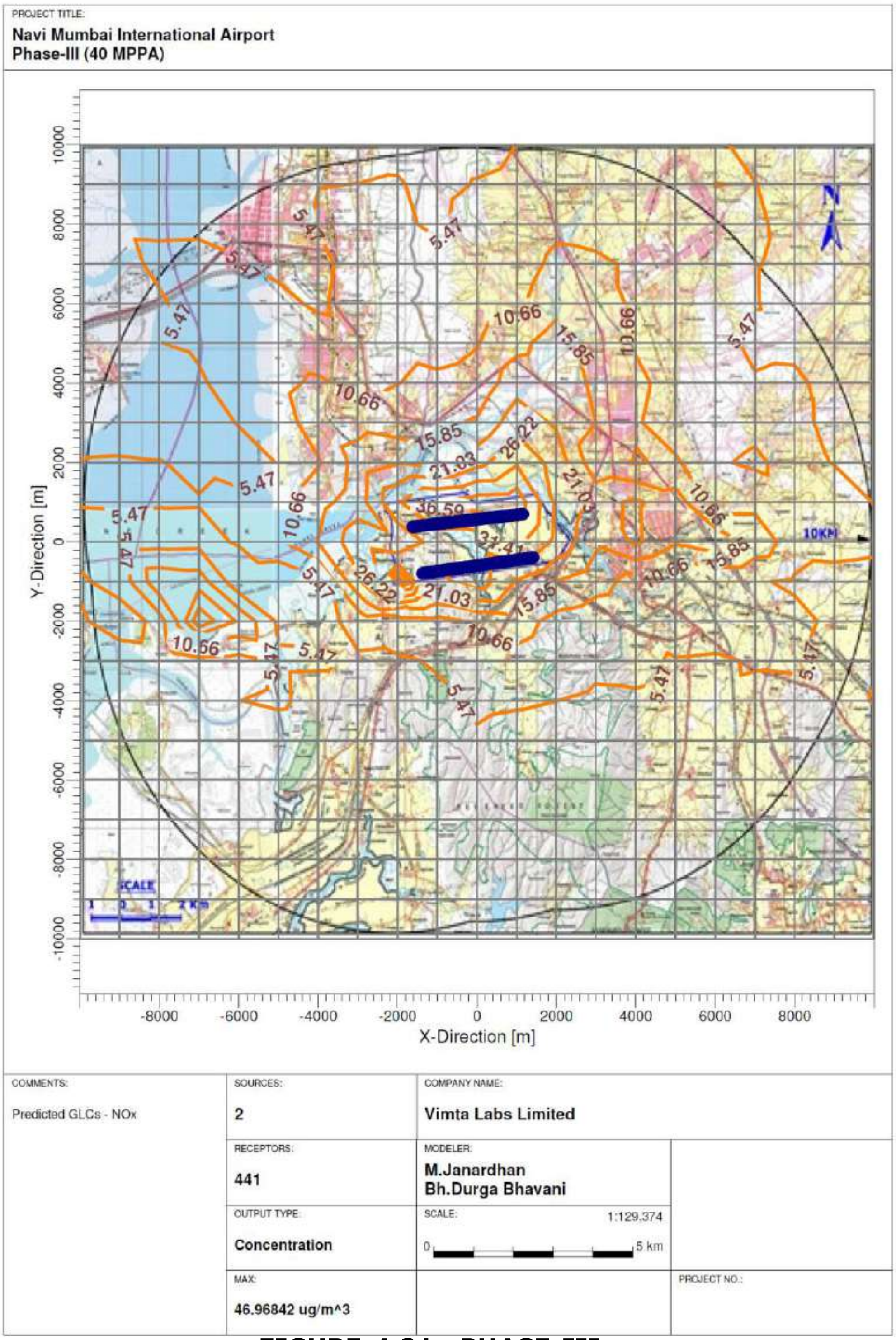


FIGURE-4.21 : PHASE-III
ISOPLETHS SHOWING GLC'S INCREMENTAL CONCENTRATION FOR NO2
RUNWAY TOWARDS SOUTH & NORTH

ANNEXURE-XXII: AIR DISPERSION MODELLING RESULTS

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -III)

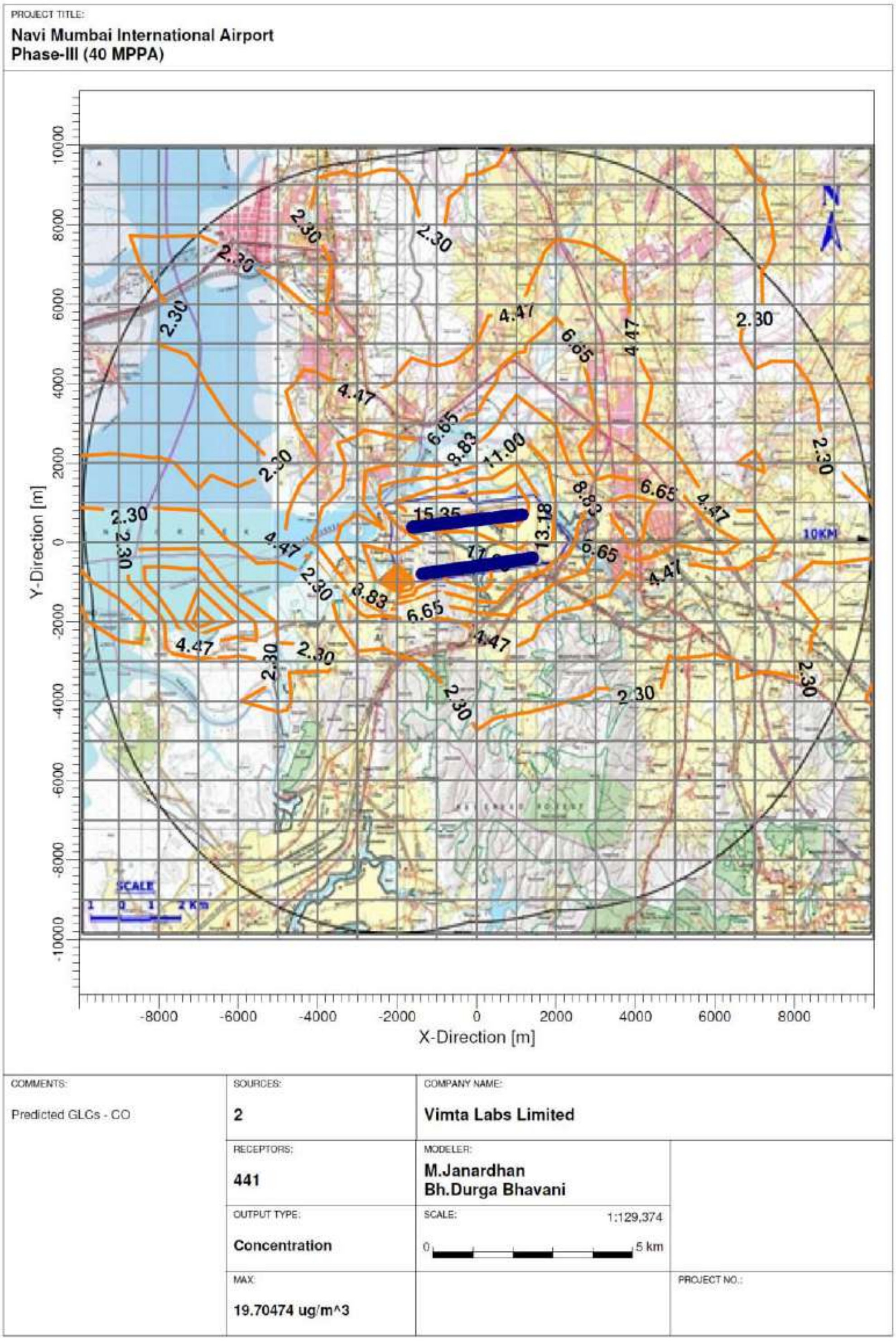
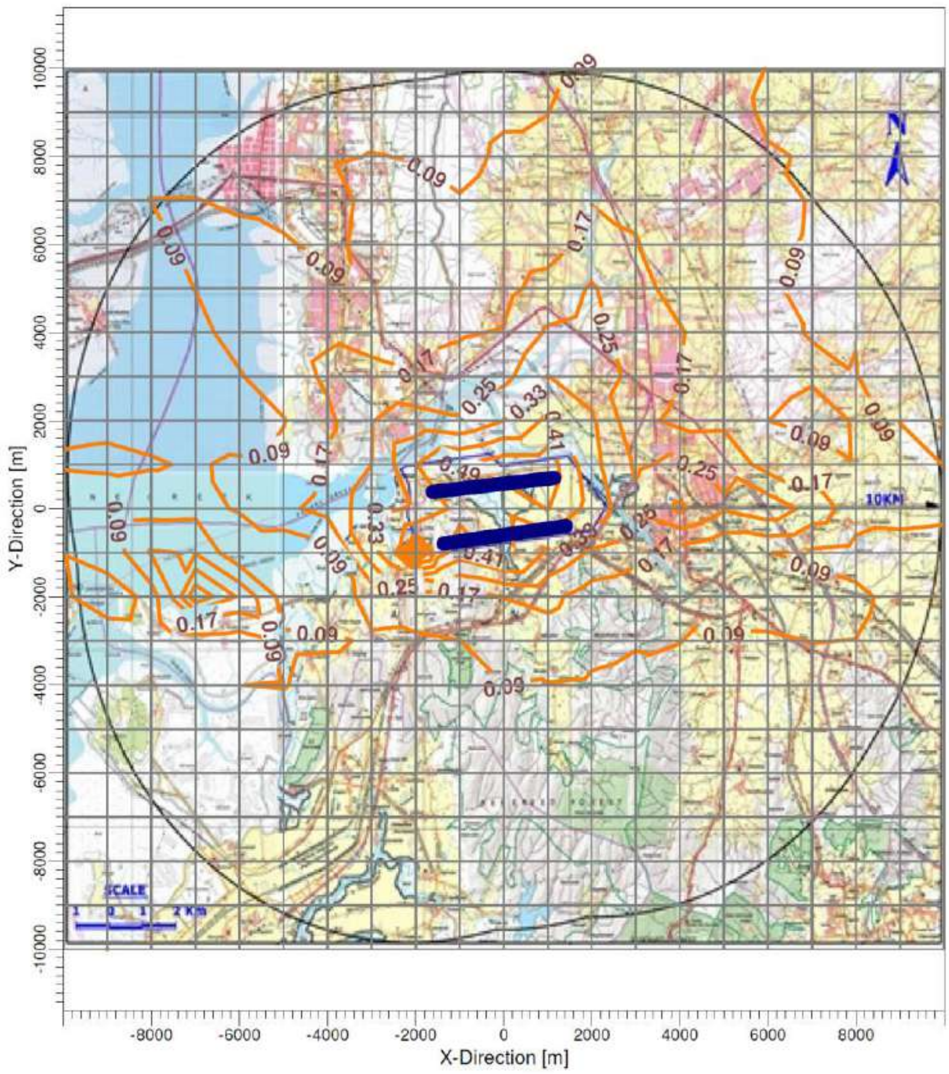


FIGURE-4.22 : PHASE-III
ISOPLETHS SHOWING GLC'S INCREMENTAL CONCENTRATION FOR CO RUNWAY TOWARDS SOUTH & NORTH

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -III)

PROJECT TITLE:
Navi Mumbai International Airport
Phase-III (40 MPPA)



COMMENTS:	SOURCES:	COMPANY NAME:	
Predicted GLCs - HC	2	Vimta Labs Limited	
	RECEPTORS: 441	MODELER: M.Janardhan Bh.Durga Bhavani	
	OUTPUT TYPE: Concentration	SCALE: 1:129,374 0 5 km	
	MAX: 0.73905 ug/m^3		PROJECT NO.:

FIGURE-4.23 : PHASE-III
ISOPLETHS SHOWING GLC'S INCREMENTAL CONCENTRATION FOR HC RUNWAY TOWARDS SOUTH & NORTH

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -III)

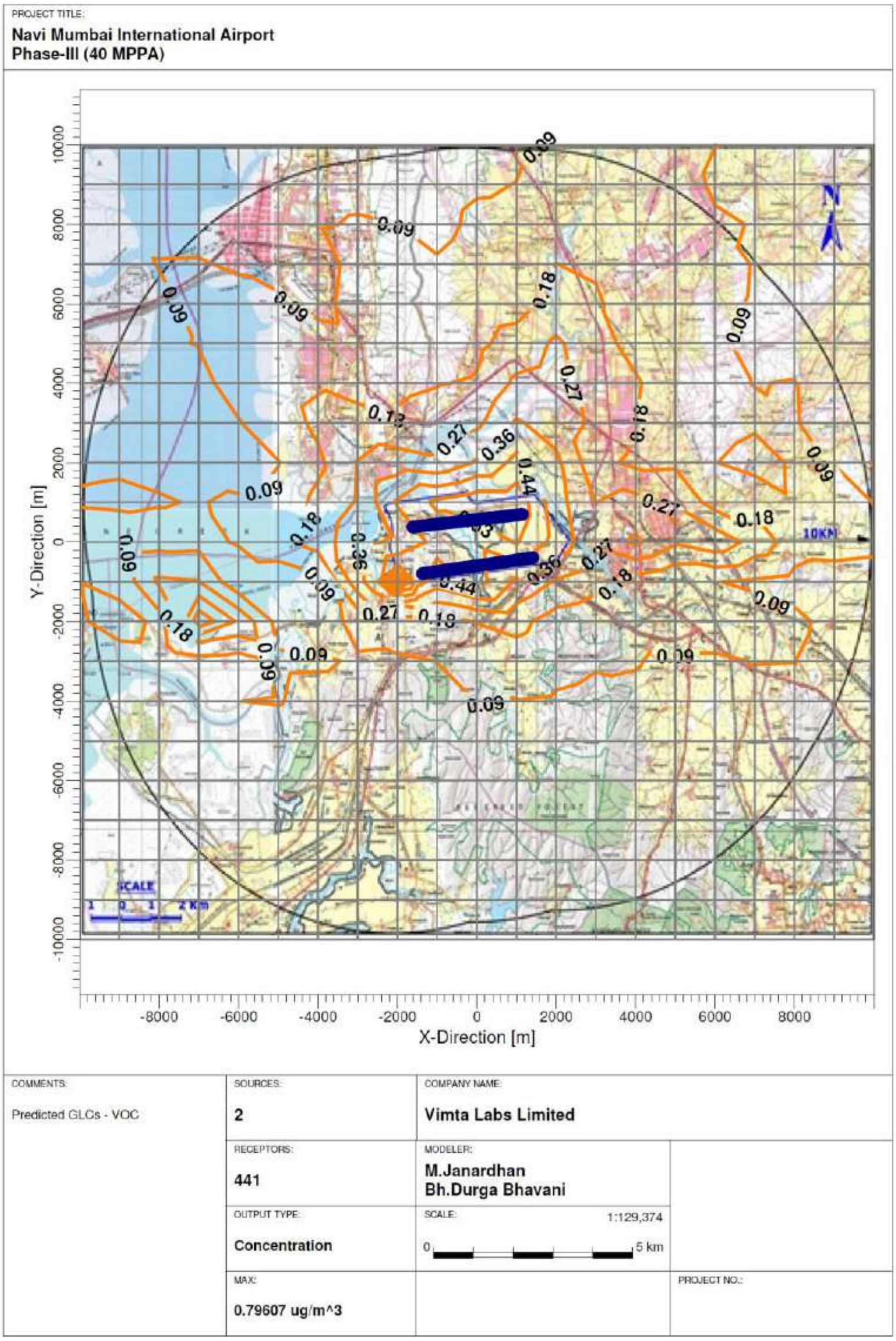


FIGURE-4.24 : PHASE-III
ISOPLETHS SHOWING GLC'S INCREMENTAL CONCENTRATION FOR VOC RUNWAY TOWARDS SOUTH & NORTH

ANNEXURE-XXII: AIR DISPERSION MODELLING RESULTS

AIR DISPERSION MODELLING RESULTS (Aircraft LTO Cycles) (PHASE -III)

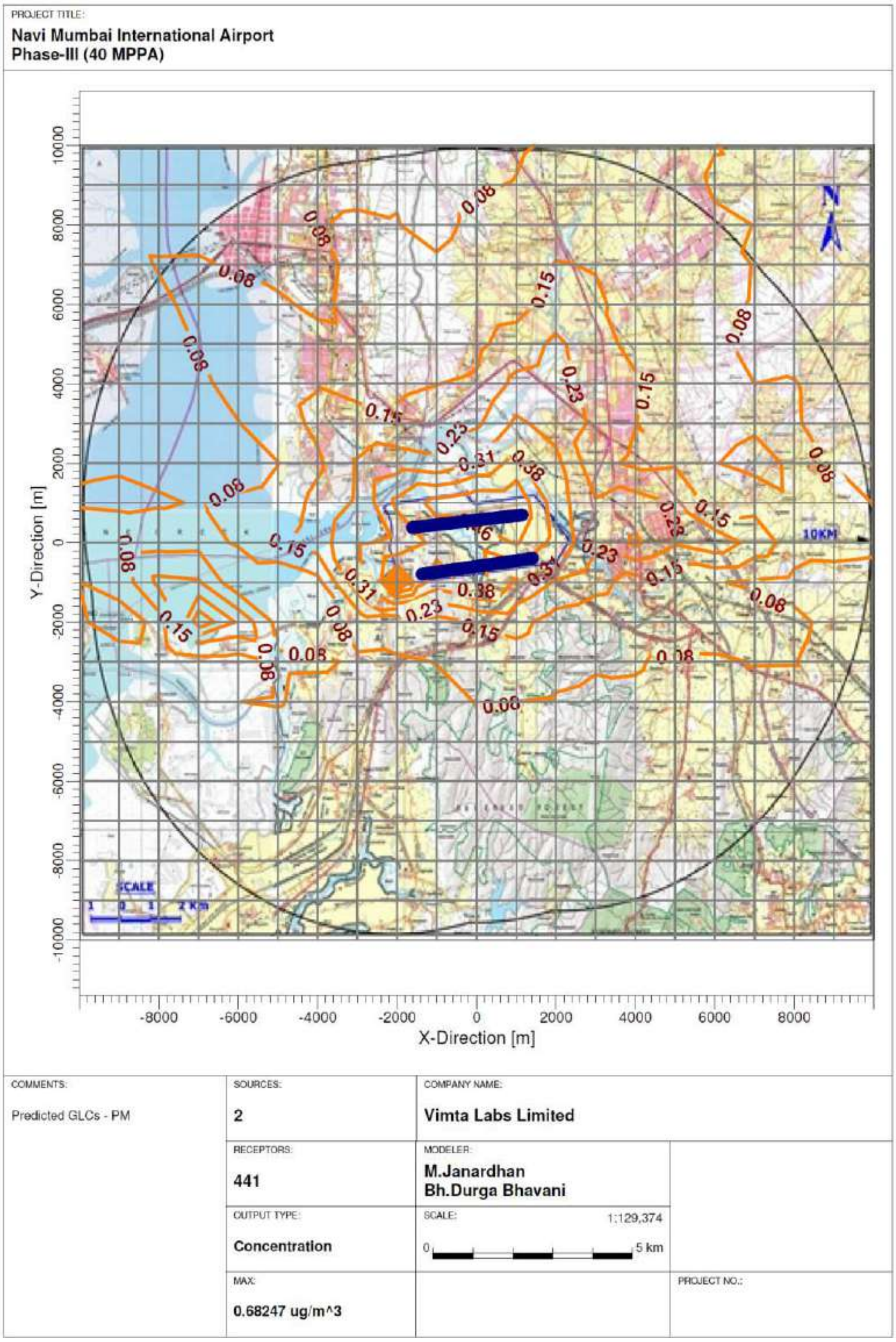


FIGURE-4.25 : PHASE-III
ISOPLETHS SHOWING GLC'S INCREMENTAL CONCENTRATION FOR PM10
RUNWAY TOWARDS SOUTH & NORTH

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessment) (PHASE -II)

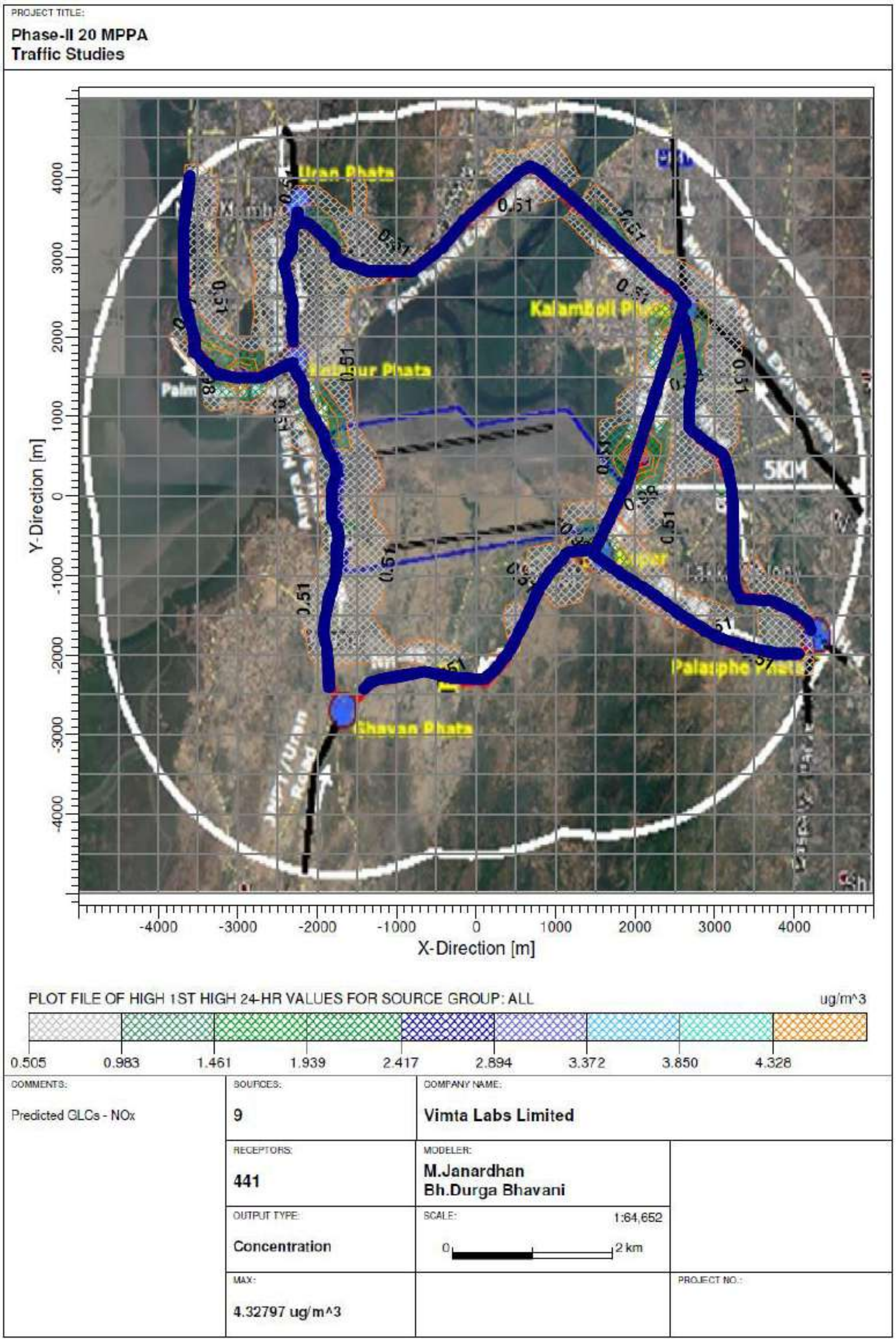


FIGURE-4.57: PHASE-II
TRAFFIC MODEL – NOX CONCENTRATIONS

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessment) (PHASE -II)

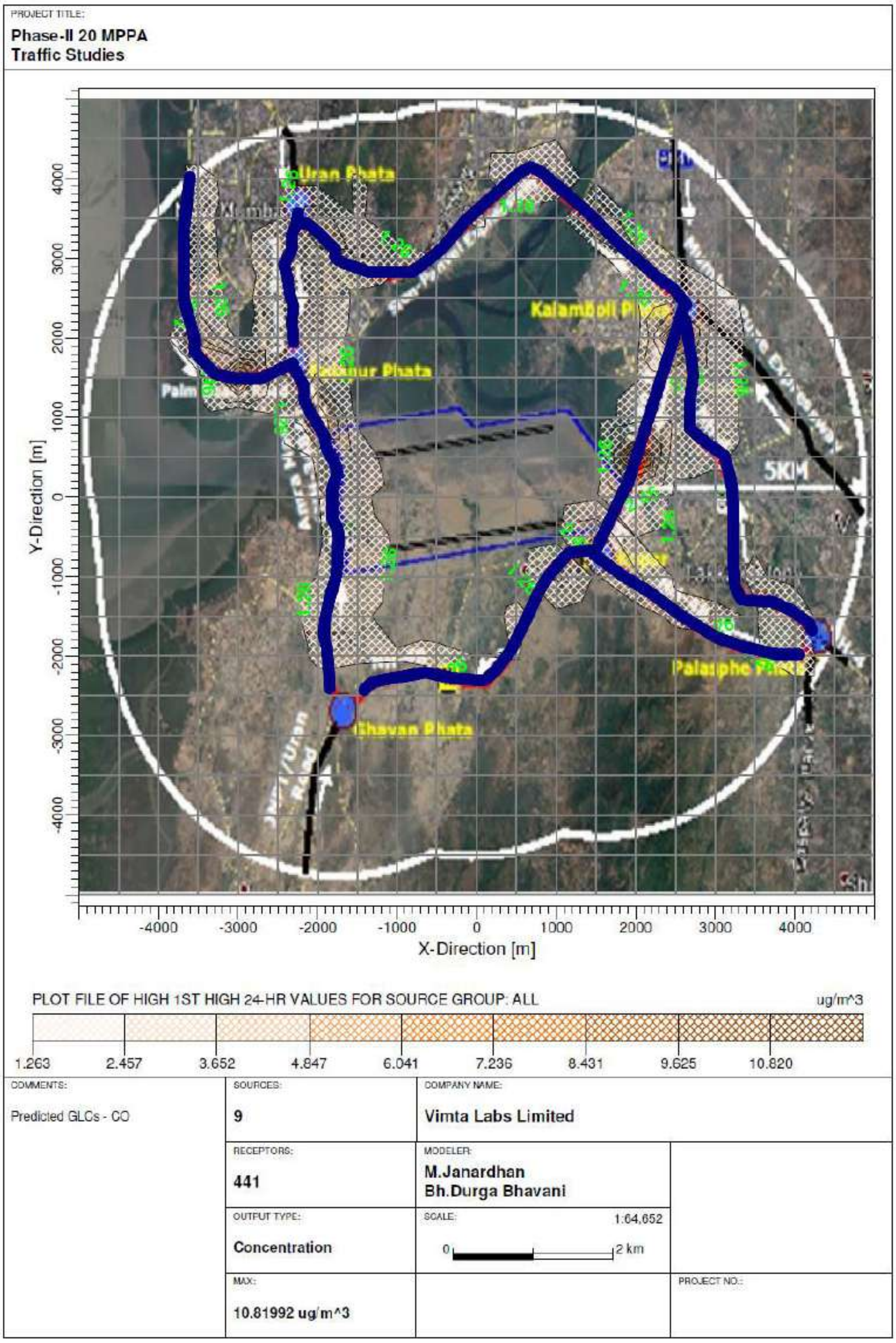


FIGURE-4.58: PHASE-II
TRAFFIC MODEL – CO CONCENTRATIONS

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessment) (PHASE -II)

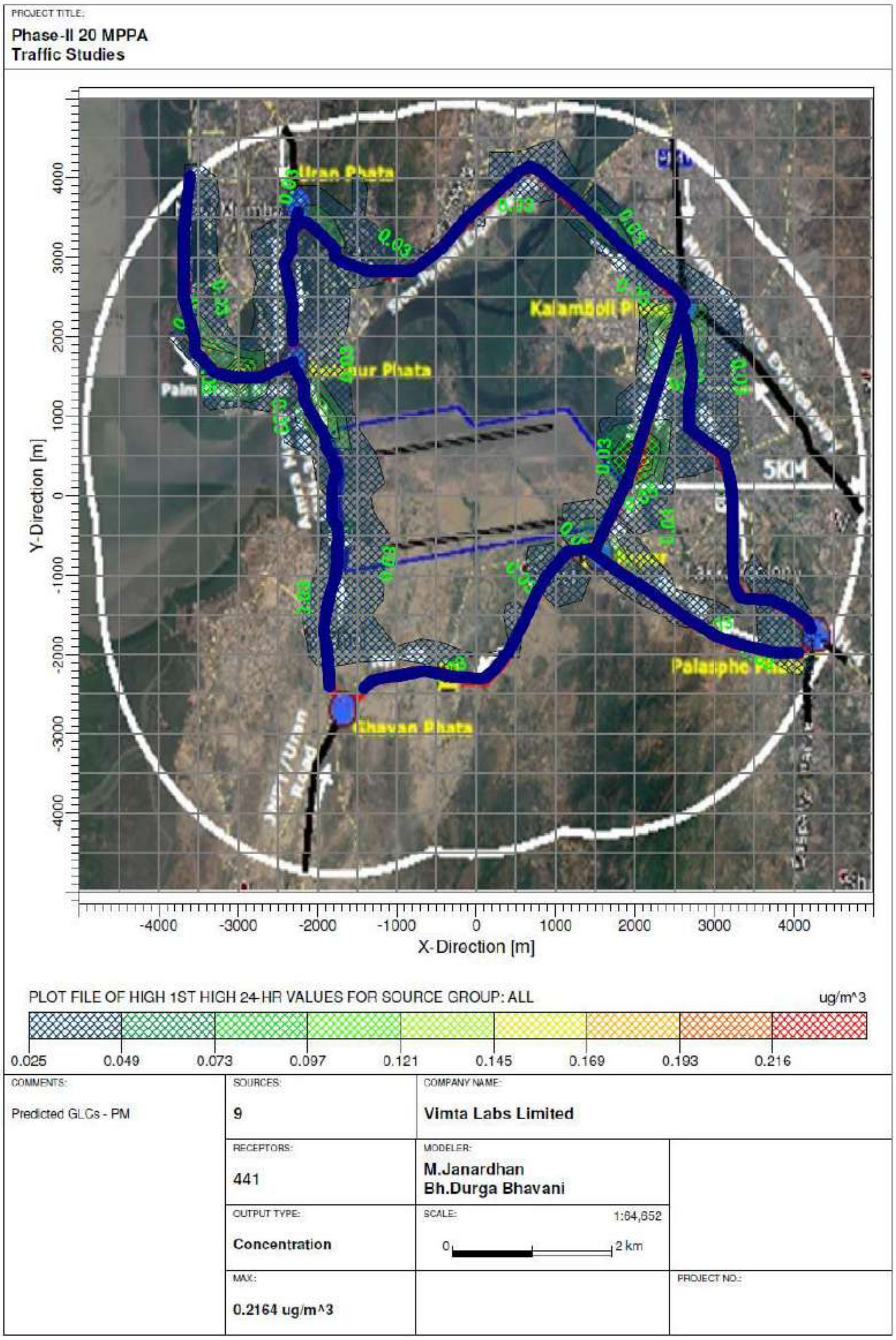


FIGURE-4.59: PHASE-II
TRAFFIC MODEL – PM10 CONCENTRATIONS

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessment) (PHASE -II)

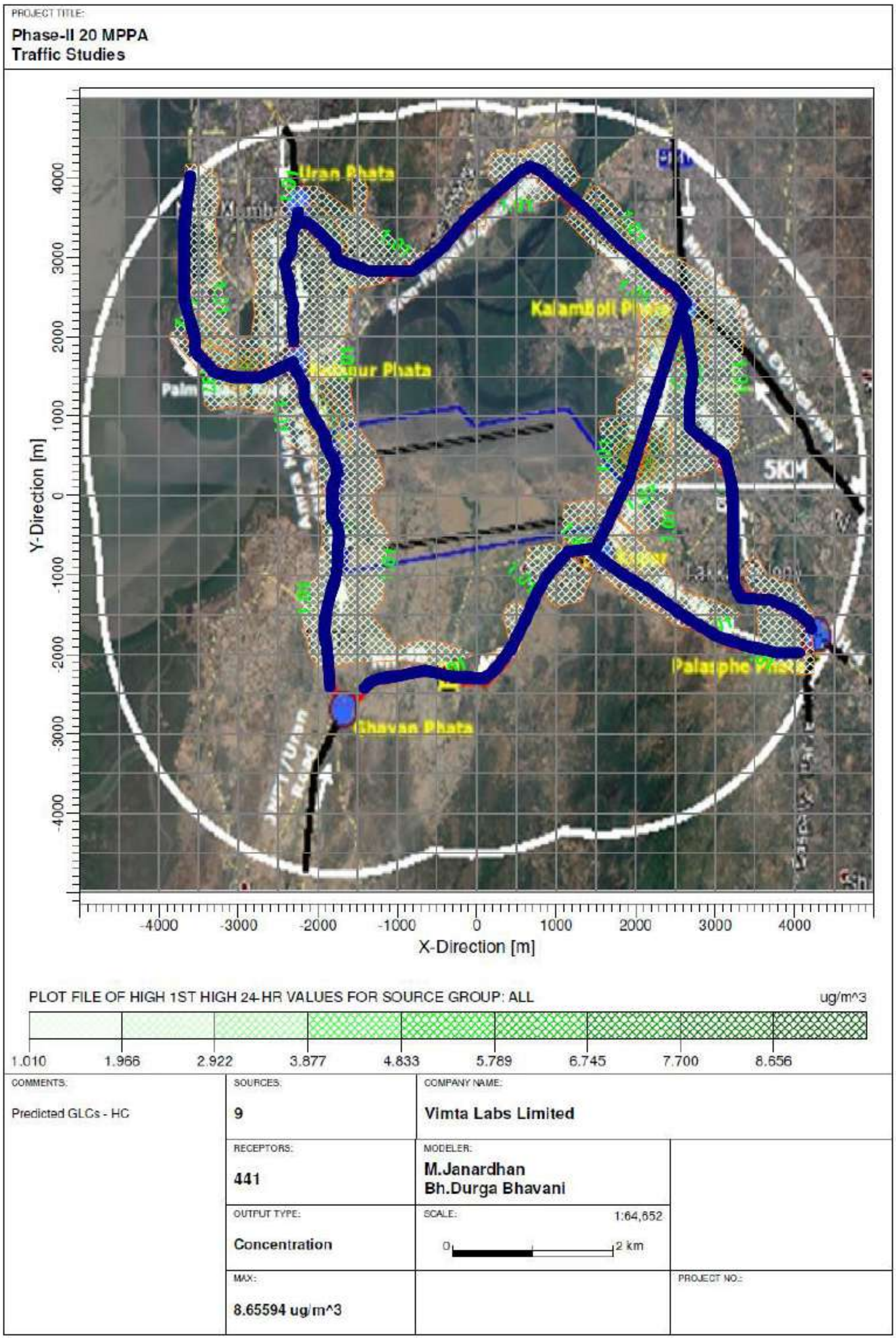


FIGURE-4.60: PHASE-II
TRAFFIC MODEL – HC CONCENTRATIONS

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessmet) (PHASE -III)

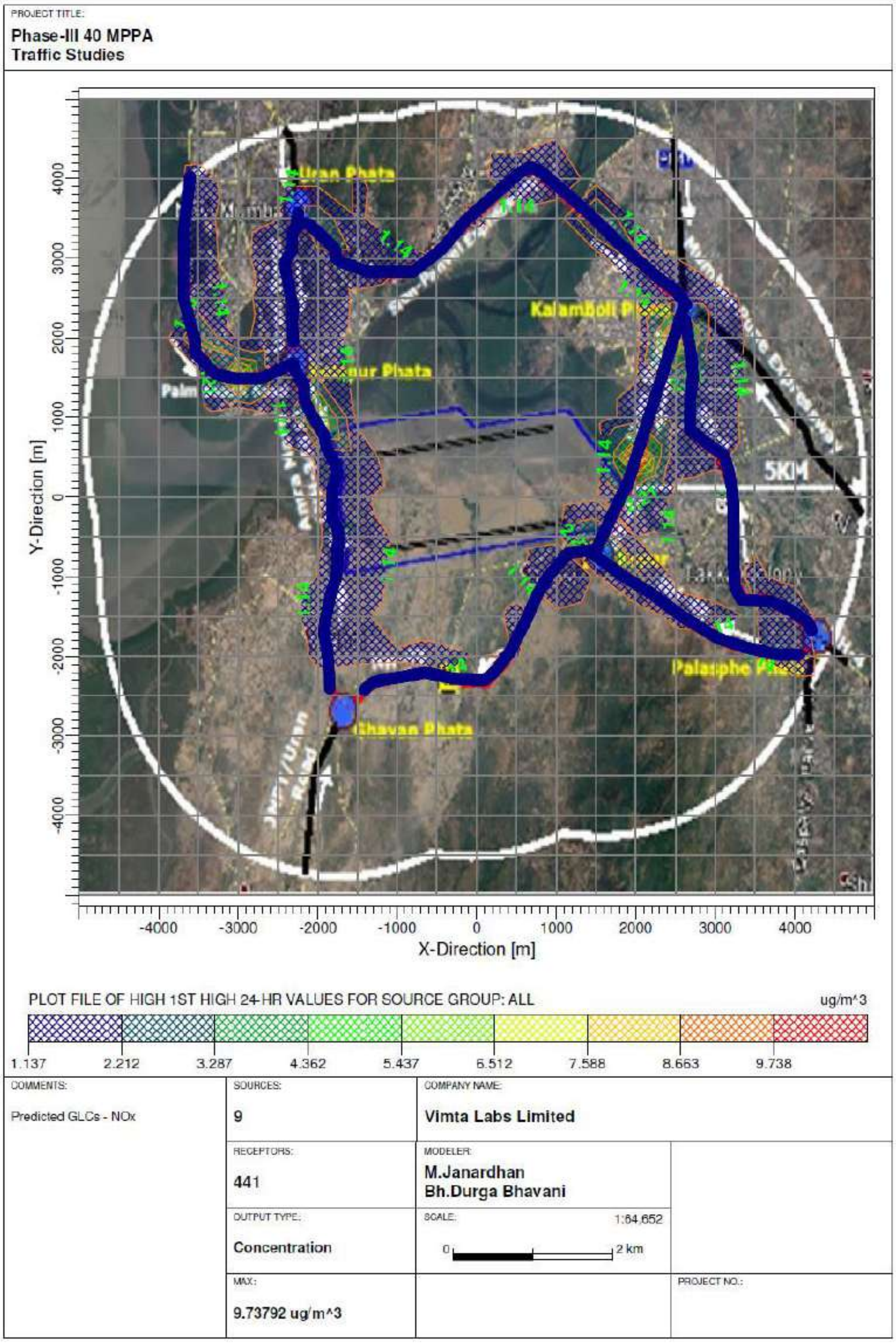


FIGURE-4.61: PHASE-III
TRAFFIC MODEL – NOX CONCENTRATIONS

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessmet) (PHASE -III)

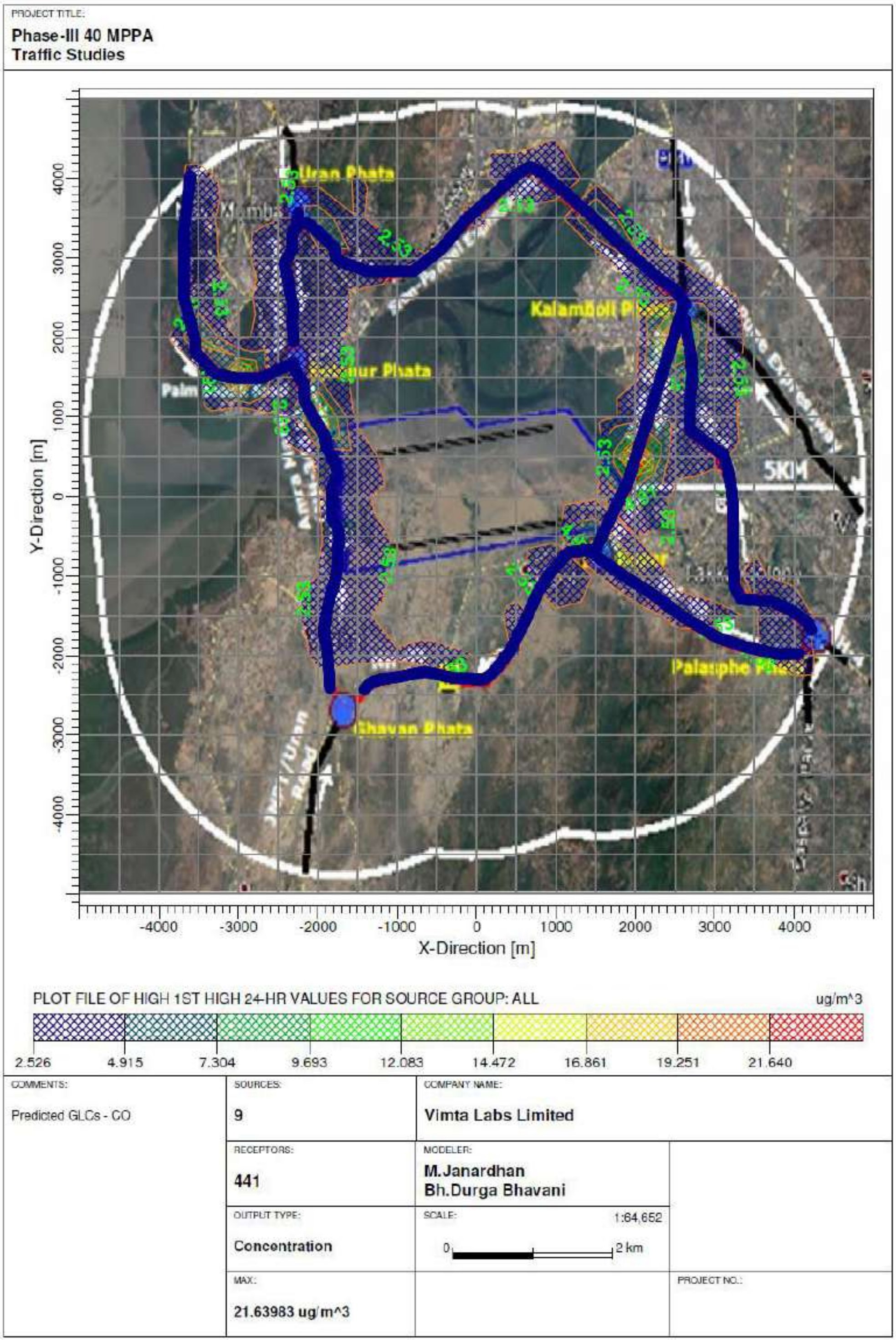


FIGURE-4.62: PHASE-III
TRAFFIC MODEL – CO CONCENTRATIONS

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessmet) (PHASE -III)

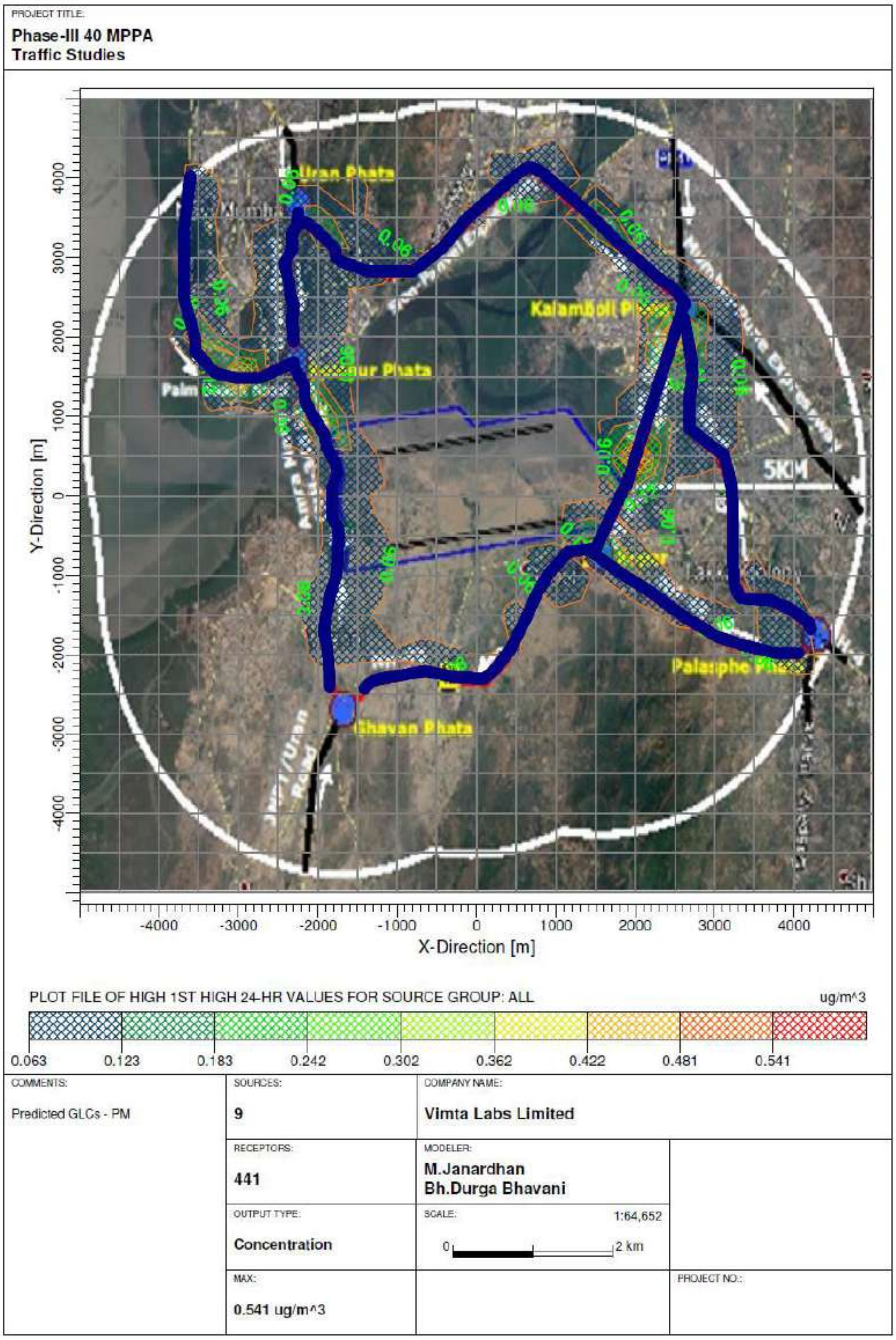


FIGURE-4.63: PHASE-III
TRAFFIC MODEL – PM10 CONCENTRATIONS

ANNEXURE-XXII: AIR DISPERSION MODELLING RESULTS

AIR DISPERSION MODELLING RESULTS (Land Traffic Assessmet) (PHASE -III)

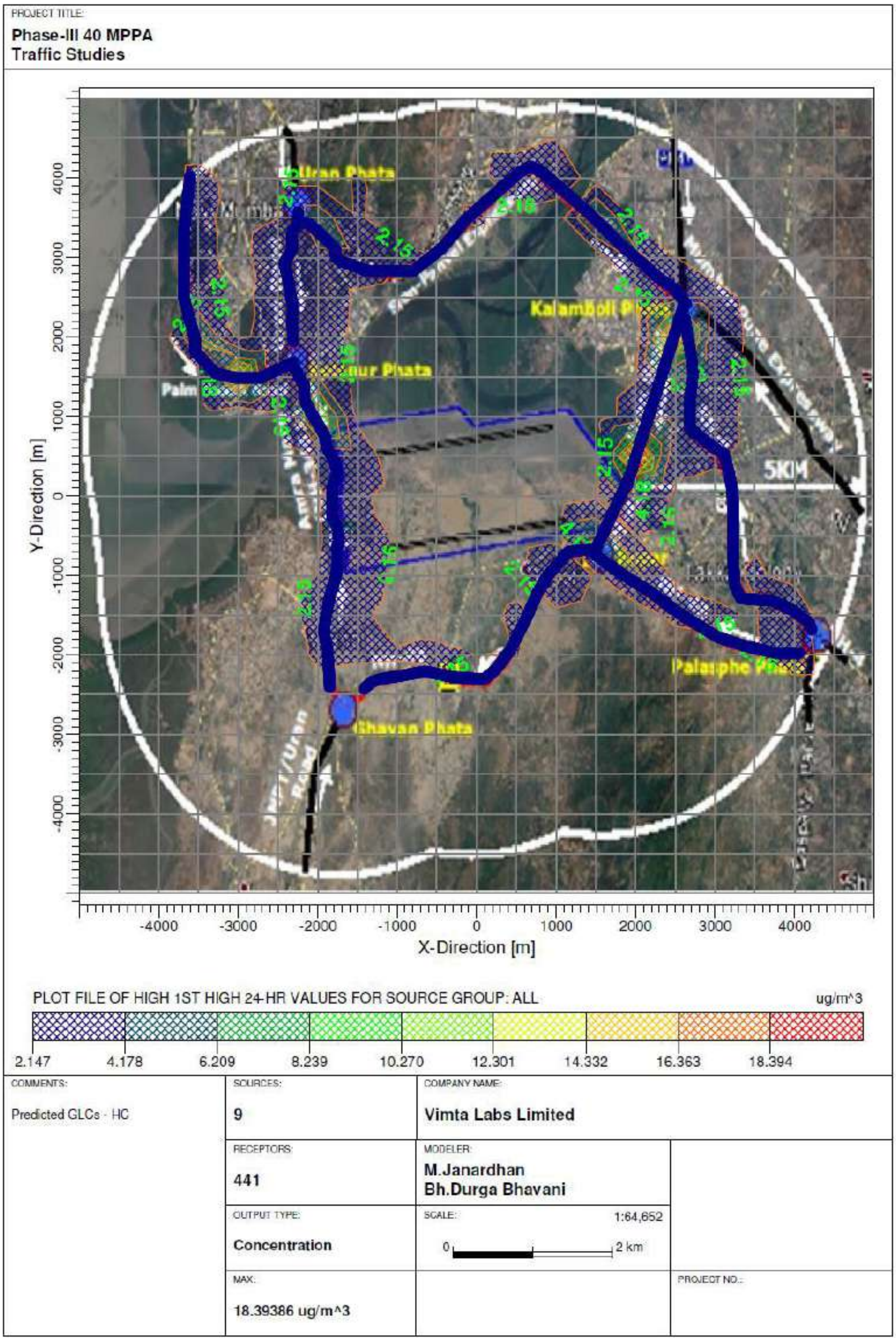


FIGURE-4.64: PHASE-III
TRAFFIC MODEL – HC CONCENTRATIONS

ANNEXURE-XXIII
QUANTITATIVE RISK ASSESSMENT (QRA) REPORT FOR NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) ATF TANK FARM

Doc. No.: PSRM-PSRR-PP16502-RP-01, Rev. 01

Date: 01 April 2021

peaksafe

Quantitative Risk Assessment (QRA)

Navi Mumbai International Airport (NMIA) ATF Tank Farm

PeakSafe Risk Management Pvt. Ltd.
Mumbai, Maharashtra (INDIA)

info@peak-safe.com
www.peak-safe.com

Project Name	NMIA ATF Tank Farm	PeakSafe Risk Management
Report Title	QRA Study Report for NMIA ATF Tank Farm	Private Limited
Customer	NMIA	Process Safety & Risk
Date of issue	31-03-2021	Management Consultancy
Project No.	PP16406	Mumbai, Maharashtra (INDIA)
Consultant	PeakSafe Risk Management, Mumbai	Email: info@peak-safe.com
Document No.	PSRM-PSRR-PP1502-RP-01, Rev. 00	Web: www.peak-safe.com

Prepared by:	Verified by:	Approved by:
A. Ansari Process Safety Engineer	A. I Ansari Head – Process Safety & Risk Management Advisory	R. Krishnan Senior Consultant – Process Safety

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QRA

01	01-04-2021	Issued for Review	AZIM	RKRISH	ANSARI
01	03-08-2020	Issued for Approval	AZIM	RKRISH	ANSARI
Rev	Date	Reason for Issue	Prepared by	Verified by	Approved by

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1 INTRODUCTION

Navi Mumbai International Airport (NMIA) has been taken up for construction. The aviation turbine fuel (ATF) for the aircraft is proposed to be dispensed through an underground fuel hydrant system designed in accordance with relevant standards. The required fuel infrastructure for the initial phases is planned to be built prior to opening of airport and the facility will then be expanded in phases to meet demand. The location of fuel facility is crucial, as it influences both incoming supply lines and potential fuel transmission lines from the facility to the apron. In earlier phases, it must allow the flexibility for bowsers to supply the airfield to augment hydrant network while it is being developed. Therefore, the facility is located close to airfield, with access to an airside gate for quick and efficient entry to the apron. **Figure 1-1** shows the Master Plan of NMIA.

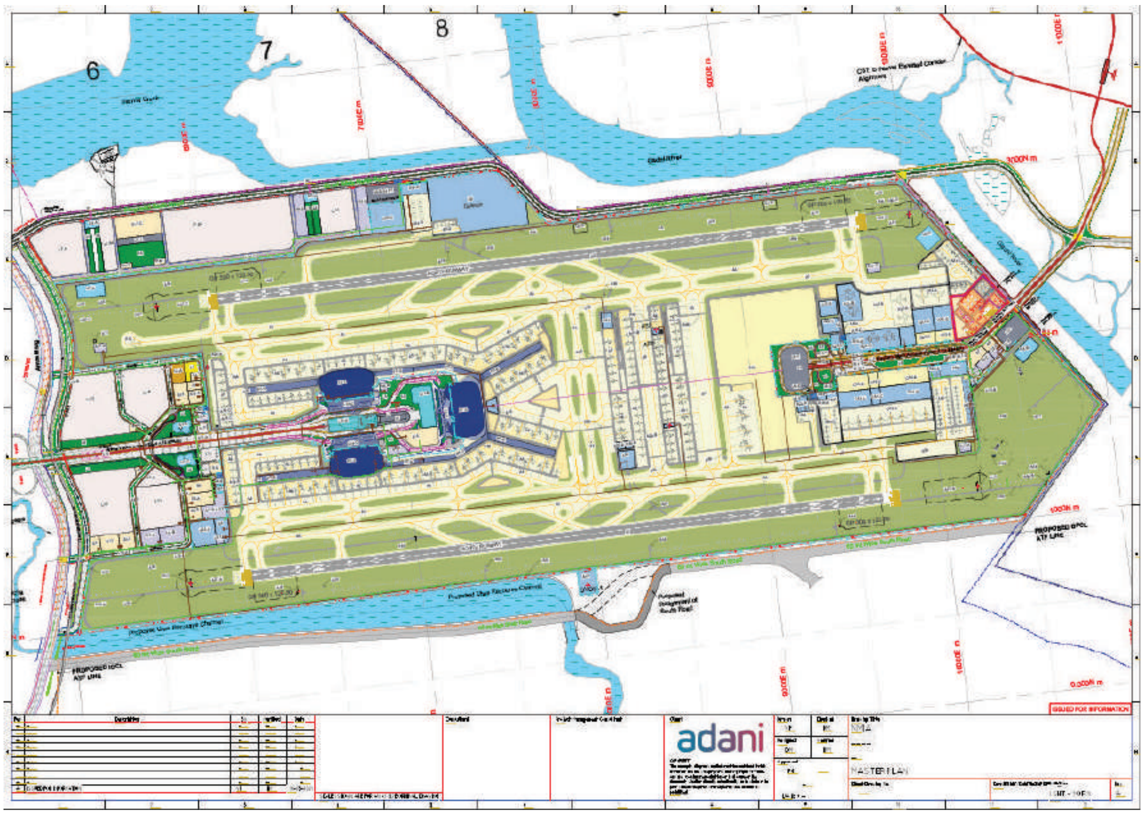


Figure 1-1 NMIA master Plan

NMIA Fuel System provision is structured as follows:

- Fuel supply
- Fuel demand & storage
- Fuel hydrant system

The Quantitative Risk Assessment (QRA) for Navi Mumbai International Airport (NMIA) at Navi Mumbai was carried out in Aug 2020. QRA study to quantify and assess the risk from identified hazards at NMIA ATF Tank Farm personnel and to ensure that they comply with the adopted risk criteria.

This study is to conduct Quantitative Risk Assessment (QRA) for Navi Mumbai International Airport (NMIA) at Navi Mumbai considering revised layout.

This document presents the Quantitative Risk Assessment (QRA) report for the fuel receipt, storage and dispensing facilities at NMIA.

1.1 Objective

The primary objective of the QRA study is to quantify and assess the risk from identified hazards to onsite and offsite personnel and to ensure that they comply with the adopted risk criteria and to demonstrate that risk has been reduced to the extent that is reasonable as per the risk management process.

The other objectives of the QRA are to:

- Quantify risks identified with major accident hazards (primarily for gas dispersion, explosion overpressure, fire and smoke and toxic gas, if applicable)
- Plot Risk Contours for individual risk and FN curve for societal risk
- Evaluate acceptability of the risks.
- Compare risk levels against risk-acceptance criteria and provide practical and effective risk control and mitigation measures, as required.
- Carry out Fire risk assessment and Consequence Analysis for the identified hazards covering Escalation analysis and Impact analysis.
- Provide conclusions and demonstrate that risks are ALARP when recommendations are implemented, if any.

1.2 Definition

Frequency: Number of occurrences of an event per unit of time.

Hazard: A chemical or physical condition that has the potential for causing damage to people, property, or the environment.

Incident: The loss of containment of material or energy. Not all events propagate into Incidents.

Event sequence: A specific unplanned sequence of events composed of initiating events and Intermediate events that may lead to an incident.

Initiating event: The first event in an event sequence.

Intermediate event: An event that propagates or mitigates the initiating event during an event sequence.

Incident outcome: The physical manifestation of the incident; for toxic materials, the incident outcome is a toxic release, while for flammable materials, the incident outcome could be a Boiling Liquid Expanding Vapor Explosion (BLEVE), flash fire, unconfined vapor cloud explosion, toxic release, etc.

Consequence: A measure the expected effects of an incident outcome case.

Effect zone: For an incident that produces an incident outcome of toxic release, the area over which the airborne concentration equals or exceeds some level of concern. The area of the effect zone will be different for each incident outcome case.

Likelihood: A measure of the expected probability or frequency of occurrence of an event. This may be expressed as a frequency (e.g., events/year), a probability of occurrence during some time interval, or a conditional probability.

Probability: The expression for the likelihood of occurrence of an event or an event sequence during an interval of time or the likelihood of occurrence of the success or failure of an event on test or demand. By definition, probability is expressed as a number ranging from 0 to 1.

Risk: A measure of human injury, environmental damage or economic loss in terms of both the incident likelihood and the magnitude of the loss or injury.

Risk analysis: The development of a quantitative estimate of risk based on engineering evaluation and mathematical techniques for combining estimates of incident consequences and frequencies.

Risk assessment: The process by which the results of a risk analysis are used to make decisions, either through a relative ranking of risk reduction strategy or through comparison with risk targets.

1.3 Abbreviation

A/G	Above Ground
ALARP	As Low As Reasonably Practicable
DCS	Distributed Control System
SDV	Shut Down Valve
HMB	Heat & Mass Balance
IRPA	Individual Risk Per Annum
LFL	Lower Flammability Limit
LSIR	Location Specific Individual Risk
NMIA	Navi Mumbai International Airport
OGP	Oil & Gas Production
OISD	Oil Industry Safety Directorate
P&ID	Piping & Instrumentation Diagram
PFD	Process Flow Diagram
PHAST	Process Hazard Analysis Software Tool
PPE	Personal Protective Equipment
QA	Quality Assurance
QRA	Quantitative Risk Analysis
ROV	Remote Operated Valve
U/G	Under Ground
VCE	Vapor Cloud Explosion

2 FACILITY DESCRIPTION

2.1 NMIA Fuel Supply

Based upon the projections, it has been planned that NMIA shall be supplied by about four pipelines to be introduced in phases. An indicative route has been identified for the location of incoming fuel supply pipelines from South-western side (near Western access main road) part of airport boundary to the proposed location of NMIA fuel farm, NMIA Master plan is as shown in

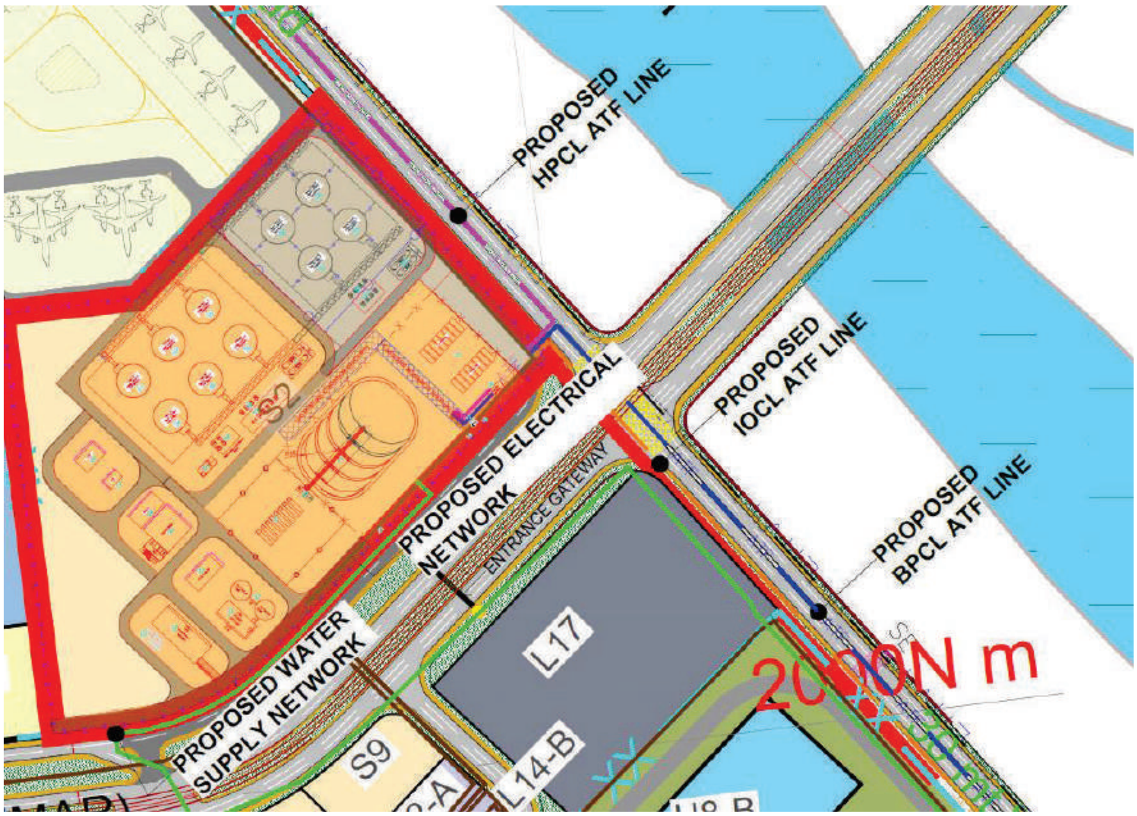


Figure 2-1 Final Phase (60 MPPA) ATF Fuel Farm And Incoming Fuel Supply Pipeline Routing

2.2 Fuel Demand & Fuel Storage

The summary of the estimated phase-wise peak fuel demand & storage for estimated 5 days storage capacity provided in fuel farm is presented in Table 2-1 below:

Table 2-1 Fuel Demand & Storage Facility Requirement

Particulars	(Phase-I & II)	(Phase-III)	(Phase-IV)
Number of Tanks (Total)	6	4	
Storage Capacity	30000 KL	30000 KL	50000 KL
Day Coverage (cum/hr)	14.9	7.2	8.3
Peak Demand (cum/hr)	780	1320	1860
Fuel Usage (Cum/day)	2020	4040	6060
Tank Dimension	D:18 m; H :20 m	D:18 m; H :20 m	
Type of Tank	All tanks are similar type: Circular tanks with Dome		

2.3 Air Rescue and Fire Fighting System [ARFF]

Two ARFF stations are required to serve the dual runway system. Location of ARFF is crucial as vehicles are required to access the runway thresholds and all movement areas within a 3-minute criterion. Therefore, a central location, with one facility in north and one in south are planned on airside of NMIA to provide ICAO Category 10 coverage in accordance with relevant standards and terms of CA and need to safeguard for ICAO Code F. Rescue equipment will be adequate to meet DGCA CAR requirements. The minimum number of ARFF vehicles will be three; this is subject to the outcome of completed 'Task Resource Analysis' (ref. DGCA, AD AC NO. 03 of 2017).

A paved emergency access road of 5 m wide for single direction and 7 m wide at curves will be provided from the locations of the ARFF facilities to both runways. A communication and alerting system will be provided linking the ARFF station with the control tower and ARFF vehicles. The location of both air rescue and firefighting facilities in northern and southern half of airport site is shown in **Figure 2-2**

Aircraft Rescue and Firefighting (ARFF) facility is required to house ARFF vehicles, staff and equipment for use in emergency situations. The facility is located and designed to ensure all potential emergencies on the airfield can be reached within the regulatory requirements. The facility is planned to include a building, watch tower (non-satellite), fire tender parking, staff areas for welfare, and parking for ARFF, as well as storage of water, extinguishing agent, and firefighting equipment. It provides adequate space to support a minimum of 3 ARFF vehicles and their respective supporting staff and equipment.

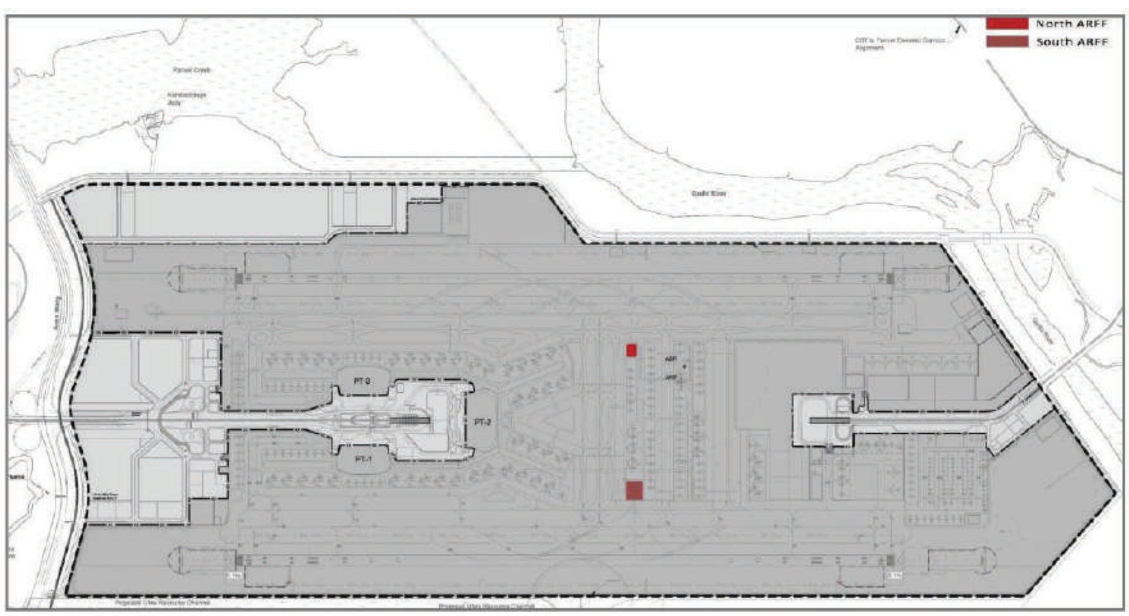


Figure 2-2 Air Rescue and Firefighting Facility 60 MAP

The ARFF facilities will be phased with the first building constructed to support the southern runway in Phase-I. A second ARFF (satellite) facility is planned to the north of first station once second runway is completed. Location of ARFF is crucial as vehicles are required to access the runway thresholds and all movement areas within a 3-minute criterion. Therefore, a central location, with one facility in north and one in south, ensures all regulatory criteria is upheld. Based on intended runway phasing at NMIA, the ARFF will be split into two phases. The main ARFF building is required in opening phase to support southern runway. Until the second runway is completed, the facility is also required to double up as a temporary ATC Tower, which means southern facility must be positioned to ensure the tower does not exceed the OLS height limitations. Based on this, the facility will be located at a distance of at least 432 m from the runway centerline.

3 SCOPE OF WORK

3.1 QRA Scope of Work

The scope of work of this Quantitative Risk Assessment (QRA) is to cover the Fuel Tank Farm at NMIA.

The scope of work includes:

- Compiling data inputs
- Carrying out QRA modelling
- Issuing Draft and Final reports

The risk to life is to be calculated as "Individual Risk" and "Group Risk".

Individual Risk: It is represented by iso-risk contours, which show the geographical distribution of risk to an individual. It is assumed that the individual is continuously present at that location, out of doors and does not shelter or try to escape.

Group Risk: it is represented by FN curves, which show the cumulative frequency distribution of accidents causing different numbers of fatalities. The FN curve therefore indicates whether the Group risk to the facility is dominated by relatively frequent accidents causing small numbers of fatalities or low frequency accidents causing many fatalities.

3.2 Facility Scope of Work

3.2.1 Inclusion

The following facility are included as part of this QRA study

- ATF Storage Tanks 5,000 KL capacity - 6 Nos (Phase-I).
- ATF Storage Tanks 5,000 KL capacity - 4 Nos (Phase-II).
- Tank associated piping/header
- 4 Nos. of Incoming pipelines
- Filtration Unit
- Main Hydrant Pump
- Fueler Loading Pumps
- Tanker Loading / Unloading Facility

The QRA was carried out in august 2020.

NMIA intent to revise the QRA considering the change in NMIA ATF Tank Farm layout rest all parameters are same.

3.2.2 Exclusion

- Outside the boundary limit of ATF tank farm is not covered as part this QRA study.

4 QRA METHODOLOGY

The following sections provide a broad overview of the methodology and assumptions adopted for the analysis.

4.1 QRA Approach

The QRA Study shall involve estimating the frequency of potentially hazardous events, failures and uncontrolled release of hydrocarbon, including toxicity, overpressure, flash fire and jet fire, and calculating the consequences of such incidents. The results will then be combined with information on the expected exposure of persons to the events being studied to establish a risk of injury or death.

The QRA process shall be divided into, but not restricted to, the following main elements:

1. Identification of hazards and their causes within the facility;
2. Definition of failure scenarios;
3. Analysis of the potential consequences of each scenario;
4. Calculation of the expected likelihood of occurrence of each scenario;
5. Summation of scenarios to produce a measure of risk;
6. Identification of key risk drivers associated with the facility;
7. Consideration of the significance of the resultant risk levels, if appropriate, mitigation measures to meet COMPANY criteria and recommendations;
8. Interpretation of the calculated risk to draw relevant and practical conclusions;

The study is based on the premises of a traditional Quantitative Risk Assessment. The key components of a QRA are explained below and illustrated in Figure 4-1 on the next page:

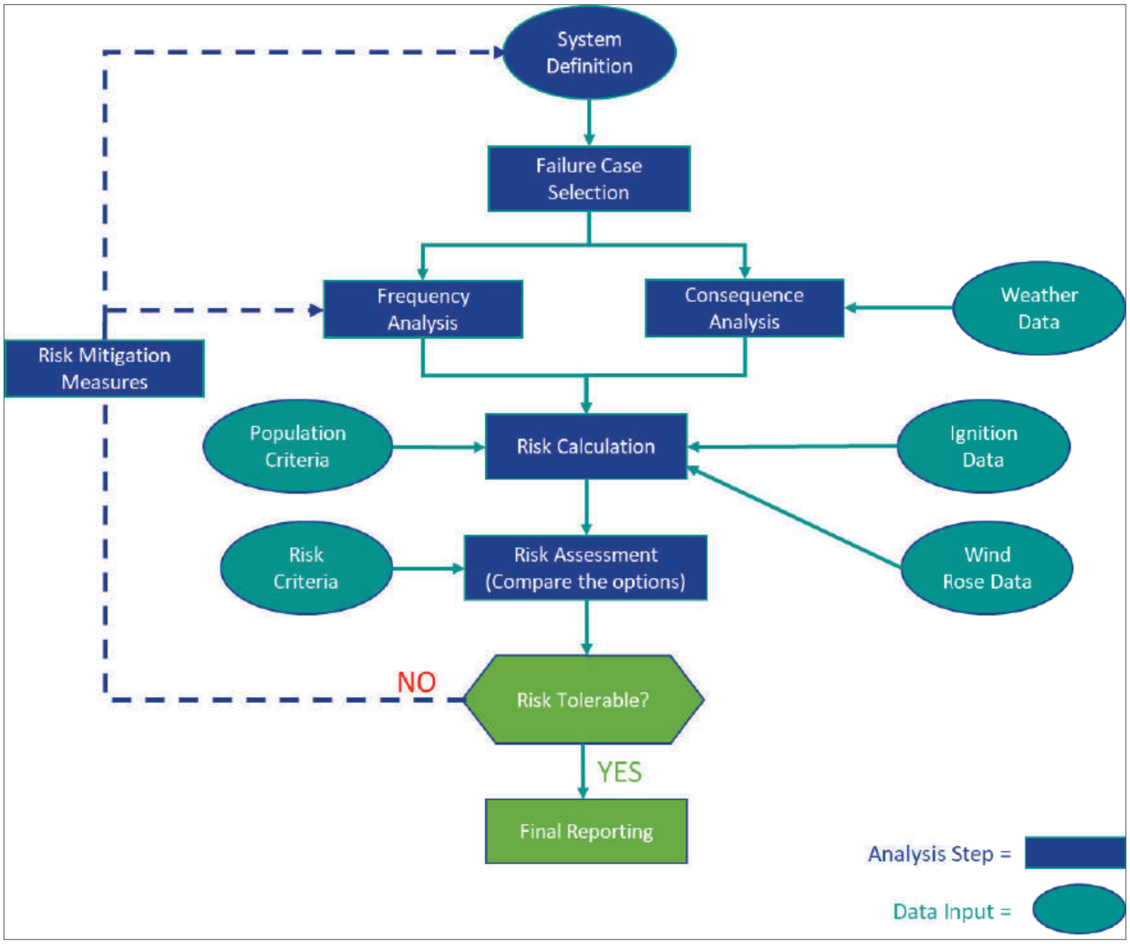


Figure 4-1 QRA Methodology

4.2 System Definition

The first stage in a QRA is defined as **system definition**, where the potential hazards associated with a facility or the activities are to be analyzed. The scope of work for a QRA should be to define the boundaries for the study, identifying which activities are to be included and which are excluded, and which phases of the facility's life are to be assessed.

4.3 Hazard Identification

The hazard identification consists of a qualitative review of possible accidents that may occur, based on previous accident experience or judgment where necessary. There are several formal techniques for this, which are useful in their own right to give a qualitative appreciation of the range and magnitude of hazards and indicate appropriate mitigation measures. This qualitative evaluation is described in this guide as "hazard assessment". In a QRA, hazard identification uses similar techniques, but has a more precise purpose – defining the boundaries of a study in terms of materials to be modelled, release conditions to be modelled, impact criteria to be used, and identifying and selecting a list of failure cases that will fully capture the hazard potential of the facilities to be studied. Failure cases are usually derived by breaking the process system down into a larger number of sub- systems, where failure of any component in the sub-system would cause similar consequences. In pipeline case, this can be performed by breaking the line into sections depending on availability of isolation valves along the line.

4.4 Failure Cases Selection

All facilities normally containing hazardous material have been considered during identification of failure cases. Failure cases and their boundaries are defined based on a study of the PFDs/P&IDs and the Plot plans. Details of failure cases identified for NMIA facility are presented in Appendix 01. This description includes failure case identification tag, area name, Isolatable section number and detailed description of isolatable section describing its starting point and end point, associated equipment PFD/P&IDs/layout.

An example of the failure case naming convention used in NMIA ATF Tank Farm is shown below:

Example: *ISO-01/Equipment with tag no./Phase of material/ Leak Size*

i.e. ISO-01/SDVXXXX/L/5MM

Where:

NMIA represents ATF Tank Farm

ISO-01 represents isolatable section number in the ATF Tank Farm facility

SDVXXXX' indicates tag number of isolation valve in the failure case section.

(L) is Liquid; it indicates the phase of material i.e. liquid or gas

'S' indicates the size (for leak cases); 5mm for small, 25mm for medium, 10mm for Large, 150mm for Very Large or FBR.

4.5 Source Term Modelling

Source term modelling has been carried out for each identified scenario to determine the release profile and release parameters for various potential Loss of Containment scenarios. Following inputs were considered for the source term modelling.

- Stored inventory
- Representative material
- Process parameters (Pressure, Temperature, Flow rate, etc.)
- Release size & direction

These parameters are determined based on process description, plot plans, P&IDs for the NMIA facility. SAFETI suite has been used for the source term modelling. Each failure case calculation in SAFETI starts with discharge modelling. Based on release duration and release phase (gas, liquid, 2-phase), SAFETI directs the dispersion and consequence calculations to one of 4 alternate, built-in consequence outcome event trees (continuous vapor release, continuous release with rain-out, instantaneous vapor release, instantaneous release with rain-out), where each event tree branch probability carries default values, which may be re-programmed by the risk analyst.

4.5.1 Isolatable section selection criteria

Identification of isolatable sections is required to determine the inventory available for release upon loss of containment event.

An isolatable section has been defined as section between two SDVs. Isolatable inventory has been considered for modelling purpose.

Only main process lines are included as failure cases sections. Normally No Flow (NNF) lines and drain lines have not been accounted in the study.

The isolatable section drawings for the NMIA facility are outlined in Appendix 01 of this QRA report.

4.5.2 Isolatable Inventory and Isolation Time

An estimate of the inventory that could potentially be released is developed for each isolatable section. The estimate of the total released inventory (I_T) is the sum of IS (Static Inventory, Kg) and I_D (Dynamic Inventory, kg). The static inventory is the amount of material within the isolatable section's vessels and piping, prior to leak. The dynamic inventory is calculated based on the pumped or pressurized in-flow rate and the isolation time by:

$I_{(T)} = I_{(S)} + I_{(D)}$

$I_{(T)} = I_{(S)} + MIN(rL,rP) \text{x } t$

Where $I_{(T)}$ = Total potential inventory released (kg)

$I_{(S)}$ = Static Inventory (kg)

$I_{(D)}$ = Dynamic Inventory (kg)

rL = Phast Calculated Leak rate (kg/s)

rP = Process Flow rate (kg/s)

t = Release duration (s)

4.5.3 Release Direction and Location:

The releases from the process equipment, process piping, and flowlines are modelled as horizontal direction as suggested by DNVGL SAFETI software for Quantitative Risk Assessment. This assumption gives worst case results for plume length and cloud travel distance in downwind direction.

Note: - For failure cases which are not associated with notable piping length and limited to the module area are modelled as point source vessel in QRA model.

4.5.4 Leak Detection, Decision Making, and Isolation time

It is assumed that SDVs are 100% reliable on the basis that they will be maintained and tested in an appropriate manner such that the probability of failure to operate on demand is very low. It is also assumed that all full-bore releases will automatically lead to closure of the SDVs and that valve closure takes less than 20 seconds.

The response time including time for detection and isolation considered for different categories of leak are considering as 60 seconds.

4.5.5 Release sizes

Following release/leak sizes have been used as representative sizes for small, medium, large, very large or full-bore rupture (FBR). The defined hole sizes are considered to be fit for the purpose of QRA study as it covers the entire range of leak sizes from minimum to maximum in line with OGP guidelines for failure frequency.

Table 4-1 Representative hole sizes for Process Equipment/Piping Releases

Representative hole size (mm)	Range represented (mm)	Explanation
5	1 to 10	Small leak
25	10 to 50	Medium leak
100	50 to 100	Large leak
150	100-150 to full bore	Very Large or FBR

4.6 Frequency Analysis

Once the potential hazards have been identified, the frequency analysis estimates how likely it is for the accidents to occur, based on the type and number of equipment components included in the defined failure cases. The component failure frequencies to be used are usually derived from an analysis of historical accident experience, or by some form of theoretical modelling.

The frequency analysis estimates how likely it is for the accidents to occur, based on the type and number of equipment components included in the defined failure cases. The component failure frequencies to be used are usually derived from an analysis of historical accident experience from OGP Data Assessment Risk Directory.

4.6.1 Pipeline Failure Frequencies

The failure frequency of onshore pipeline extracted from OGP Risk Assessment Data Directory (Ref: Process Release Frequencies, Report No. 434-04 Sept. 2019). The failure frequency of process release is provided in Table 4-2 below.

Table 4-2 Onshore Pipeline Failure Frequency

Pipeline	Category	Failure frequency	Unit
Oil pipelines onshore	Diameter < 8 inch	4.7×10^{-4}	per km-year
	8 inch ≤ Diameter < 12 inch	3.5×10^{-4}	per km-year
	12 inch ≤ Diameter < 16 inch	2.7×10^{-4}	per km-year
	16 inch ≤ Diameter < 24 inch	3.3×10^{-4}	per km-year
	24 inch ≤ Diameter < 30 inch	1.9×10^{-4}	per km-year
	Diameter ≥ 30 inch	2.1×10^{-4}	per km-year

Pipeline	Category	Failure frequency	Unit
Gas pipelines onshore	Diameter < 5″	4.1×10^{-4}	per km-year
	5″ ≤ Diameter < 11″	2.6×10^{-4}	per km-year
	11″ ≤ Diameter < 17″	1.3×10^{-4}	per km-year
	17″ ≤ Diameter < 23″	9.1×10^{-5}	per km-year
	23″ ≤ Diameter < 29″	5.9×10^{-5}	per km-year
	29″ ≤ Diameter < 35″	2.0×10^{-5}	per km-year
	35″ ≤ Diameter < 41″	1.6×10^{-5}	per km-year
	41″ ≤ Diameter < 47″	3.3×10^{-6}	per km-year
	Diameter ≥ 47″	8.6×10^{-6}	per km-year

Recommended hole size distribution for onshore pipeline is provided in Table 4-3 below.

Table 4-3 Hole Size distribution for Pipeline

Hole size (diameter)	Onshore pipeline	
	Gas	Oil
Very Small (< 5mm)	55%	15%
Small (5-20 mm)	15%	16%
Medium (20 to 80 mm)	15%	34%
Large (> 80 mm)	5%	16%
Full Rupture (>150mm)	10%	19%

4.6.2 Process Release Failure Frequencies

The process release failure frequencies extracted from OGP Risk Assessment Data Directory (Ref: Process Release Frequencies, Report No. 434-01, Sept. 2019). The failure frequency of process release is provided in Table 4-4 below.

Table 4-4 Process Release Failure Frequencies

Equipment	1 to 10	10 to 50	50 to 150	>150
Process Pipe < =2"	2.14E-05	2.80E-06	-	-
Process Pipe <= 6"	1.34E-05	1.60E-06	3.20E-07	-
Process Pipe < =12"	1.28E-05	2.10E-06	5.20E-07	4.60E-07
Process Pipe <= 16"	1.29E-05	3.00E-06	9.70E-07	1.30E-06
Process Pipe < =24"	1.26E-05	3.30E-06	1.20E-06	1.70E-06

Equipment	1 to 10	10 to 50	50 to 150	>150
Process Pipe < =36"	1.26E-05	3.30E-06	1.20E-06	1.70E-06
Flanges <= 2"	6.40E-06	9.10E-07	-	-
Flanges <= 6"	1.01E-05	1.40E-06	3.20E-07	-
Flanges < =12"	1.80E-05	1.90E-06	3.70E-07	1.30E-06
Flanges <= 16"	2.55E-05	2.10E-06	3.40E-07	2.00E-06
Flanges < =24"	2.79E-05	2.20E-06	3.30E-07	2.20E-06
Flanges < =36"	2.79E-05	2.20E-06	3.30E-07	2.20E-06
Manual Valves < =2"	2.30E-05	4.60E-06	-	-
Manual Valves <= 6"	2.50E-05	3.80E-06	9.10E-07	-
Manual Valves < =12"	4.40E-05	8.00E-06	2.20E-06	2.20E-06
Manual Valves < =16"	6.10E-05	1.40E-05	4.30E-06	5.50E-06
Manual Valves < =24"	6.60E-05	1.60E-05	5.30E-06	7.20E-06
Manual Valves < =36"	6.60E-05	1.60E-05	5.30E-06	7.20E-06
Actuated Valves < =2"	1.98E-04	2.30E-05	-	-
Actuated Valves <= 6"	1.16E-04	1.80E-05	4.30E-06	-
Actuated Valves <= 12"	1.08E-04	1.50E-05	3.30E-06	2.60E-06
Actuated Valves < =16"	1.17E-04	1.30E-05	2.60E-06	1.70E-06
Actuated Valves < =24"	1.19E-04	1.30E-05	2.40E-06	1.40E-06
Actuated Valves< =36"	1.19E-04	1.30E-05	2.40E-06	1.40E-06
Small Bore Fittings - 1"	1.70E-04	2.70E-05	-	-
Small Bore Fittings - 2"	1.70E-04	2.00E-05	-	-
Pressure Vessels Inlet 5-150mm	5.00E-04	9.30E-05	4.90E-05	-
Pressure Vessels Outlet>150mm	5.00E-04	9.30E-05	2.50E-05	2.40E-05
Pumps - Centrifugal 5-150mm	3.34E-03	1.40E-04	1.80E-05	-
Pumps - Centrifugal >150mm	3.34E-03	1.40E-04	1.40E-05	4.00E-06
Pumps - Reciprocating 5-150mm	1.36E-03	4.20E-04	4.40E-04	-
Pumps - Reciprocating >150mm	1.36E-03	4.20E-04	1.60E-04	2.80E-04
Compressor - Centrifugal 5-150mm	4.90E-03	6.70E-04	2.50E-04	-
Compressor - Centrifugal >150mm	4.90E-03	6.70E-04	1.50E-04	1.10E-04
Compressor - Reciprocating 5-150mm	9.90E-03	1.40E-03	5.60E-04	-
Compressor - Reciprocating >150mm	9.90E-03	1.40E-03	3.20E-04	2.40E-04
Heat Exchanger HC in Shell 5-150mm	1.33E-03	2.10E-04	9.70E-05	-
Heat Exchanger HC in Shell >150mm	1.33E-03	2.10E-04	5.30E-05	4.40E-05
Heat Exchanger HC in Tube 5-150mm	6.20E-04	1.50E-04	1.10E-04	-
Heat Exchanger HC in Tube >150mm	6.20E-04	1.50E-04	4.90E-05	6.20E-05
Heat Exchanger Plate types 5-150mm	7.60E-03	6.80E-04	1.70E-04	-
Heat Exchanger Plate types >150mm	7.60E-03	6.80E-04	1.10E-04	5.80E-05
Coolers 5-150mm	1.20E-03	1.10E-04	2.80E-05	-
Coolers >150mm	1.20E-03	1.10E-04	1.80E-05	9.30E-06

Equipment	1 to 10	10 to 50	50 to 150	>150
Filters 5-150mm	1.64E-03	1.50E-04	3.90E-05	-
Filters >150mm	1.64E-03	1.50E-04	2.60E-05	1.30E-05

4.6.3 Storage Incident Frequencies

The Storage Tank frequency extracted from OGP Risk Assessment Data Directory (Ref: Storage Incident Frequencies, Report No. 434-03, March 2010). The failure frequency of Storage incident is provided in Table 4-5 below.

Table 4-5 Atmospheric Storage Tank Fire Frequencies

Type of Fire	Floating Roof Tank (per tank year)	Fixed Roof Tank (per tank year)	Fixed plus Internal Floating Roof Tank (per tank year)
Rim seal fire	1.60E-03	-	1.60E-03
Full surface fire on roof	1.20E-04	-	-
Full surface fire	-	9.00E-05	9.00E-05
Small bund fire	9.00E-05	9.00E-05	9.00E-05
Large bund fire	6.00E-05	6.00E-05	6.00E-05

4.6.4 Parts Count

An equipment parts count is carried out for each isolatable section (based on location of SDV's) for determining appropriate frequencies for the representative failure cases (frequency analysis). The equipment parts count assessment is based on Process Piping and Instrumentation Diagrams (P&IDs) or calculated from PFDs if P&IDs are not available.

4.6.5 Calculated Inventories & Failure Frequencies

The calculated inventory of NMIA ATF Tank Farm that could potentially be released is developed for each isolatable section. The estimate of the total released inventory (I_T) is the sum of I_S (Static Inventory, kg) and I_D (Dynamic Inventory, kg). The inventory is calculated based upon guideline indicated in section 4.5.

Calculated frequency of releases from an isolatable section involves pipeline frequency process release frequency and tank incident frequencies. The frequency analysis has been carried out considering the failure frequencies indicated in section 4.6

The calculated inventory and failure frequency of each isolatable section used in this study are presented in Appendix 2.

4.7 Ignition probabilities

The OGP database consists of a total of 28 different mathematical functions and lookup correlations to define the ignition probability for all types of facilities and surrounds, based on data drawn from UKOOA. The total ignition probability is estimated based on the initial release rates.

4.8 Consequence Modelling

In parallel with the frequency analysis, **consequence modelling** evaluates the resulting effects if the accidents occur, and their impact on people, equipment and structures, the environment or business, depending on the defined scope of the QRA study. Estimation of the consequences of each possible event often requires some form of computer modelling. Consequence analysis requires the modelling of a number of distinctive phases, i.e. discharge, dispersion, fires and explosions (for flammable materials).

Closely liaised with the consequence assessment is the impact assessment, i.e. how does the fire, explosion or toxic cloud affect human beings. When the frequencies and consequences / impact of each modelled event have been estimated, they can be combined to produce risk results. Various forms of risk presentation may be used, commonly grouped as follows:

- **Individual Risk** – the risk exposure by an individual person.
- **Societal Risk** – the risk exposure by a group of people exposed to the hazard.

4.9 Risk Assessment

Up to this point, the process has been purely technical, and is known as **risk analysis**. The next stage is to introduce criteria, which are yardsticks to indicate whether the risks are acceptable, or to make some other judgment about their significance. Risk assessment is the process of comparing the level of risk against a set of criteria as well as the identification of major risk contributors. The purpose of **risk assessment** is to develop mitigation measures for unacceptable generators of risk, as well as to reduce the overall level of risk to As Low as Reasonably Practical (following figure).

4.10 Risk Acceptability Criteria

4.10.1 Individual Risk Criteria

The following criteria shall apply when judging the tolerability of risk to persons for NMIA ATF Tank Farm, sites, combined operations or activities. The same is graphically expressed in Figure 4-2 below.

a) Individual risk to any worker above 10^{-3} per annum shall be considered intolerable and fundamental risk reduction improvements are required.

b) Individual risk below 10^{-3} but above 10^{-6} per annum for any worker shall be considered tolerable if it can be demonstrated that the risks are as low as reasonably practicable (ALARP).

c) Individual risk below 10^{-6} per annum for any worker shall be considered as broadly acceptable and no further improvements are considered necessary provided documented control measures are in place and maintained.

d) Individual risk to any member of the general public as a result of NMIA Businesses activities shall be considered as intolerable if greater than 10^{-4} per year, broadly acceptable if less than 10^{-6} per year and shall be as low as reasonably practicable between these limits.

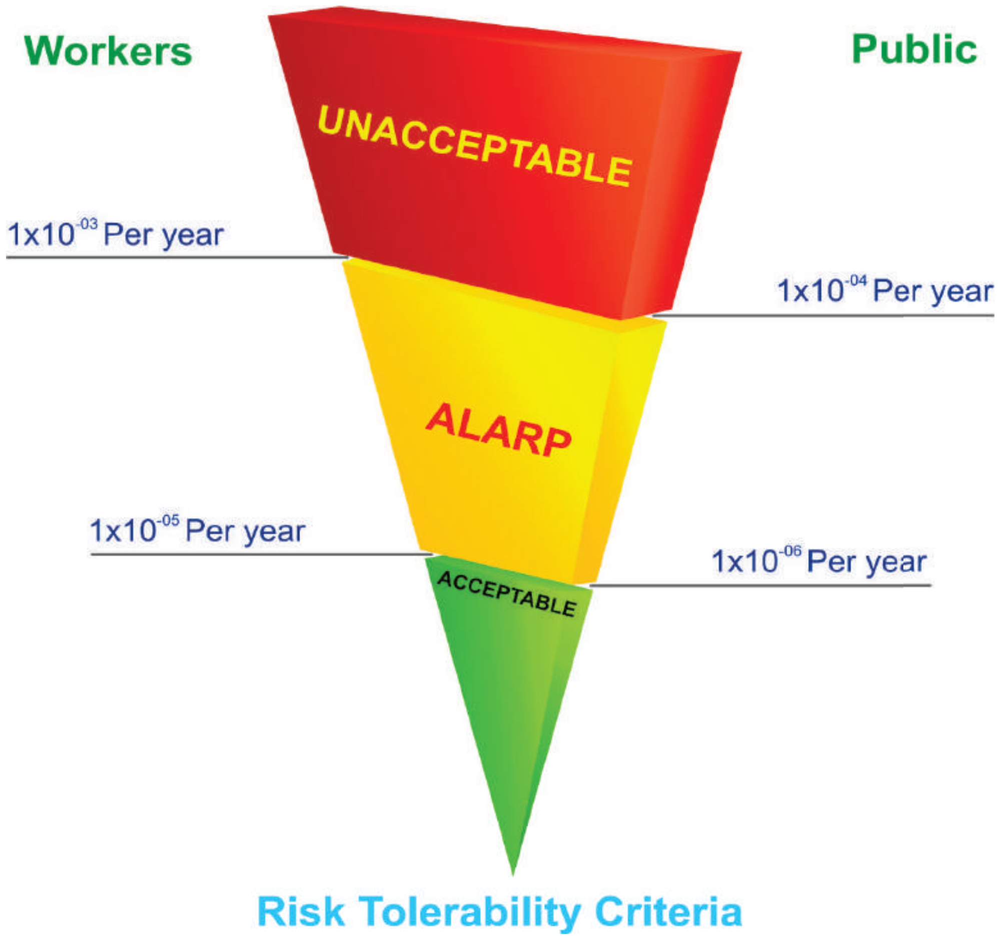


Figure 4-2 Graphical Representation of Individual Risk Criteria

4.10.2 Societal Risk Criteria – FN Curves

When considering the risks associated with a major hazard facility, the risk to an individual is not always an adequate measure of total risks; the number of individuals at risk is also important. Catastrophic incidents with potential multiple fatalities have little influence on the level of individual risk but have a disproportionate effect on the response of society and impact on company reputation.

Societal (or Group) risk is the relationship between frequency of an event and the number of people affected. Societal risk from a major hazard facility can thus be expressed as the relationship between the number of potential fatalities N following a major accident and the frequency F at which N fatalities are predicted to occur. The relationship between F and N, and the corresponding relationship involving F, the cumulative frequency of events causing N or more fatalities, are usually presented graphically on log-log axes. Minimum criteria for Group risk based on F-N curves are presented in Figure 7-7. These are based on historical major accident experience which indicates a F-N slope of (-) 1. The tolerability criteria for Societal Risk for use in QRA of NMIA installations are as follows.

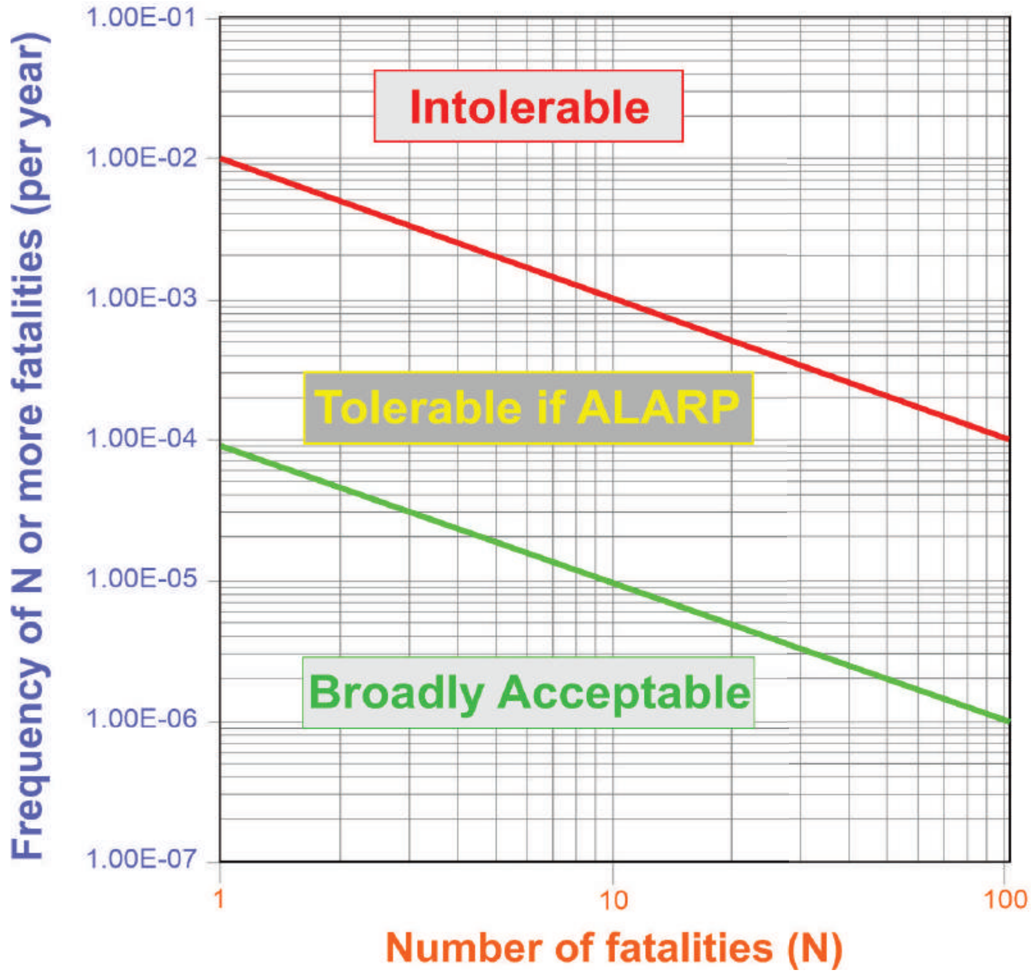


Figure 4-3 Societal Risk Criteria

5 STUDY INPUTS

The following data are used in this QRA study.

- Plant data
- Meteorological data
- Population data
- Ignition source

5.1 Plant Data

The details of storage tanks in each phase of NMIA Tank farm are provided in Table 5-1**Error! Reference source not found.**.

Table 5-1 Technical Details of NMIA

Development Phase (year)	Gross Cumulative Capacity Installer (Total No. of Tanks and Dimension)		JET A1 storage Tank Schedule	Type of Tank	ATF Pumps
	5,000 KL	Tank Dimensions			
Phase I & II	6	D:18 m H :20 m	5 Days	Circular tanks with Dome	Discharge rate of 277 cum/hr
Phase III & IV	4				

5.2 Meteorological Data

a) Wind Direction

The consequences of releases of flammable materials into the atmosphere are strongly dependent upon the rate at which the released material is diluted and dispersed to safe concentrations. The local meteorology is important in two respects. Firstly, the wind direction determines whether a release drifts towards or away from vulnerable locations. Secondly, the actual weather conditions, in terms of wind speed and stability (a measure of atmospheric turbulence), determine how quickly the flammable plume disperses to lower non-hazardous concentrations. SAFETI accounts for the different wind directions from the wind distribution probability input and combine the values into the risk calculation. This wind rose is proposed to be used for the study as it provides consolidated average of wind speed and distribution probability in 8 cardinal directions.

Data received from IMD and same is distributed wind direction probability based on wind speed with stability class of 8 cardinal direction.

b) Wind Speed and Pasquill Stability Class

The wind speed and directional probability for day and night derived from the wind rose is presented in Table 5-2.

Table 5-2: Wind Speed distribution and Pasquill Stability Class

Wind Speed (m/s)		% Distribution in 16 cardinal directions							
		N	NE	E	SE	S	SW	W	NW
		337.5-22.5	22.5-67.5	67.5-112.5	112.5-157.5	157.5-202.5	202.5-247.5	247.5-292.5	292.5-337.5
Day	1F	4.27	5.98	6.41	3.42	4.27	5.98	7.69	4.70

	5D	5.56	7.79	8.34	4.45	5.56	7.79	10.01	6.12
	10D	0.16	0.23	0.25	0.13	0.16	0.23	0.30	0.18
Night	1F	0.20	0.02	0.02	0.02	0.02	0.22	0.66	1.03
	5D	8.09	0.90	0.90	0.90	0.90	8.99	26.96	42.24
	10D	0.72	0.08	0.08	0.08	0.08	0.79	2.38	3.73

Based on the above observations, the following stability/wind-speed categories will be used for QRA studies

1F - Low wind speed (1m/s), Pasquill stability factor (F) represents typical worst-case dispersion condition during late night-time for ground level passive /dense gas cloud

5C- The typical wind speed (5m/s), Pasquill stability factor (D) represents moderate unstable typical of very windy/sunny or overcast/light wind conditions.

10D- The typical wind speed (10m/s), Pasquill stability factor (D) represents neutral condition typical of overcast day or night-time conditions.

5.3 Population Data

In order to calculate the level of Group risk created by the different failure cases, the SAFETI requires information about the population distribution. Combined the results associated with each in order to produce overall risk levels.

People also act as ignition sources and thus SAFETI also uses information from the population data files when it calculates ignition probabilities.

The population data around ATF Tank farm considered for QRA are shown in Table 5-3.

Table 5-3: Population around ATF Tank farm

Worker Category	Population	
	Day	Night
Shift Supervisors	1	1
Loading/Unloading Operators	5	5
Operators	4	4
Maintenance Filed Crew	8	8
Security Guard	4	4
Office Staff	20	10
Electrical Staff	4	4
Fire Fighting Operator	4	4
Total	**50**	**40**

5.4 Ignition Sources

Ignition of a hydrocarbon release is influenced by a large number of parameters, at least some of which are not well understood, or not amenable to quantification. However, the total number of ignited hydrocarbon releases is well documented, and in principle, a good estimate of the frequency of ignition is available. However, it should be noted that there is always some uncertainty in this estimate.

If a flammable release is not ignited immediately, then its chance of ignition is dependent upon the presence of ignition sources that may be in the vicinity. The probability of immediate ignition, however, is normally due to the nature of the release (e.g. a release due to external impact is likely to be ignited immediately due to heat caused by friction).

If an ignition source is not reached, or the ignition source is insufficient to ignite the release, then the release will have no impact.

In order to address delayed ignition, PHAST requires information about the distribution of ignition sources in the vicinity of the plant, together with information about their ignition strength. Several different types of ignition source are possible, such as boilers, workshops (welding), motor vehicles, electrical room and people. With regard to people, PHAST takes the population data and assigns a probability of ignition for each person to account for activities such as smoking and cooking (offsite).

Other ignition sources must be individually defined. Each source can be defined as a point source (e.g. fired heater), an area source (e.g. a workshop and electrical) or a line source (e.g. a road, electrical line). For every source probability of it being present at any given time must be defined along with its ignition strength.

6 CONSEQUENCE ANALYSIS & FIRE RISK ASSESMENT

6.1 Consequence Analysis

The consequence analysis is performed using DNV GL proprietary software PHAST 8.4. PHAST is a consequence and impact assessment module integrated within DNV GL risk calculation software SAFETI.

The objective of consequence analysis is as under:

- To calculate the different heat radiation downwind distance due to fire.
- To check the impact on Buildings near the ATF tank farm due to fire.
- To check the impact of heat radiation nearby equipment.
- Calculate the release duration of each isolatable section.

PHAST calculates wide range of possible consequences from the Loss of Containment events, including:

- ✓ HC/Gas jet fire: due to immediate ignition of HC/gas release.
- ✓ Flash fire: due to delayed ignition of vapour cloud formed due to the gas release.
- ✓ Flammable gas dispersion: due to un-ignited HC releases as applicable.
- ✓ Liquid pool fire: resulting from release of liquid hydrocarbon from process facility/tank farm.
- ✓ Toxic gas dispersion: due to release of HC mixture containing H2S or due to pool vaporization of toxic HC liquids.
- ✓ Explosion due to delayed ignition of flammable vapour cloud due to obstructed regions.
- ✓ To check the impact on Buildings near the ATF tank farm.

6.2 Physical Effect Modelling

Physical effect of process release, fire and explosion presents danger to personnel, assets, and the environment. The physical effect (flammable/ toxic dispersion, liquid pool evaporation, jet fire, pool fire, flash fire) modelling considers estimating the potential effects using predictive tools in PHAST/SAFETI software.

PHAST calculate all alternate consequence outcomes (e.g. jet fire, pool fire, flash fire, toxic effects, explosion etc.) of the event tree selected, in terms of hazard range and event duration (where applicable), for each weather class / wind speed combination. To produce risk results, SAFETI perform impact frequency calculations, using the failure case specified leak frequency as starting point. This section provides a brief overview of the physical effect models within PHAST/SAFETI software tool.

6.2.1 Dispersion

PHAST uses the Unified Dispersion Model (UDM version 2) for dispersion. The UDM contains modelling modules for passive, jet and heavy/ dense gas dispersion.

UDM models the dispersion following ground level or elevated level two phase unpressurised or pressurised release. It allows for continuous, instantaneous, constant finite duration, and general time varying releases. It includes a unified model for jet, heavy, and passive two-phase dispersion including possible droplet rainout, pool spreading and re-evaporation. It calculates the phase distribution and cloud temperature using either a non-equilibrium thermodynamics model, a non-reactive equilibrium model, or an equilibrium model.

6.2.2 Jet Fire Modelling

Jet flames can fully develop in an unconfined environment. At first, the influence of wind is disregarded to estimate its shape in idealised conditions. The flame shape is usually defined as the envelope of the visible flame.

PHAST uses surface emitter model for jet fire calculations. For this study, DNV GL recommended correlation (model) was selected for jet fires. DNV PHAST decides correlation that is most appropriate for the release conditions. DNV GL PHAST considers Jet Fire model.

6.2.3 Pool Fire Modelling

A pool fire can be defined as a turbulent diffusion fire burning above a horizontal pool vaporising flammable material under conditions where the flammable material has zero or very low initial momentum. A key feature of these fires is that there is a degree of feedback between the fire and the flammable material. To a greater or lesser extent, there is a heat transfer back from the fire to the pool that influences or even controls the rate of evaporation and hence the fire size and other characteristics. The pool with flammable material is not necessarily static. It may be spreading or contracting. Additional flammable material could be fuelling the fire from the leak source. Depletion of a local flammable material supply can occur via drainage or overflow to other areas.

6.2.4 Vapor Cloud Explosion Modelling:

Vapor cloud can result by either release of a gas from containment or by an evaporation of a liquid that was released from containment. A vapor cloud explosion happens upon ignition of such cloud given following conditions are met.

Release material must be flammable with suitable pressure and temperature.

A cloud is formed prior to ignition.

Part of the cloud must be within the flammable range of the material.

Rapid Flame propagation

Multi-Energy method developed by Van Den Berg has been used for determining overpressure and based on principle that deflagrative combustion generates blast only in those part of the quiescent vapor cloud which are sufficiently obstructed and / or partially confined. TNO Games methodology has been adopted for the determination of the realistic blast strength curve used in multi-energy model using SAFETI.

6.2.5 Toxic gas dispersion:

Accidental release of two-phase mixture will lead to the flashing of light end hydrocarbons and H_2S into atmosphere. In PHAST, for toxic releases the averaging time is set to 600 seconds. Large hole size releases tend to form a finite gas cloud which travels for a distance downwind as a hemisphere before reaching negligible concentration due to diffusion

Pls note that the above possible consequence will be depend upon loss of containment phases. As the plant stored only liquid; jet fire, flash fire and explosion will not be applicable.

6.3 Fire Risk Assessment

The purpose of FRA study is to characterize fully the radiant heat associated with credible fire hazards for the NMIA facilities. The study provides further supporting information to ensure risk-based decision making related to Fire Protection Design and verify requirements for followings:

- An active fire protection system (e.g. water spray systems, deluge systems, sprinkler systems) for equipment and ATF tank to assist against escalation from a fire scenario as applicable.
- Passive fire protection of structures and equipment containing large hydrocarbon inventory, if applicable.
- Requirement of Firefighting system (Firewater monitors and fire hydrant).
- Deluge protection on equipment containing large hydrocarbon inventory.

7 STUDY RESULTS AND DISCUSSIONS

7.1 Risk Indicator

The following risk indicators have been used to present the individual risk:

- Location Specific Individual Risk (LSIR)
- Individual Risk Per Annum (IRPA)

LSIR is used to indicate risk at a particular location. It is the risk for an individual who is positioned there for 24 hours per day, 365 days per year. It is a standard output from a QRA. In QRA study, the geographical variation of LSIR is represented by risk contour plots and used for land-use planning. Since in reality people do not remain continually at one location, this is not a realistic risk measure.

IRPA is more realistic estimation of risk, for an individual, taking account of them being at different locations for different duration of time at/near the facility. Risk estimates from QRA are normally converted to this form before comparing with risk criteria or historical data.

$$\text{IRPA} = \sum \text{LSIR x presence factor}$$

7.2 Individual Risk

Iso-risk contours for individual risk for NMIA ATF Tank Farm are shown in Figure 7-1 below.

The maximum individual risk contours are in the order of 10^{-3} per year represented by red colour in the Figure 7-1.

The enlarge view of iso-risk contour in loading / unloading area is shown in Figure 7-2 and Main Hydrant Pump area is shown is in Figure 7-3.

The following observations are perceived at the NMIA Tank Farm.

1. The maximum LSIR observed, at any location, is more than 10^{-3} per year.
2. The risk contour of 10^{-3} per year covers Main Hydrant Pumps area.
3. The risk contour of 10^{-4} per year covers storage tanks.
4. The main building and workshop areas are outside 10^{-5} per year contour.
5. The 10^{-6} per year contour is mostly within the ATF Tank Farm boundary, except for the south west side and a short length in the middle of the north side where it extends slightly outside. However, members of the public are not subject to individual risk exceeding 10^{-6} per year.

The iso-risk contours show that the maximum individual risk resulting from the ATF tank in "ALARP" region.

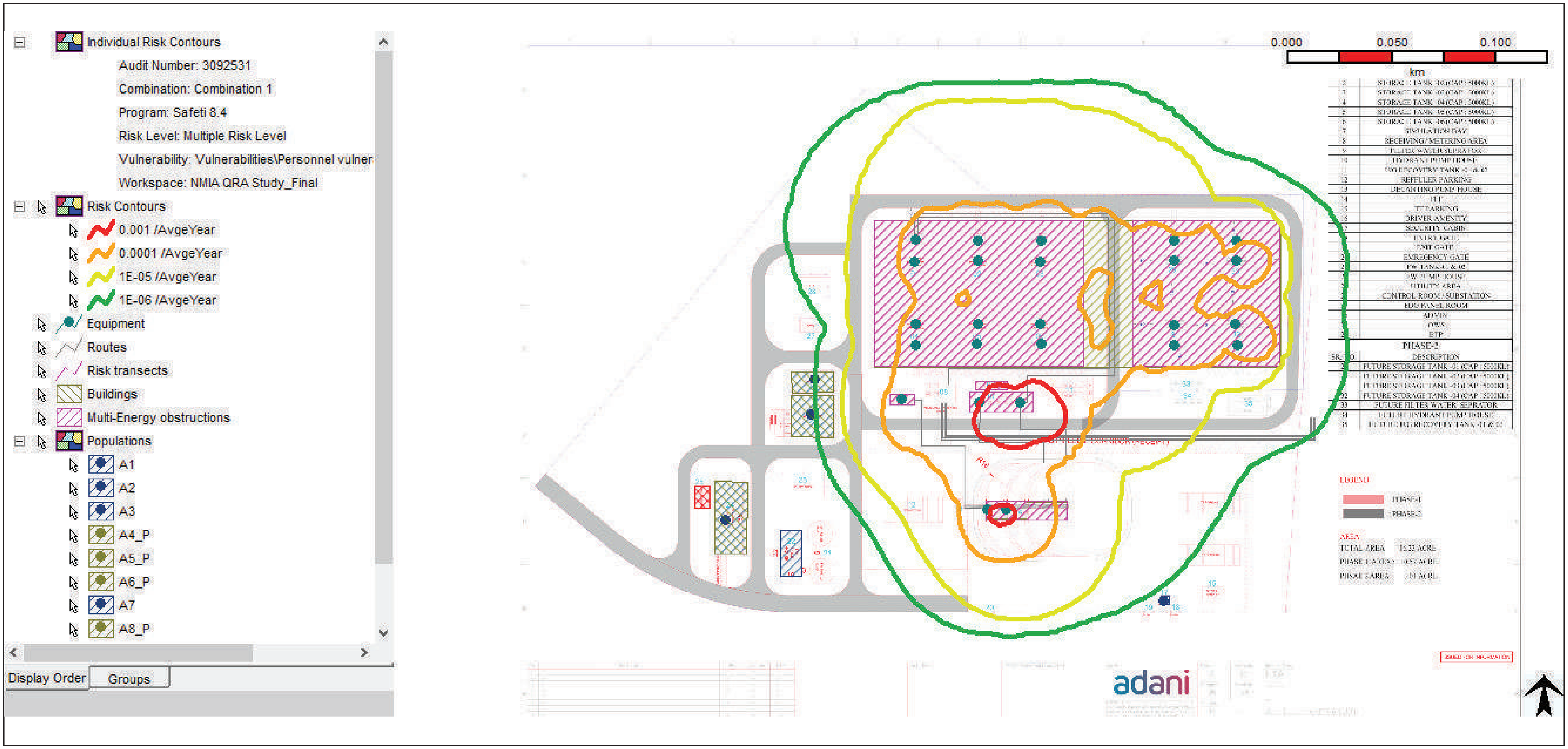


Figure 7-1 ISO-Risk Contour – Overall

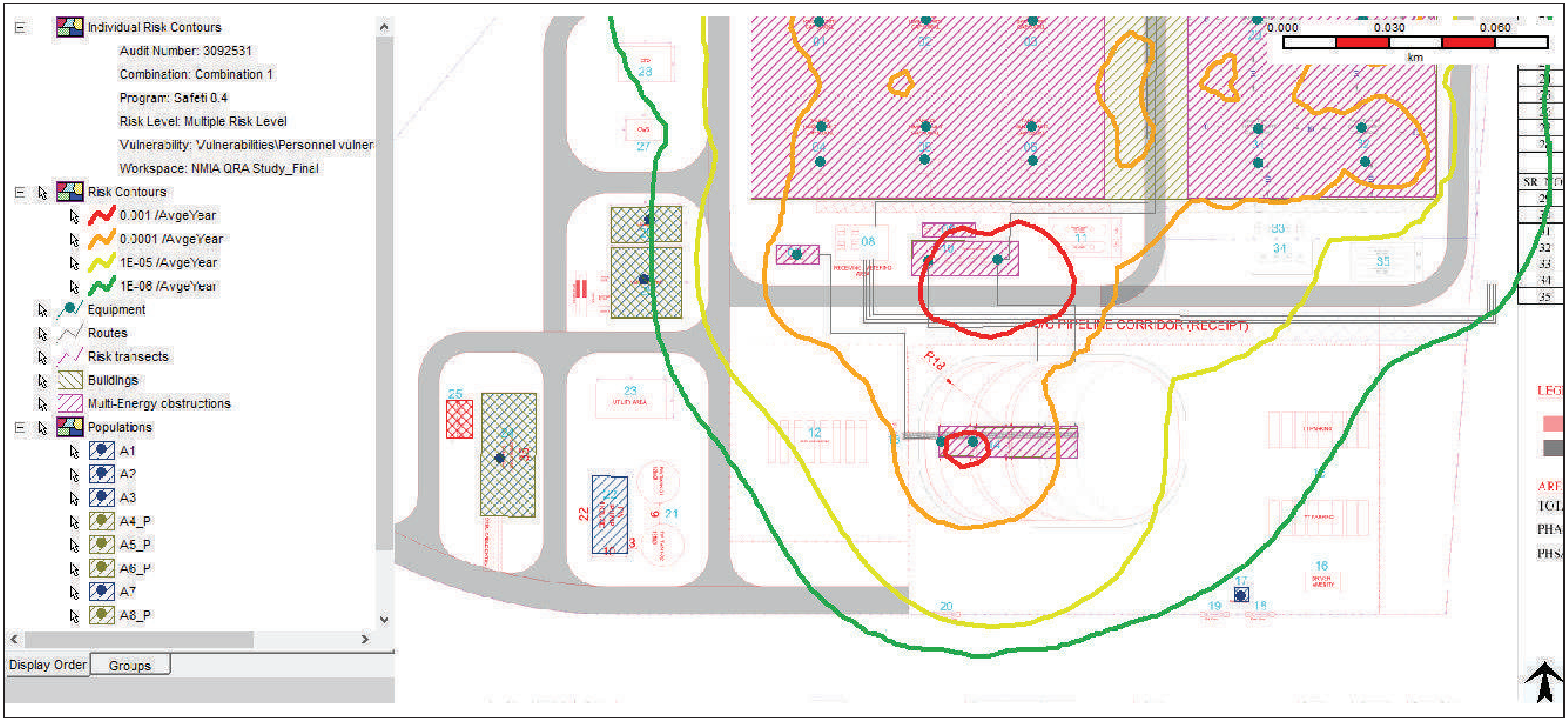


Figure 7-2 ISO-Risk Contour – Enlarge View (Loading/Unloading Enlarge View)

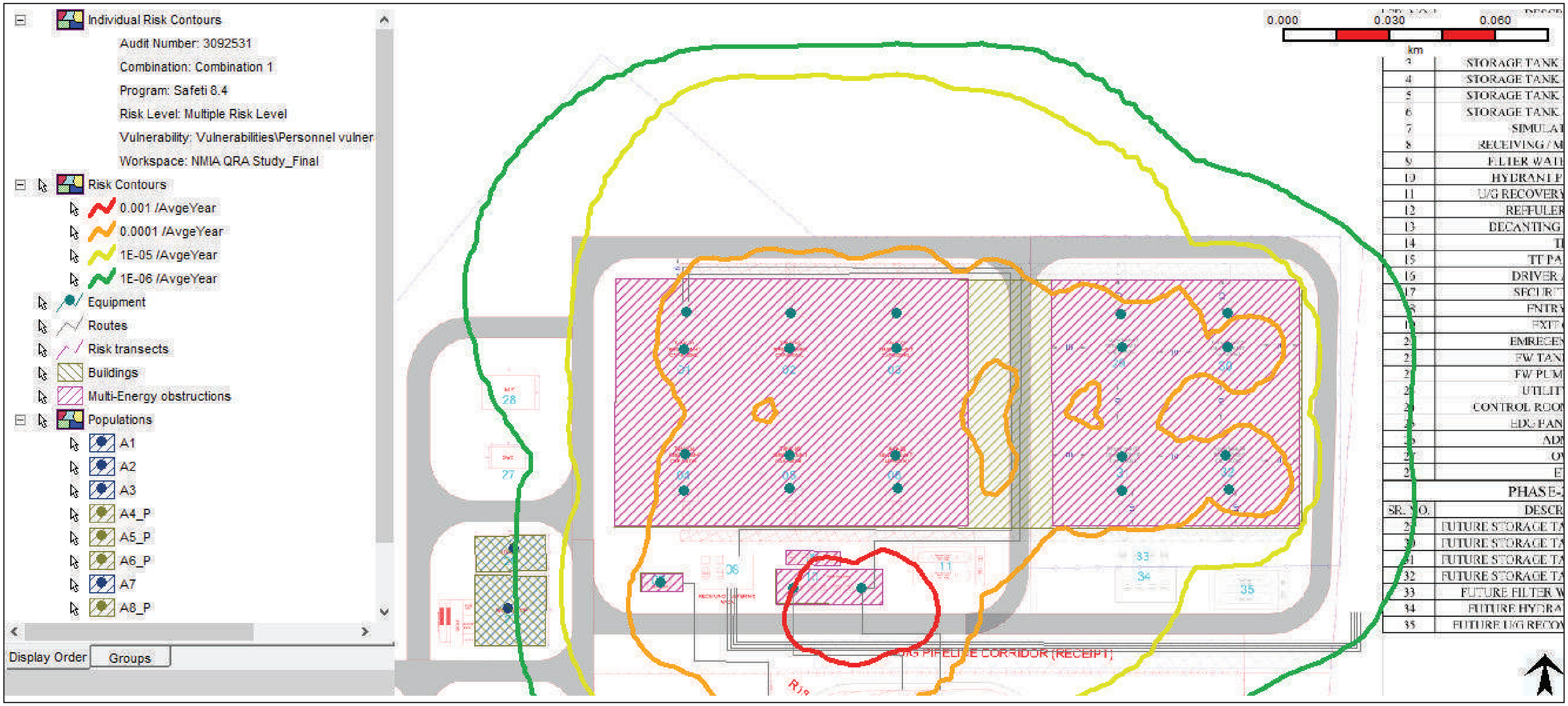


Figure 7-3 ISO-Risk Contour – Enlarge View (Tank Farm & Main Hydrant Pump Enlarge View)

7.2.1 Location Specific Individual Risk (LSIR)

The LSIR values at NMIA ATF Tank Farm are presented in Table 7-1. The maximum LSIR found at NMIA ATF Tank Farm is 4.71E-04/year at Main Hydrant Pump, which is mainly due to high failure frequency and pump operating pressure followed by loading/unloading facility.

Calculated LSIR values are used to estimate IRPA based on time an individual spends at different locations.

Table 7-1: LSIR for Different Locations at Terminal-1

Sr. No.	Areas/Buildings	LSIR
1	A1_Electrical room	3.44E-10
2	A2_Administration Building	4.24E-09
3	A3_Maintenance shed/Storeroom	1.28E-08
4	A4_Tank Farm Area	2.96E-05
5	A5_Main Hydrant Pump Area	4.71E-04
6	A6_Filter & PLR Area	1.72E-04
7	A7_Fire Fighting Area	7.57E-09
8	A8_Loading/Unloading Area	2.76E-04
9	A9_Security Gate	7.27E-07

LSIR for each area are presented in Figure 7-4 below.

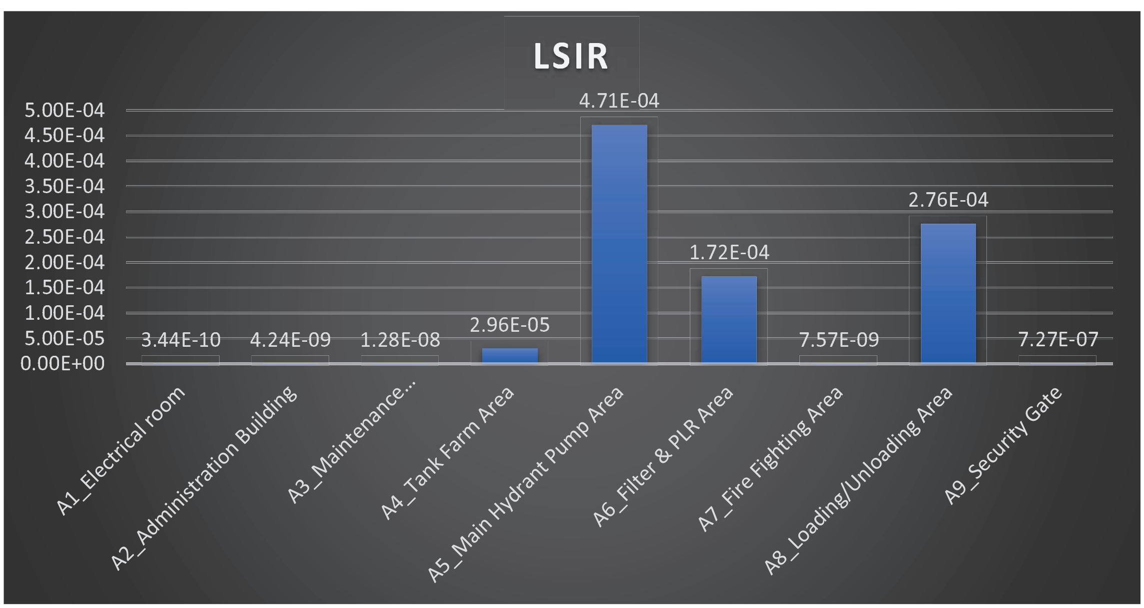


Figure 7-4 LSIR for different location

7.2.2 Individual Risk Per Annum (IRPA)

IRPA is calculated for different workers group based on their presence near/within the hazardous facilities. Manning data is indicated in section 5.3.

The level of risk for different worker categories depends on proportion of time that members of that category spend in process areas. Working hours, therefore, are distributed across the terminal, based on the nature of works that individuals do.

The presence factor (PF) is calculated based upon manning data and rotation pattern, PF calculated as under:

e.g. PF = (12 hrs./24hrs) X (6/7)

e.g. PF = 0.43

The calculated IRPA to the personnel in hazardous area i.e. pumps area; tank farm area and buildings are calculated and presented in Table 7-2 and assessed by comparing with NMIA risk criteria for existing installations. It is clear from the Table 7-2 most of the personnel are exposed to ALARP i.e. risk less than 10^{-3} per year.

Table 7-2 IRPA Calculation for NMIA ATF Tank Farm

Sr. No.	Worker Category	IRPA
1	Shift Supervisors	1.82E-09
2	Loading / Unloading Operators	2.24E-05
3	Operators	2.91E-05
4	Maintenance Field Crew	3.52E-05
5	Security Guard	3.12E-07
6	Office Staff	1.82E-09
7	Electrical Staff	1.47E-10
8	Fire Fighting Operator	3.24E-09

From the above Table 7-2 it is found that the maximum individual risk is 3.52E-05 **per year**. As the risk from fire is in ALARP.

IRPA for each group of workers are presented in Figure 7-5 below.

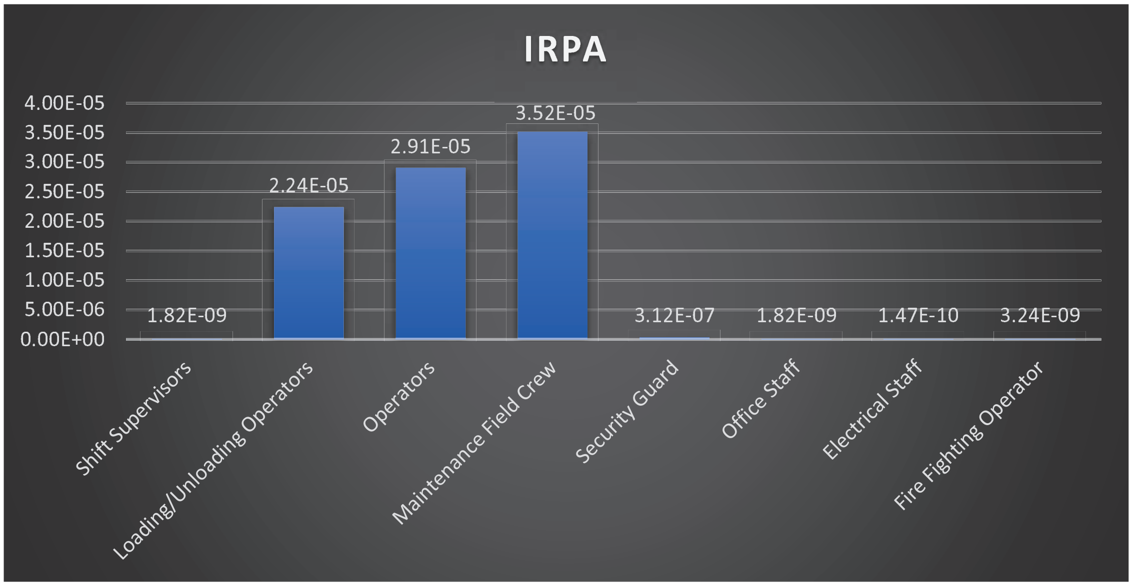


Figure 7-5 IRPA for different Worker Category

7.2.3 Maximum Individual Risk

The individual risk from NMIA ATF Tank Farm is in the lower part of “ALARP” region. The presentation of Individual Risk is provided in Figure 7-6 below.

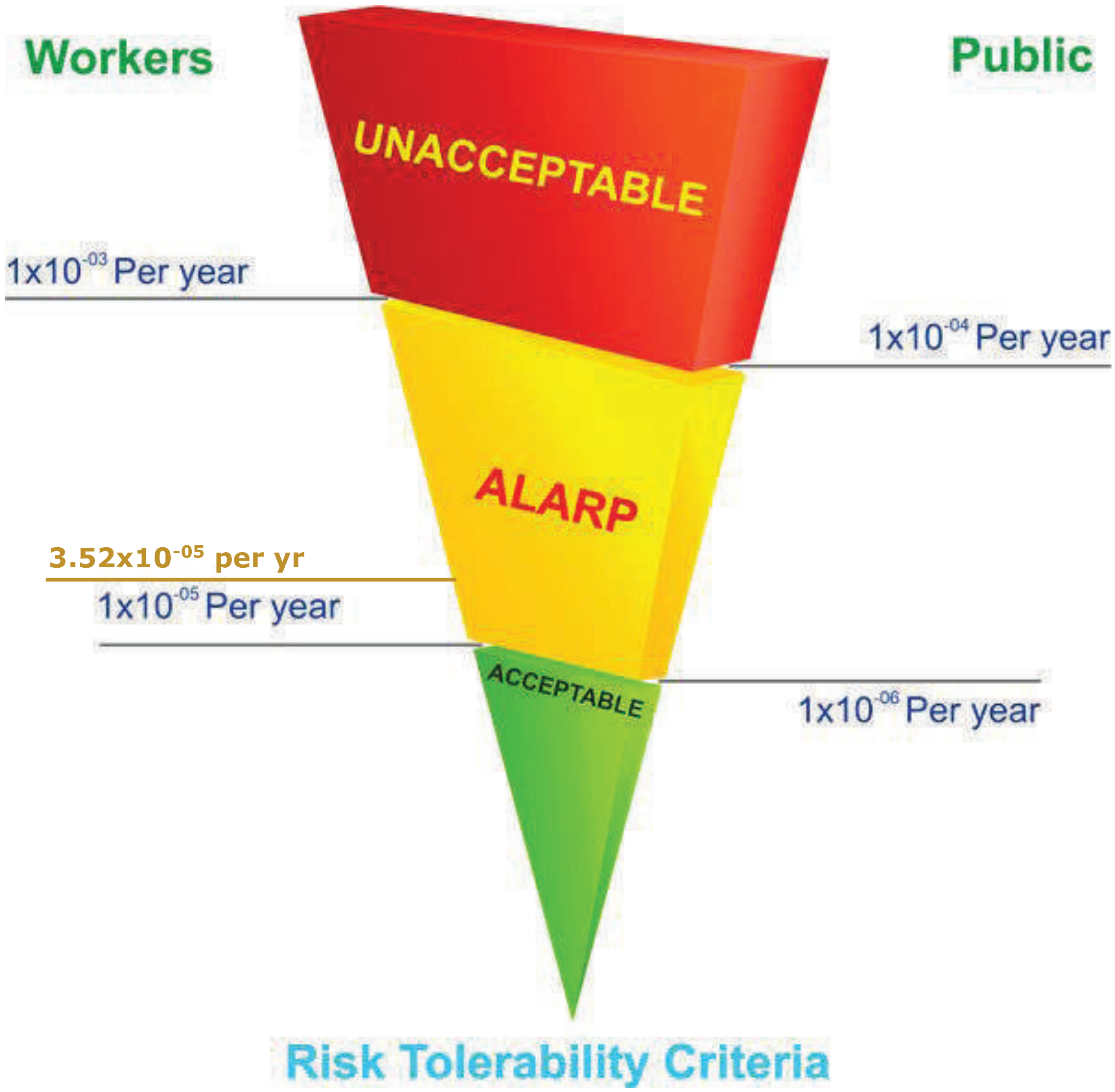


Figure 7-6 Maximum Individual Risk

7.3 Societal Risk

The Societal (Group) risk from NMIA ATF Tank Farm is shown in Figure 7-7 the form of an FN curve. The criteria used here is the NMIA Societal Risk Criteria for FN curves.

The results of FN curves show that the societal risk is negligible. There is potential of some events which may cause multiple fatalities; however, the cumulative frequency of such events is well below the negligible risk criteria set for this analysis.

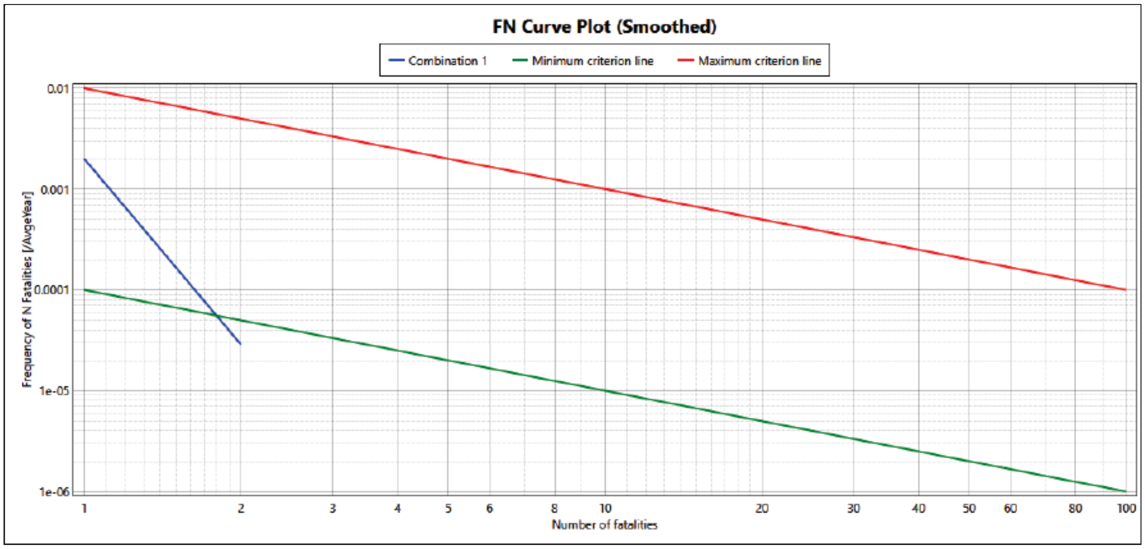


Figure 7-7 FN Curve for Societal Risk

7.3.1 Top Risk Contributors

Table 7-3: Top Risk Contributors

Equipment/ Location	PLL	Risk Percent (%)
ISO-07/TLS-01/L/S/5MM (Tanker Loading Facility)	6.74E-04	36.64%
ISO-07/TLS-02/L/S/5MM (Tanker Loading Facility)	4.48E-04	24.37%
ISO-05/MHP-01/L/S/5MM (Main Hydrant Pump)	3.26E-04	17.72%
ISO-08/TOS-01/L/S/5MM (Tanker Off-loading Facility)	1.12E-04	6.09%
ISO-07/TLS-02/L/M/25MM (Tanker Loading Facility)	8.14E-05	4.43%
ISO-05/MHP-03/L/S/5MM (Main Hydrant Pump)	7.69E-05	4.18%
ISO-08/TOS-02/L/S/5MM (Tanker Off-loading Facility)	3.76E-05	2.04%

Equipment/ Location	PLL	Risk Percent (%)
ISO-07/TLS-01/L/M/25MM (Tanker Loading Facility)	3.69E-05	2.01%
ISO-07/TLS-02/L/FBR/150MM (Tanker Loading Facility)	2.32E-05	1.26%
ISO-05/MHP-01/L/M/25MM (Main Hydrant Pump)	2.29E-05	1.25%

There is no single equipment which is coming up very high in overall risk contribution. The loading/unloading facility and main hydrant pumps are the main contributors due to high frequency of leakages & high discharge pressure from the pumps and manning in this area.

7.4 Consequence Analysis Results

Physical effect of process release, fire and explosion presents danger to personnel, assets, and the environment. The physical effect (flammable/ toxic dispersion, liquid pool evaporation, jet fire, pool fire, flash fire) modelling considers estimating the potential effects using predictive tools in PHAST/SAFETI software.

PHAST calculate all alternate consequence outcomes (e.g. jet fire, pool fire, flash fire, toxic effects, explosion etc.) of the event tree selected, in terms of hazard range and event duration (where applicable), for each weather class / wind speed combination. To produce risk results, SAFETI perform impact frequency calculations, using the failure case specified leak frequency as starting point. This section provides a brief overview of the physical effect models within PHAST/SAFETI software tool.

Multi-Energy method developed by Van Den Berg has been used for determining overpressure and based on principle that deflagrative combustion generates blast only in those part of the quiescent vapor cloud which are sufficiently obstructed and / or partially confined. TNO Games methodology has been adopted for the determination of the realistic blast strength curve used in multi-energy model using SAFETI.

The consequence analysis results tabulated in Appendix-3, and graphs are presented in Appendix 4.

It may be noted that for the scenarios involving release of ATF, pool fire is the main consequence. Gas dispersion, flash fire and jet fire are not significant. There are no vapour cloud explosion results.

7.5 Fire Risk Assessment Results

Based on

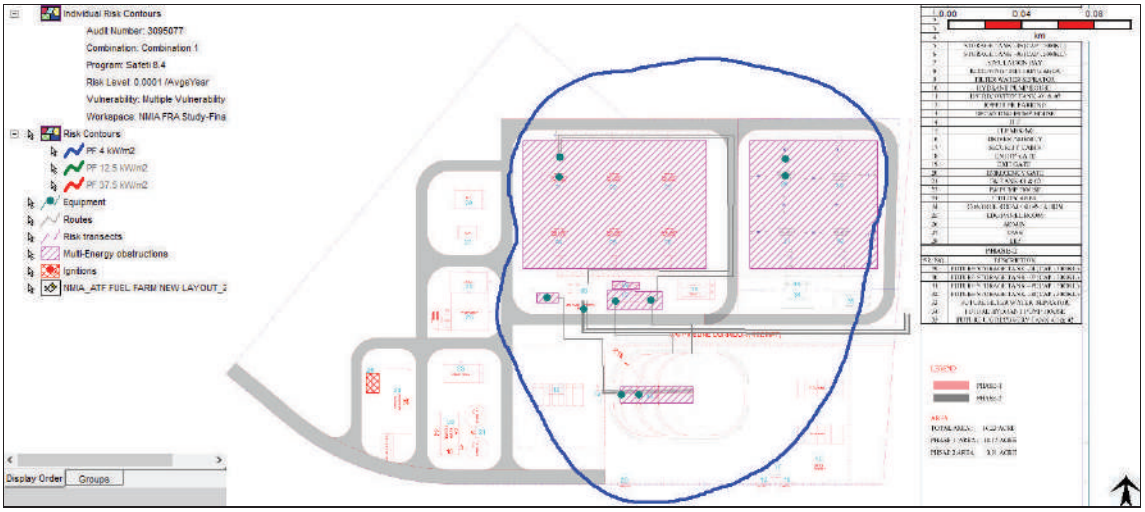


Figure 7-8 and

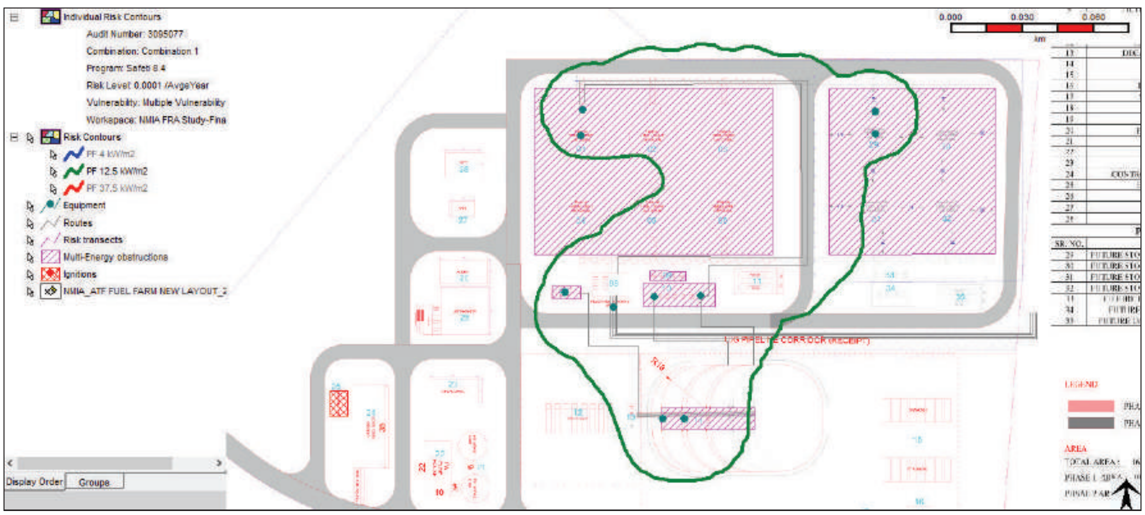
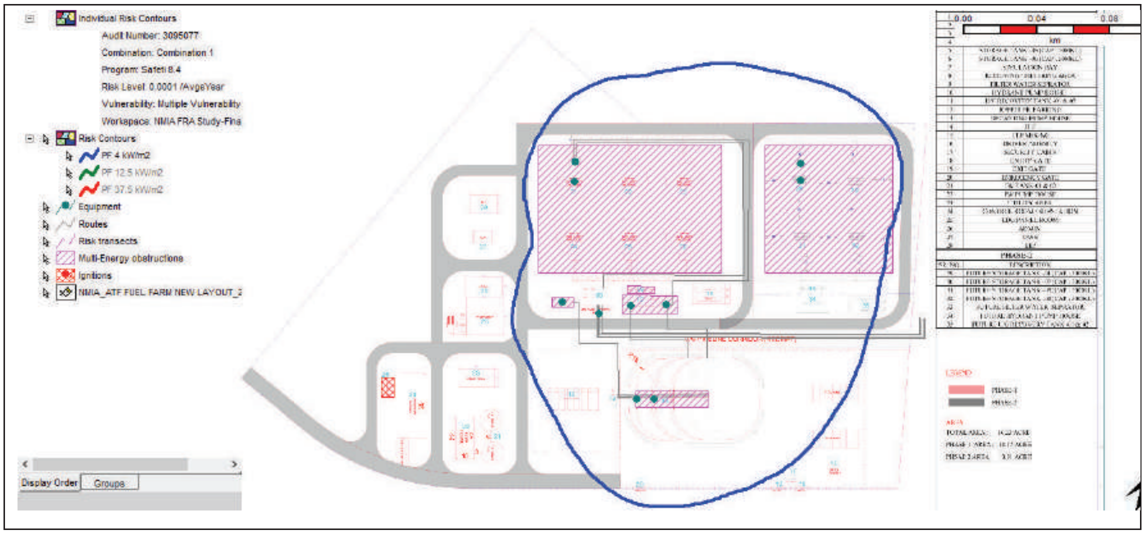


Figure 7-9, it may be concluded that:

1. As per IP 19, Emergency Responders (ER's) wearing appropriate PPE should be able to carry out longer duration operation if subjected to between 3-6 kW/m2. For this study, 4 kW/m2 has been selected conservatively to assess the safe location for emergency responders for firefighting in case of requirement.



2. Figure 7-8 shows the extent of 4 kW/m2 heat radiation contour (1E-04) for the NMIA ATF Tank Farm facility. The effect level (radiation level) is reported at 1-meter effect height (average height of person).
3. Heat Radiation (12.5 kW/m^2) extent from credible pool fire scenario for 1E-04/year contour is covering whole process area including tank farm are and diesel storage area. However, one monitor (remotely operated elevated monitors / locally operated grade level monitor) is available outside 12.5kW/m^2 exposed area.
4. Heat Radiation (4 and 12.5 kW/m^2) extent from credible jet fire scenario for 1E-04/year contour is not realized.

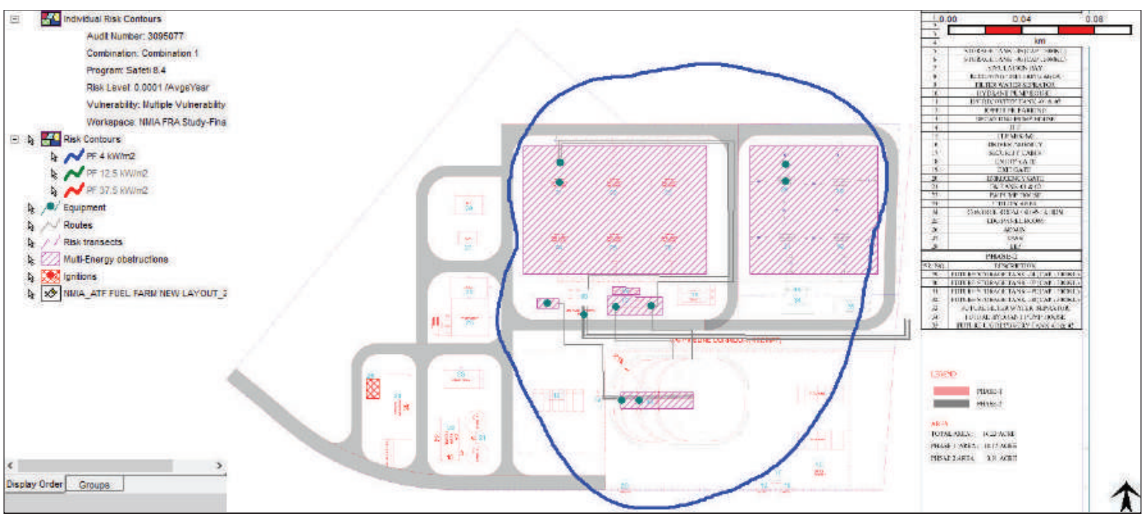


Figure 7-8: Heat Radiation (4 kW/m^2) extent from pool fire scenario for 1E-04/year

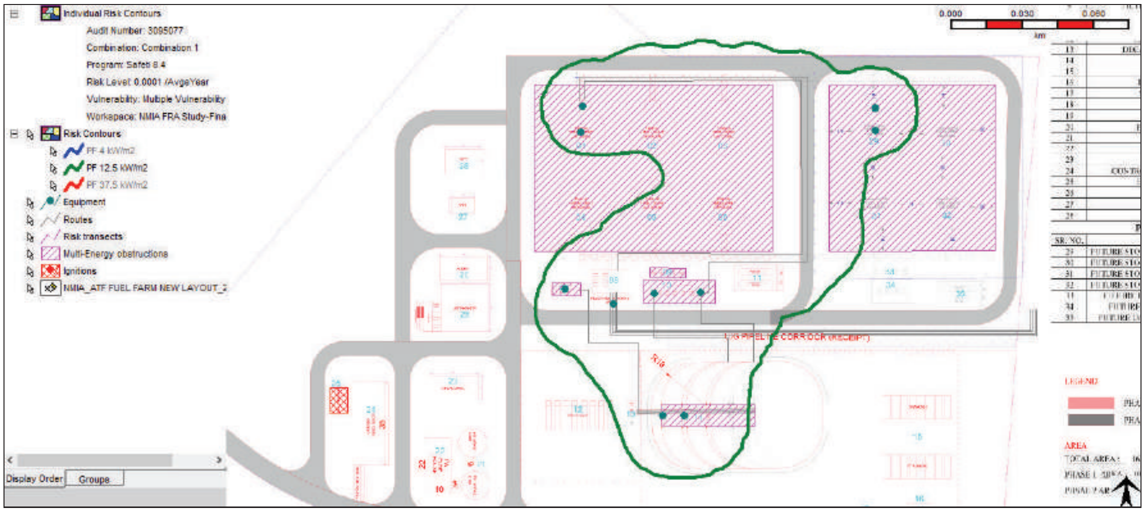


Figure 7-9: Heat Radiation (12.5 kW/m²) extent from pool fire scenario for 1E-04/year

The objective of the passive fire protection assessment is to identify any PFP requirements for the facility. The assessment for PFP draws upon the results from the fire risk assessment, which details the consequence modelling results of identified fire scenarios.

The PFP assessment methodology followed:

a) Pool from a release will be assessed to identify the heat radiation 37.5 kW/m² extent of pool fire (10 min).

b) Determine the fire proofing needs for 1E-04/year contour, if required.

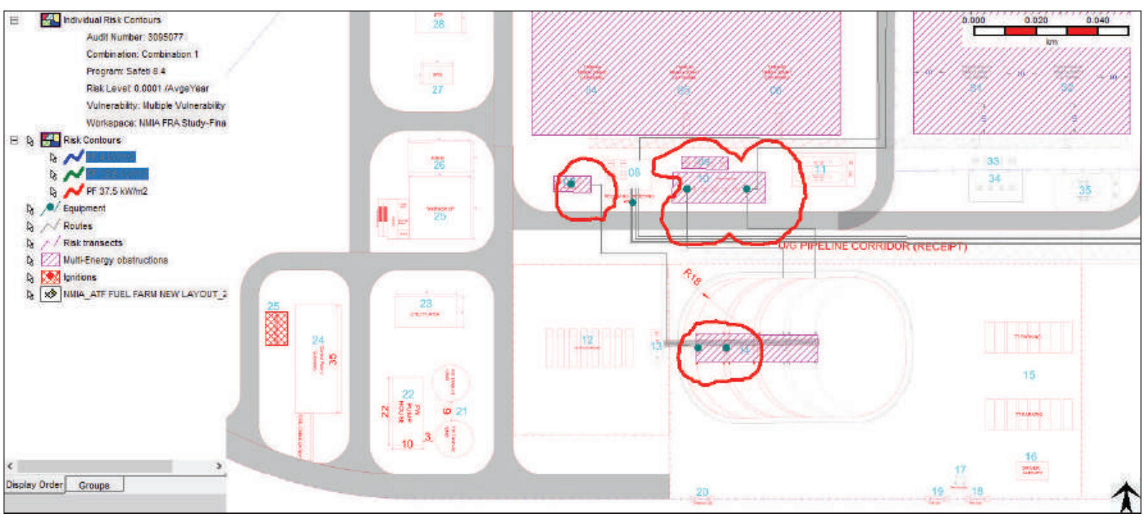


Figure 7-10: Heat Radiation (37.5 kW/m²) extent from pool fire scenario for 1E-04/year

8 CONCLUSIONS & RECOMMENDATIONS

8.1 Conclusions

A qualitative review was performed for possible accidents that may occur, based on industry fire accident experience or judgment where necessary. Potential failure scenarios are developed based on hazard identification and QRA studies conducted for the NMIA ATF Tank Farm, considering the nature of process, materials being processed and handled.

Individual risk members of the public is within 10^{-6} per year.

The highest individual risk to personnel working in the tank farm is 3.52E-05 per year which is in the lower part of ALARP region.

The societal risk is in the lower part of ALARP region for events involving up-to 2 fatalities, and in Acceptable region for events involving 3 fatalities. No event with higher than 3 fatalities is predicted.

As such, the ATF Tank Farm facility at NMIA meets the criteria for individual risk and societal risk.

The tank farm facility inside the international airport will have all necessary provisions for fire protection.

The following observations are made on the results of consequence analysis:

- There is no impact on building from any of pool fire scenarios.
- In case of ATF tank surface fire, radiation intensity of 37.5 kW/m^2 which can cause damage does not impact the adjacent tanks as presented in Appendix-4.
- In case of dyke fire ATF tank, thermal radiation intensity does not reach 37.5 kW/m^2 and thermal radiation intensity of 4 kW/m^2 falls well within the NMIA Tank Farm boundary.
- In case of dyke fire ATF tank, the fire water storage tanks and pump house may be subject to fire radiation intensity exceeding 4 kW/m^2.

The following observations are made on the results of fire risk analysis:

- The fire risk contour of 1E-04/ year frequency for heat radiation intensity 4 kW/m^2 covers the whole tank farm, pump house and filling bays. However, the administration building, storeroom and electrical rooms are outside the contour.
- The fire risk contour of 1E-04/ year frequency for heat radiation intensity 12.5 kW/m^2 covers the whole tank farm, pump house and filling bays. However, the buildings are outside the contour It is concluded that all building are safe in case of fire in any of the tank and pumps.
- The fire risk contour of 1E-04/ year frequency for heat radiation intensity 37.5 kW/m^2 covers mainly main hydrant pumps, loading/unloading facility & Fueller loading Pump. Hence there is no requirement of passive fire protection (PFP) of tanks etc.

8.2 Recommendation

The following recommendations are made to ensure that the risks at the ATF tank farm facility of NMIA are maintained as low as reasonably practicable.

1. Provision of adequate instrumentation and controls for overfill protection of storage tanks in the tank farm on the same lines as specified in OISD 244.
2. Provision of 2 Nos. portable type medium expansion foam generators (MEFG) for fighting syke fires.
3. Provision of jumbo water curtains to shield the fire water pump house and storage tanks in case of dyke fire in ATF tank.
4. Provision for stoppage of oil transfer pumps by emergency shut down (ESD) system from a safe location in case of any leakage/fire.
5. One or more pushbuttons for ESD are to be provided in the tanker loading area.
6. Implementation of emergency response plan to be included for the NMIA ATF Tank farm.

Appendix-1 Failure Case ID & ISO Section Marked on PFD

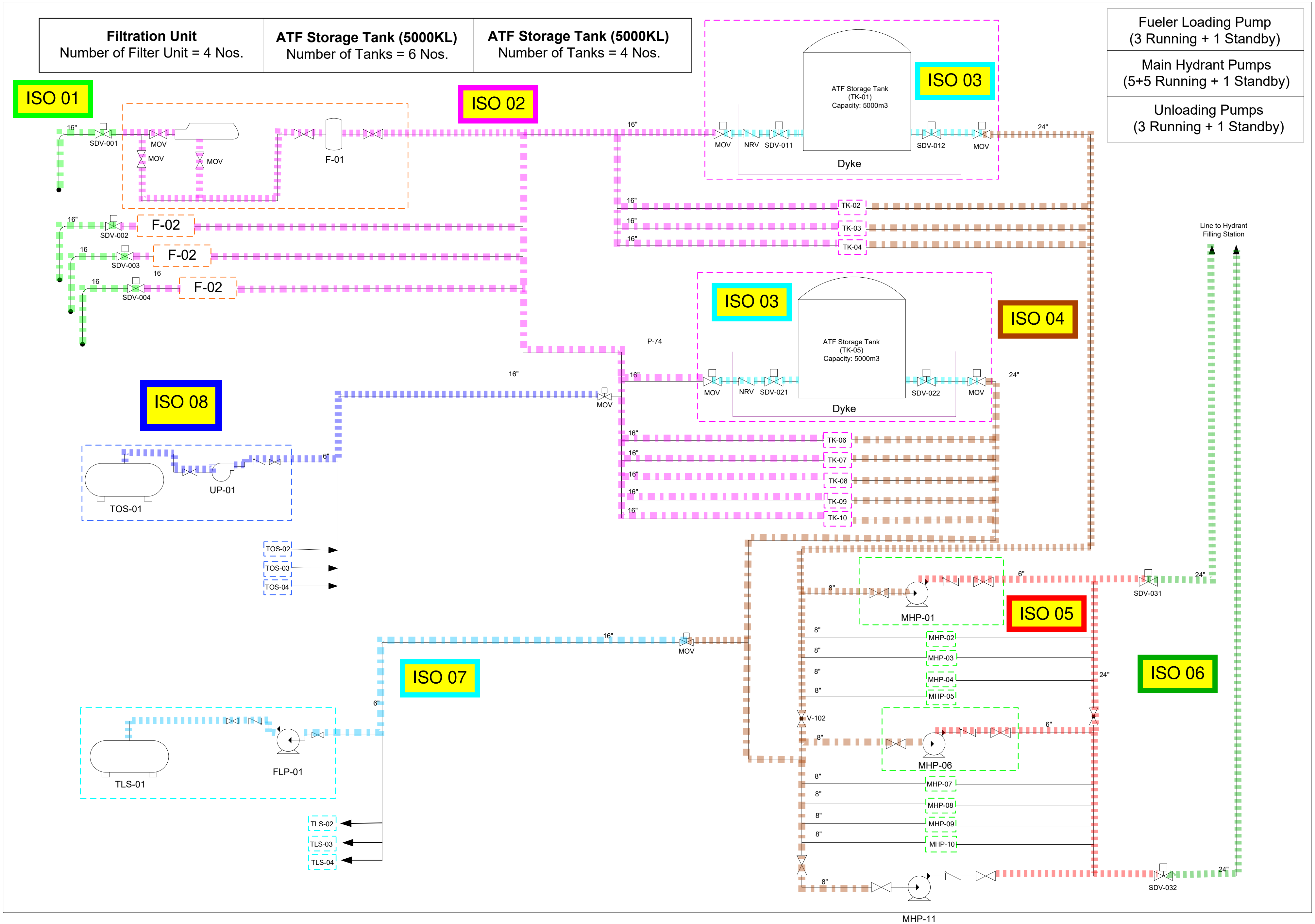
Appendix-1(A) Failure Case ID

APPENDIX-1(a)

Failure Case Selection

Sec. No.	Isolatable Section		Failure Case ID	Failure Case Definition	Associated Equipment	Reference Layout/PFD	Temperature (°C)	Pressure (barg)	Remark
	Section Start	Section Finish							
ISO-01	Incoming pipe line	To receiving/Meetering area	ISO-01/IP/L	LOC at pig reciever Header	Incoming header	A3-1840-210-001 (3 of 4) Rev-E	45	3	Underground pipeline
ISO-02	From eceiving/Meetering area	Tank inlet SDVs	ISO-02/FLTR/L	LOC at Filter	Filter Unit	A3-1840-210-001 (3 of 4) Rev-E	45	3	
ISO-03	Inlet SDVs of tank	Tank Outlet SDVs	ISO-03A/TK-01/L	LOC at Tank (A)	Phase-I Tank (5000 m3) - Tank A	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03B/TK-02/L	LOC at Tank (B)	Phase-I Tank (5000 m3) - Tank B	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03C/TK-03/L	LOC at Tank (C)	Phase-I Tank (5000 m3) - Tank C	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03D/TK-04/L	LOC at Tank (D)	Phase-I Tank (5000 m3) - Tank D	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03E/TK-05/L	LOC at Tank (E)	Phase-I Tank (5000 m3) - Tank E	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03F/TK-06/L	LOC at Tank (F)	Phase-I Tank (5000 m3) - Tank-F	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03G/TK-07/L	LOC at Tank (G)	Phase-II Tank (5000 m3) - Tank-G	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03H/TK-08/L	LOC at Tank (H)	Phase-II Tank (5000 m3) - Tank-H	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03I/TK-09/L	LOC at Tank (I)	Phase-II Tank (5000 m3) - Tank-I	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
			ISO-03J/TK-10/L	LOC at Tank (J)	Phase-II Tank (5000 m3) - Tank-J	A3-1840-210-001 (3 of 4) Rev-E	45	atm	
ISO-04	From outlet SDV of tank	Main hydrant pump house suction	ISO-05/HEADER/L	LOC at tank outlet Header	Tank outlet header	A3-1840-210-001 (3 of 4) Rev-E	45	10	
ISO-05	Main hydrant pump discharge	Loading facility pipeline battery limit	ISO-05/MHP-01/02/03/-04/05/L	LOC at main hydrant pump	Main Hydrant pump (MHP-1/2/3/4/5)	A3-1840-210-001 (3 of 4) Rev-E	45	10	Total 11 number of main hydrant pump (5runing+5 runing+1standby), for QRA modelling considering two set of main hydrant pumps each set was considered as 5 nos of pumps.
			ISO-05/MHP-06/07/08/-09/10/L	LOC at main hydrant pump	Main Hydrant pump (MHP-6/7/8/9/10)				
ISO-06	Main hydrant pump discharge SDV	Flight filling facility pipeline battery limit	ISO-06A/HEADER/L	LOC at Main Hydrant pump discharge pipeline	Main Hydrant pump discharge pipeline	A3-1840-210-001 (3 of 4) Rev-E	45	10	Underground pipeline
			ISO-06B/HEADER/L	LOC at Main Hydrant pump discharge pipeline	Main Hydrant pump discharge pipeline				
ISO-07	Tanker	Tanker loading connection	ISO-08A/TLS-01/L	LOC at tanker loading facility	Loading Facility	A3-1840-210-001 (3 of 4) Rev-E	45	3	
			ISO-08B/TLS-02/L						
			ISO-08C/TLS-03/L						
			ISO-08D/TLS-04/L						
ISO-08	Tanker	Tanker off-loading connection	ISO-07A/TOL-01/L	LOC at tanker off-loading facility	Off-loading Facility	A3-1840-210-001 (3 of 4) Rev-E	45	3	
			ISO-07B/TOL-02/L						
			ISO-07C/TOL-03/L						
			ISO-07D/TOL-04/L						

Appendix-1(B) ISO Section Marked on PFD



Filtration Unit
Number of Filter Unit = 4 Nos.
ATF Storage Tank (5000KL)
Number of Tanks = 6 Nos.
ATF Storage Tank (5000KL)
Number of Tanks = 4 Nos.
Fueler Loading Pump
(3 Running + 1 Standby)
Main Hydrant Pumps
(5+5 Running + 1 Standby)
Unloading Pumps
(3 Running + 1 Standby)
ISO 01
ISO 02
ISO 03
ISO 03
ISO 04
ISO 05
ISO 06
ISO 07
ISO 08
SDV-001
MOV
F-01
F-02
F-02
F-02
SDV-002
SDV-003
SDV-004
ATF Storage Tank
(TK-01)
Capacity: 5000m3
NRV
SDV-011
SDV-012
Dyke
TK-02
TK-03
TK-04
ATF Storage Tank
(TK-05)
Capacity: 5000m3
SDV-021
SDV-022
P-74
TK-06
TK-07
TK-08
TK-09
TK-10
TOS-01
UP-01
TOS-02
TOS-03
TOS-04
Line to Hydrant
Filling Station
MHP-01
MHP-02
MHP-03
MHP-04
MHP-05
MHP-06
MHP-07
MHP-08
MHP-09
MHP-10
MHP-11
V-102
SDV-031
SDV-032
TLS-01
FLP-01
TLS-02
TLS-03
TLS-04

Appendix-2 Calculated Inventory & Failure Frequency

APPENDIX-2

Isolatable Section	Failure Case ID	Hole Szie	Calculated Inventory				Calculated Failure Frequency		
			Static Inventory (kg)	Release Rate (kg/s)	Dynamic Inventory (kg)	Total Inventory (kg)	Failure Frequency	Total Failure Frequency	Hole Size Distribution (%)
ISO-01/PIPELINE/L	ISO-01/PIPELINE/L/S	5	97751	0.27	486	98237	1.02E-04	3.30E-04	0.31
	ISO-01/PIPELINE/L/M	25		6.75	12154	109904	1.12E-04		0.34
	ISO-01/PIPELINE/L/L	100		59.00	35400	133151	5.28E-05		0.16
	ISO-01/PIPELINE/L/FBR	150		59.00	35400	133151	6.27E-05		0.19
ISO-02/FLTR/L	ISO-02/FLTR/L/S	5	25415	0.27	16	25431	7.18E-03	9.15E-03	0.78
	ISO-02/FLTR/L/M	25		27.01	1620	27036	1.21E-03		0.13
	ISO-02/FLTR/L/L	100		59.00	3540	28955	3.20E-04		0.03
	ISO-02/FLTR/L/FBR	150		59.00	3540	28955	4.36E-04		0.05
ISO-03/TK-01-10/L (Phase-I&II)	ISO-03/TK-01/L/S	5	3837136	0.23	-	3837136	9.37E-04	1.16E-03	0.81
	ISO-03/TK-01/L/M	25		4.49	-	3837136	1.46E-04		0.13
	ISO-03/TK-01/L/L	100		71.94	-	3837136	3.07E-05		0.03
	ISO-03/TK-01/L/FBR	150		161.86	-	3837136	4.68E-05		0.04
	ISO-03/TK-01/L/DF	Dyke Fire		-	-	3837136	6.00E-05	-	
	ISO-03/TK-01/L/SF	Tank Surface Fire		-	-	3837136	9.00E-05		
ISO-04/HEADER/L	ISO-04/HEADER/L/S	5	51991	0.38	23	52014	8.70E-03	1.11E-02	0.78
	ISO-04/HEADER/L/M	25		3.44	206	52197	1.53E-03		0.14
	ISO-04/HEADER/L/L	100		38.19	2292	54283	3.90E-04		0.04
	ISO-04/HEADER/L/FBR	150		59.00	3540	55531	4.79E-04		0.04
ISO-05/MHP/L	ISO-05/MHP/L/S	5	3437	0.38	23	3459	1.98E-02	2.10E-02	0.94
	ISO-05/MHP/L/M	25		3.44	206	3643	1.09E-03		0.05
	ISO-05/MHP/L/L	100		29.00	2292	5177	1.14E-04		0.01
	ISO-05/MHP/L/FBR	150		29.00	3540	5177	2.85E-05		0.00
ISO-06/HEADER/L	ISO-06/HEADER/L/S	5	54985	0.38	23	55008	3.66E-03	5.28E-03	0.69
	ISO-06/HEADER/L/M	25		3.44	206	55191	8.82E-04		0.17
	ISO-06/HEADER/L/L	100		29.00	1740	56725	3.03E-04		0.06
	ISO-06/HEADER/L/FBR	150		29.00	1740	56725	4.31E-04		0.08

APPENDIX-2

Isolatable Section	Failure Case ID	Hole Szie	Calculated Inventory				Calculated Failure Frequency		
			Static Inventory (kg)	Release Rate (kg/s)	Dynamic Inventory (kg)	Total Inventory (kg)	Failure Frequency	Total Failure Frequency	Hole Size Distribution (%)
ISO-07/TLS-01/L	ISO-07A/TLS-01/L/S	5	5437	0.16	23	5447	1.19E-02	1.26E-02	0.94
	ISO-07A/TLS-01/L/M	25		3.44	206	5644	6.56E-04		0.05
	ISO-07A/TLS-01/L/L	100		29.00	1740	7177	8.05E-05		0.01
	ISO-07A/TLS-01/L/FBR	150		29.00	1740	7177	3.90E-06		0.00
	ISO-07B/TLS-01/L/S	5		0.16	9	5447	3.41E-03	4.21E-03	0.81
	ISO-07B/TLS-01/L/M	25		3.44	206	5644	5.56E-04		0.13
	ISO-07B/TLS-01/L/L	100		29.00	1740	7177	1.17E-04		0.03
	ISO-07B/TLS-01/L/FBR	150		29.00	1740	7177	1.30E-04		0.03
ISO-08/TOS-01/L	ISO-08A/TOS-01/L/S	5	5437	0.16	9	5447	1.19E-02	1.26E-02	0.94
	ISO-08A/TOS-01/L/M	25		3.44	206	5644	6.56E-04		0.05
	ISO-08A/TOS-01/L/L	100		29.00	1740	7177	8.05E-05		0.01
	ISO-08A/TOS-01/L/FBR	150		29.00	1740	7177	3.90E-06		0.00
	ISO-08B/TOS-01/L/S	5		0.16	9	5447	3.41E-03	4.21E-03	0.81
	ISO-08B/TOS-01/L/M	25		3.44	206	5644	5.56E-04		0.13
	ISO-08B/TOS-01/L/L	100		29.00	1740	7177	1.17E-04		0.03
	ISO-08B/TOS-01/L/FBR	150		29.00	1740	7177	1.30E-04		0.03

Appendix-3 Consequence Analysis Results - Tables

APPENDIX-3

Consequence Analysis Results

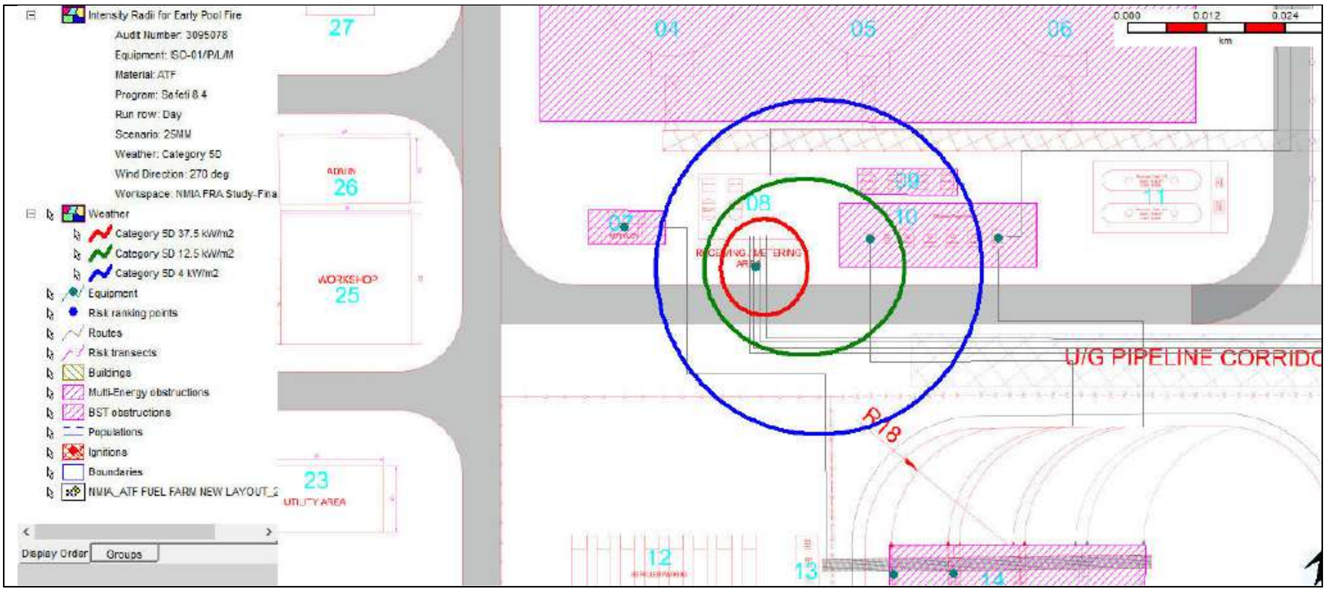
Path	Hole size (mm)	Release Rate (kg/s)	Inventory (kg)	Release Duration	Material	Pool Diameter (m)	Distance downwind to intensity level 1 (4 kW/m2) (m)	Distance downwind to intensity level 2 (12.5 kW/m2) (m)	Distance downwind to intensity level 3 (37.5 kW/m2) (m)	Maintenance Building/Workshop (m)	Admin Building (m)	Electrical room (m)	Assessment
Incoming Pipeline	5	0.3	98237	101 hrs	ATF	2	13	9	6	59.84	55	110.93	NR
	25	6.8	109904	4 hrs & 30 min	ATF	11	34	23	8				
	100	59.0	133151	38 min	ATF	33	59	23	NR				
	150	59.0	133151	38 min	ATF	33	59	23	NR				
Tank Surface Fire	TK-01	25.8*	3837136	~40 hrs	ATF	22	47	22	NR	97.95	85.82	156	NR
	TK-07	25.8*	3837136	~40 hrs	ATF	22	47	22	NR	168.09	174	235.08	
Dyke Fire	TK-01	19.6*	3837136	~37 hrs	ATF	42	68	26	NR	57.77	53.3	126.4	NR
	TK-07	19.6*	3837136	~37 hrs	ATF	42	68	26	NR	172.65	167.37	226.06	
Main Hydrant Pumps	5	0.4	3459	3 hrs	ATF	2	21	18	14	79.29	82.14	134.32	NR
	25	3.4	3643	18 min	ATF	14	45	31	17				
	100	29.0	5177	3 min	ATF	23	52	25	NR				
	150	29.0	5177	3 min	ATF	23	52	25	NR				
Fueler / Unloading Pumps	5	0.155	5447	10 hrs	ATF	2	14	11	9	48.06	58.76	98.43	NR
	25	3.43728	5644	27 min	ATF	8	36	26	14				
	100	29	7177	4 min	ATF	23	63	36	NR				
	150	29	7177	4 min	ATF	23	63	36	NR				
Tanker Loading / Unloading System	5	0.155	5447	10 hrs	ATF	2	14	11	9	98.32	108.65	131.78	NR
	25	3.43728	5644	27 min	ATF	8	36	26	14				
	100	29	7177	4 min	ATF	23	63	36	NR				
	150	29	7177	4 min	ATF	23	63	36	NR				
* Tank Surface Fire burning rate (kg/s)													
NR - Not Reached													

Appendix-4 Consequence Analysis Results - Graphs

1 Incoming Pipeline

1.1 Leak Size – 25mm; Wind speed with stability class - 5D

Intensity Radii for Pool Fire on Map

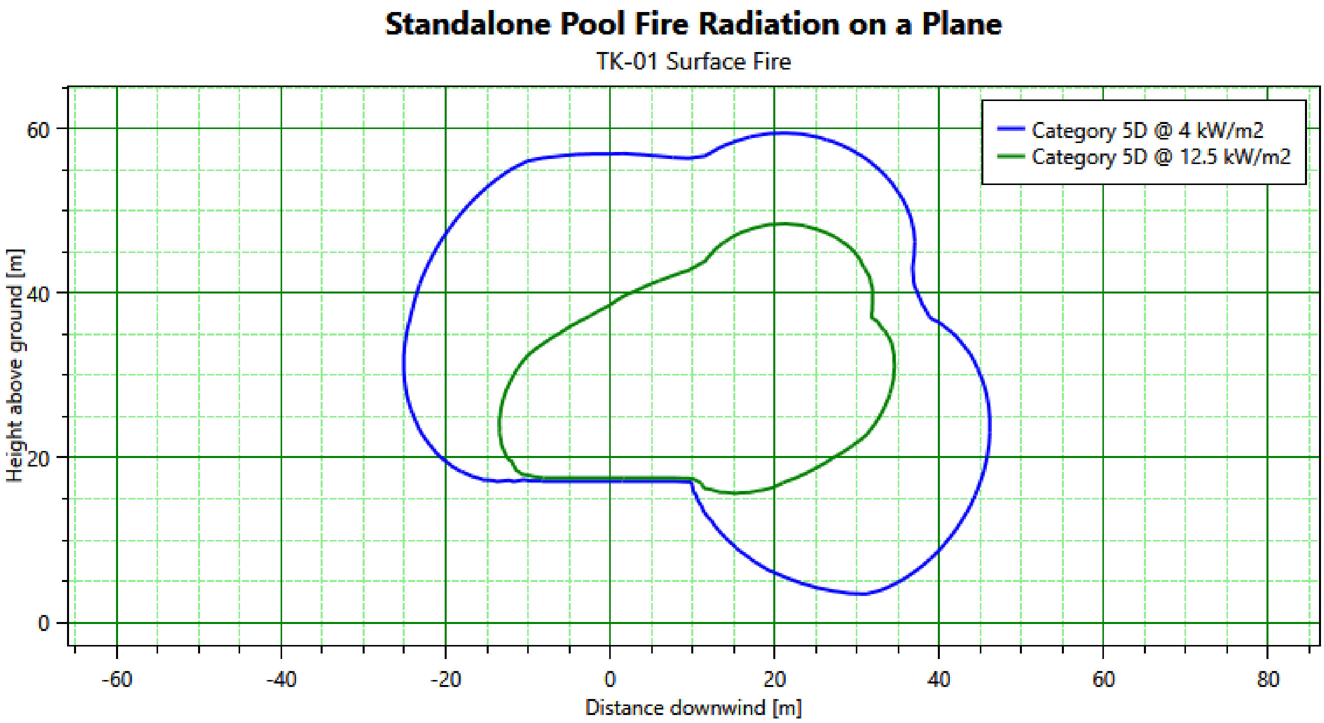


2 Tank (TK-01 to TK-06) – Tank Diameter 18m- Phase-I

2.1 Tank Surface Fire; Wind speed with stability class - 5D

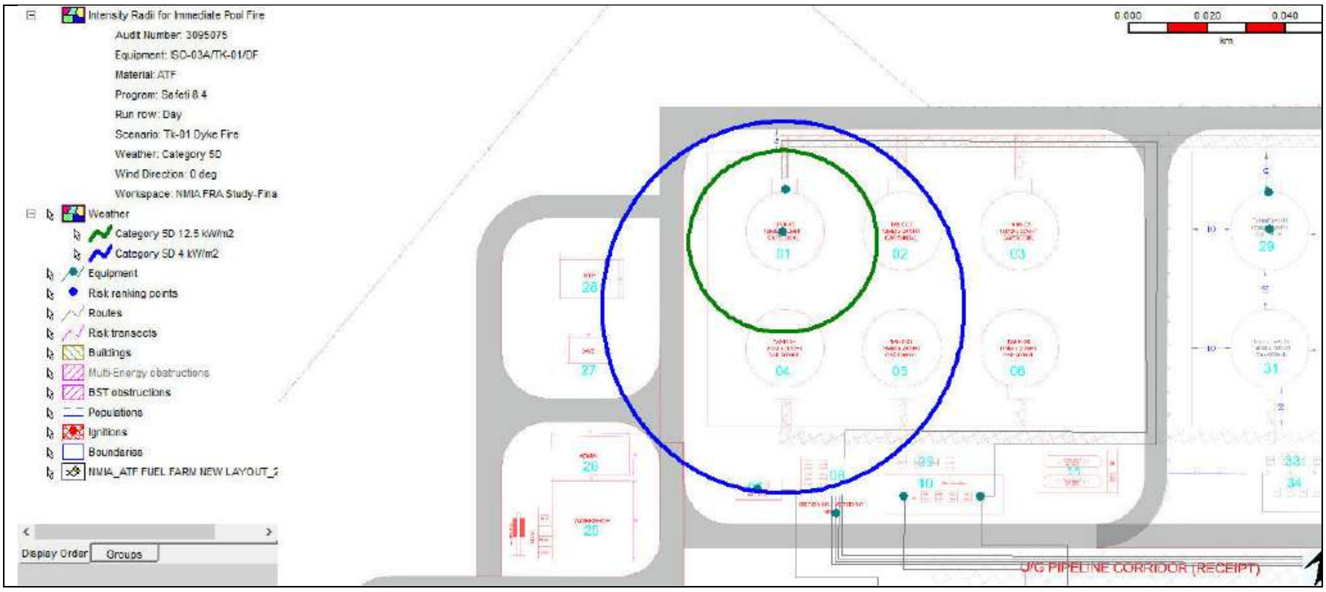
Intensity Radii for Pool Fire on map

Tank Full Surface Fire (TK-01 to TK-10) Front View

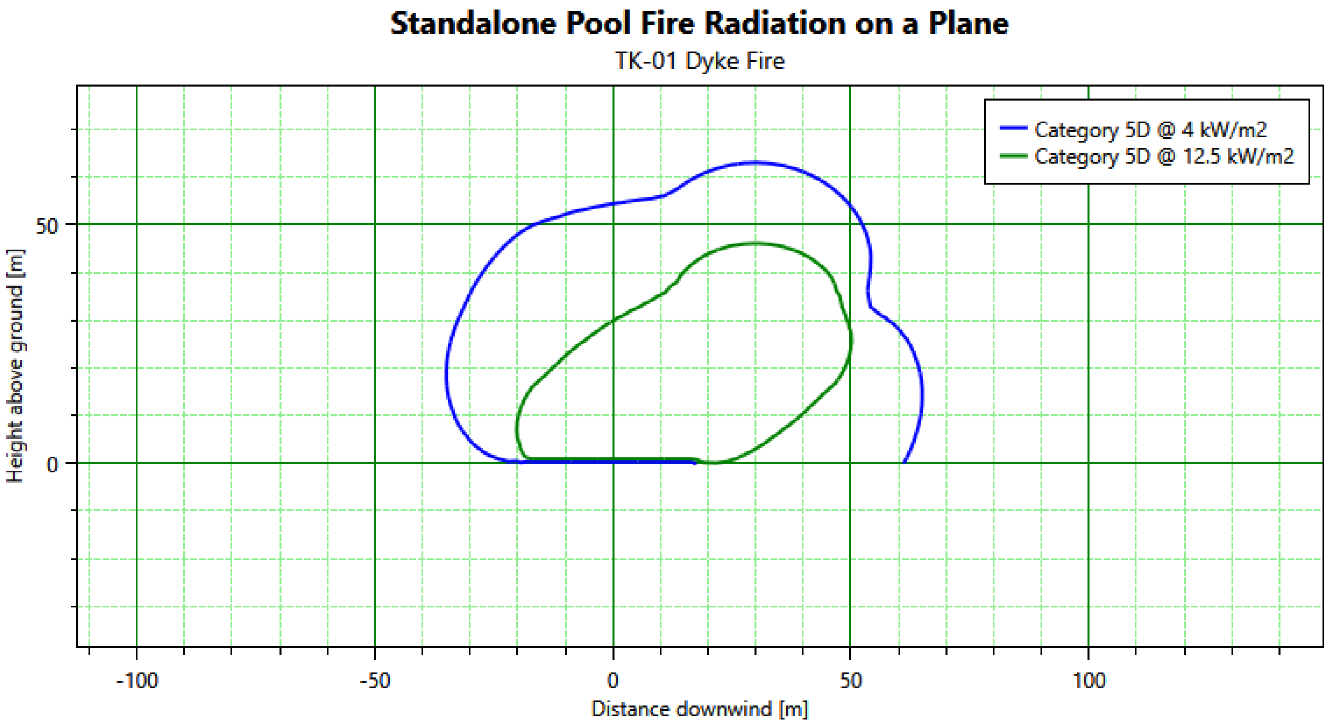


2.2 Dyke Fire; Wind speed with stability class - 5D

Intensity Radii for Pool Fire on map



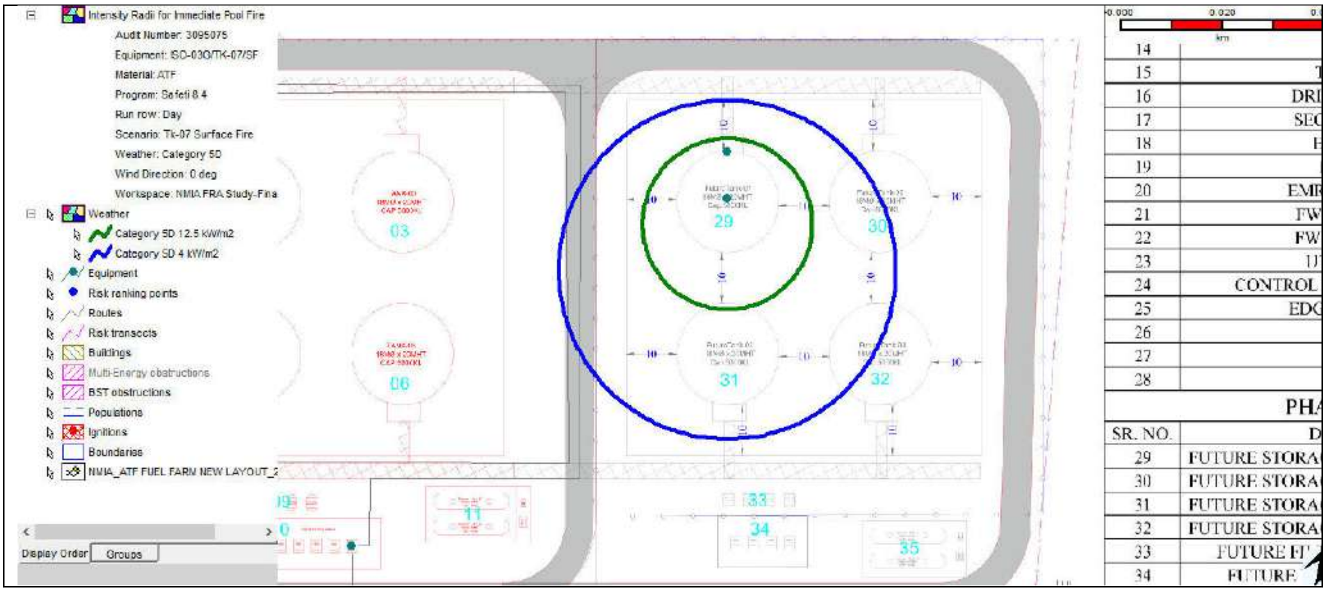
Tank Dyke Fire (TK-01 to TK-10) Front View



3 Tank (TK-07 to TK-10) – Tank Diameter 18m – Phase-II

3.1 Tank Surface Fire; Wind speed with stability class - 5D

Intensity Radii for Pool Fire on map



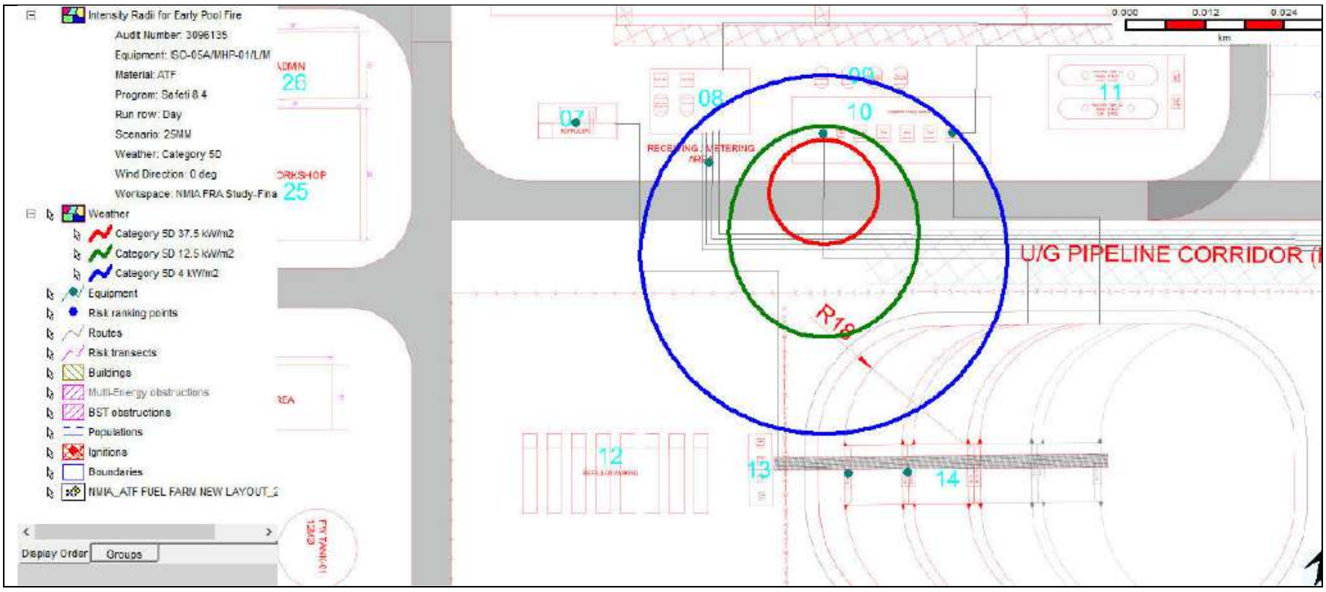
3.2 Dyke Fire; Wind speed with stability class - 5D

Intensity Radii for Pool Fire on map

4 Main Hydrant Pumps

4.1 Leak Size – 25mm; Wind speed with stability class - 5D

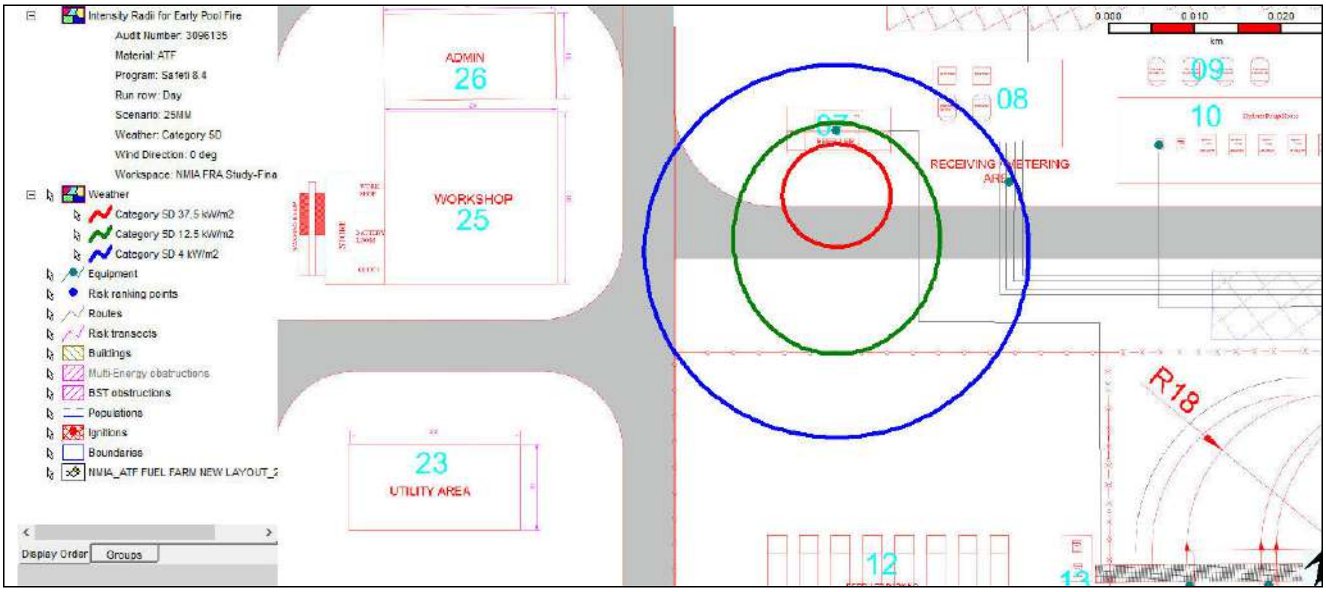
Intensity Radii for Pool Fire on Map



5 Fueler Loading/Unloading Pump

5.1 Leak Size – 25mm; Wind speed with stability class - 5D

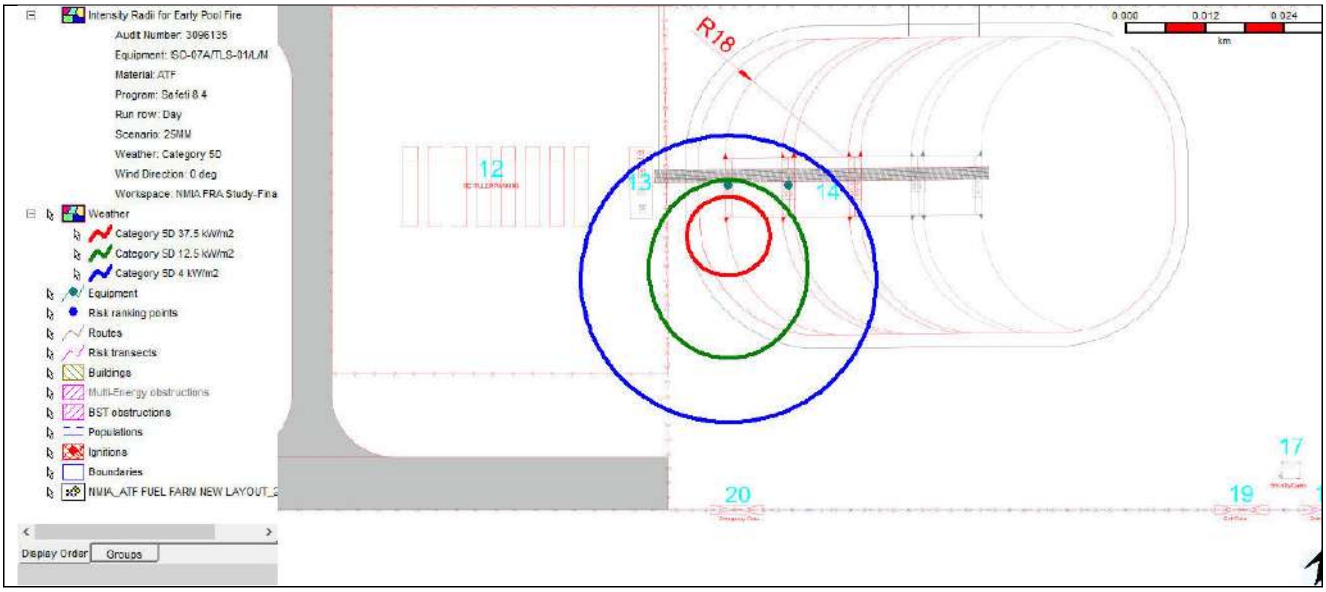
Intensity Radii for Pool Fire on Map



6 Tanker Loading/Unloading Facility

6.1 Leak Size – 25mm; Wind speed with stability class - 5D

Intensity Radii for Pool Fire on Map



ANNEXURE-XXIV
HYDROGEOLOGICAL STUDY IN THE IMPACT ZONE OF PROPOSED NAVI MUMBAI INTERNATIONAL AIRPORT, 2010

(Scientific Investigation Report, January 2010 By Groundwater Surveys and Development Agency (GSDA), Govt. Of Maharashtra)

HYDROGEOLOGICAL STUDY IN THE IMPACT ZONE OF PROPOSED NAVI MUMBAI INTERNATIONAL AIRPORT MAHARASHTRA

SCIENTIFIC INVESTIGATION REPORT
JANUARY 2010

Director
Groundwater Surveys and Development Agency
WATER SUPPLY & SANITATION DEPARTMENT
Government of Maharashtra

HYDROGEOLOGICAL STUDY IN THE IMPACT ZONE OF PROPOSED NAVI MUMBAI INTERNATIONAL AIRPORT MAHARASHTRA

SCIENTIFIC INVESTIGATION REPORT
JANUARY 2010

Director
Groundwater Surveys and Development Agency
WATER SUPPLY & SANITATION DEPARTMENT
Government of Maharashtra

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Our sincere thanks to

***Shri Ajit Kumar Jain** IAS*

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Executive Summary

1. Study Area

The proposed Navi Mumbai International Airport is located near Panvel City, at a distance of about 35 km from Mumbai. The study area comprises of 10 sq km area around the proposed Airport. About 100 villages from Uran and Panvel taluka of Raigad district and Thane taluka of Thane district fall in the study area.

The climate is generally hot and humid and the temperature ranges in between 28^0 c to 32^0 c and the humility range from 44% to 76% throughout the year.

2. Rainfall

The monsoon period is from June to September and the normal rainfall ranges from 2072 mm to 2741 mm. The actual rainfall for last 20 years at Panvel meteorological station ranges from 1829 mm to 4136mm.

3. Drainage

5 main rivers drain through the study area. They are Taloja and Navdi Nadi in the north, Kalundri and Kolkhewadi River in the west and Ulve nadi in the south. These rivers join together to from the Panvel creek. Kalundri River as also called as Gadhi River.

4. Geology

The geological formations of the entire study area consist of dark coloured volcanic lava flows basaltic in composition and are intruded by dykes.They belong to Upper Cretaceous to Lower Eocene period approximately 80 to 100 million years of age. The main characteristic feature of these flows is their horizontal disposition and considerable lateral extent, with almost incredible uniformity in their composition and appearance. The flows are compact and massive with fine to medium grained texture. The dugwells and borewell data reveals that the weathering is up to 3 to 5 m only below that there is hard massive rock. Few dykes are observed to intrude the lava flows.

Panvel Flexure

Panvel flexure has been noted for more than a century (Blanford 1867, Wynne 1886). These workers have described the flexure as a monoclinal bending of the lava pile. But later workers have linked the origin of the flexure to the west coast rifting, subsidence and uplift of Western Ghats. It is observed that the drainage is not controlled by any structure.

Delineation of watersheds

The study area is divided into 3 elementary watersheds. WF 40, W42 and WF 36. These watersheds are again subdivided into mini watersheds. Groundwater assessment is done on the basis of Elementary watersheds which indicate that the Stage of Development in each watershed is 27.57%, 13.82% and 5.81% respectively.

5. Hydrogeology

The hydro geological studies indicate that the rocks are not suitable to store groundwater as there is no primary porosity. Secondary porosity like weathering and fractures store groundwater to some extent. The depth of dug well varies from 2.5 to 11.10 m and the diameter varies from 2.2 to 6.3 m. The drinking water borewells have a depth range of 40 m to 90m. Post monsoon water table in 38 dugwells ranges from 0.20 m to 5.00 m.

Hydrograph from observation well at Panvel reveals that the pre monsoon and post monsoon water level is showing rising trend. The pre monsoon water level ranges from 0.4 to 2.10 m bgl.

6. Groundwater Quality

The data from 49 water quality network stations indicate that Panvel city, Taloja and Ulve have very high TDS ranging from 2000 ppm to 14,000 ppm. High concentration of Chloride is found near Turbhe, Kamote and Kharghar area.

7. Conclusions

i) Diversion of Ulve River – This River forms the main drainage of mini watershed WF40/7. The water holding capacity of the aquifer in the mini watershed is limited, hence the dugwells yield less, due to which there are no agricultural activities in Rabi Season. Few farmers cultivate vegetables. Diversion of Ulve River near the creek will not have any adverse effect on groundwater in this mini watershed. The runoff in the Ulve River can be reduced by construction of few Water Conservation Structures from Village Garade to Village Bhangarpada.

ii) Training of Gadhi River – The tidel water reaches the upstream of this river up to the confluence of Kalundri and Kolkhewadi river. Hence training of this river will have no adverse effect on groundwater.

8. Recommendations

The development of groundwater potential by means of dugwells and borewells is severely restricted in view of the rugged and hilly nature of the terrain in the Eastern & Southern part of study area. The plains in the West of study area are covered with mud land and creek water After due observations, following conclusions and recommendations are made.

*i) **Rising water table:** From the pre monsoon and post monsoon groundwater levels of 4 observation wells it is observed that there is a rising trend which indicates that optimal usage of groundwater for agriculture is not done. The stage of development indicates that there is further scope for groundwater usages. Due to urbanization, drinking water is supplied through pipe water supply schemes hence the dependency on groundwater is reduced. The density of wells in these elementary watersheds is just 1.7 well per sq.km.*

ii) ***Groundwater quality*** *is the main issue in Panvel city and Taloja Industrial area. The unconfined aquifers are yielding sweet water, but in some cases the deeper confined aquifers are polluted, due to sea water intrusion and industrial waste.*

iii) ***Water conservation Structures:*** *The dugwells, though fully saturated during monsoon are not sustainable and dry up in early summer due to geological constraints. To make these wells sustainable, additional non monsoon recharge is essential so that continuous recharge will take place against withdrawal. This can be achieved only through construction of water conservation structures, on the existing drainage. Ulve river, Kalundri river, Kolkhewadi river and Taloja river and Navadi river are best suitable for this purpose. The type of structure can be recommended after detailed survey in Phase II. These structures will also help in reducing surface run off, which otherwise this will have some impact on the proposed site.*

iv) ***Desilting of Panvel creek and Gadhi river, Navadi river and Taloja river*** *: Through the years Gadhi river and its tributaries Taloja river and its tributaries have deposited large amount of silt near the confluence of these two rivers. It is observed that due to silting, the water spread area has increased converting the land into mud plains. It is suggested that desilting of Panvel creek upto Gadhi and Taloja river will reduce water spread area in the proposed airport site. The desilting will also have no adverse impact on the groundwater regime in all the mini watersheds. In fact it will create more space for the accommodation of freshwater in the surrounding areas.*

v) ***Rowing Channel****: The Gadhi river after training at the proposed location will be suitable for International Standard Rowing Channel of length 2300m, width 110m and height 3.5m. If this is considered then Rowing channel will be ready with no extra cost. Further Rowing channel will have no adverse impact on Groundwater regime in the mini watersheds.*

Preamble

Mumbai is famous since pre historic times particularly for its leading role in promoting foreign trade. Presently it is financial and commercial capital of India. Mumbai is growing and has now expanded to Navi Mumbai and still new cities are being developed along the creek of Thane and Panvel. To keep pace with growing trade and population faster mode of transportation are required, hence a new International Airport has been proposed between Ulve Village and Panvel city. The Airport is being developed by Government of Maharashtra Public Enterprise CIDCO.

The development of Navi Mumbai International Airport has been approved "in principle" by the Ministry of Civil Aviation, Government of India. For EIA and environment clearance, Ministry of Environment and Forest (MoEF) GOI has suggested to study different environmental components within 10 sq.km. radius area around the proposed site. One of the components is "Groundwater Study". The livelihood of rural people mainly depends on water both surface and groundwater. Hence it is of utmost importance to study the impact of land reclaimation on groundwater availability and quality.

At present River Ulve and River Gadhi are flowing through the proposed site. Training of River Gadhi and diversion of river Ulve has been purposed. It is essential to find out the impact of these activities on groundwater. To study groundwater, one has to study the hydrogelogy of the area, so that occurrence, movement and distribution of groundwater can be better understood.

Description of Study Area

The proposed Navi Mumbai International Airport is located near Panvel Creek in Raigad district on the western coast of India and occurs between North latitudes 18^0 59' 33" & East longitudes 73^0 04' 18". The area is included in Survey of India toposheet nos. 47-E/4, 47-F/1

The Proposed site is at a distance of 35 km. from Mumbai. Two National Highways (i) NH-4 (Mumbai-Chennai) & (ii) NH 17 – (Mumbai-Goa) originate from Panvel. It is also linked to Mumbai - Agra (NH 3) & Mumbai – Delhi (NH8). Highways. Total area of airport zone is about 1615 ha, out of which on-airport areas is 1140 ha. Impact Assessment Study is proposed within a radius of 10 sq.km. and covers about 100 villages from Panvel and Uran talukas of Raigad District and Thane taluka of Thane districts (Fig-1).

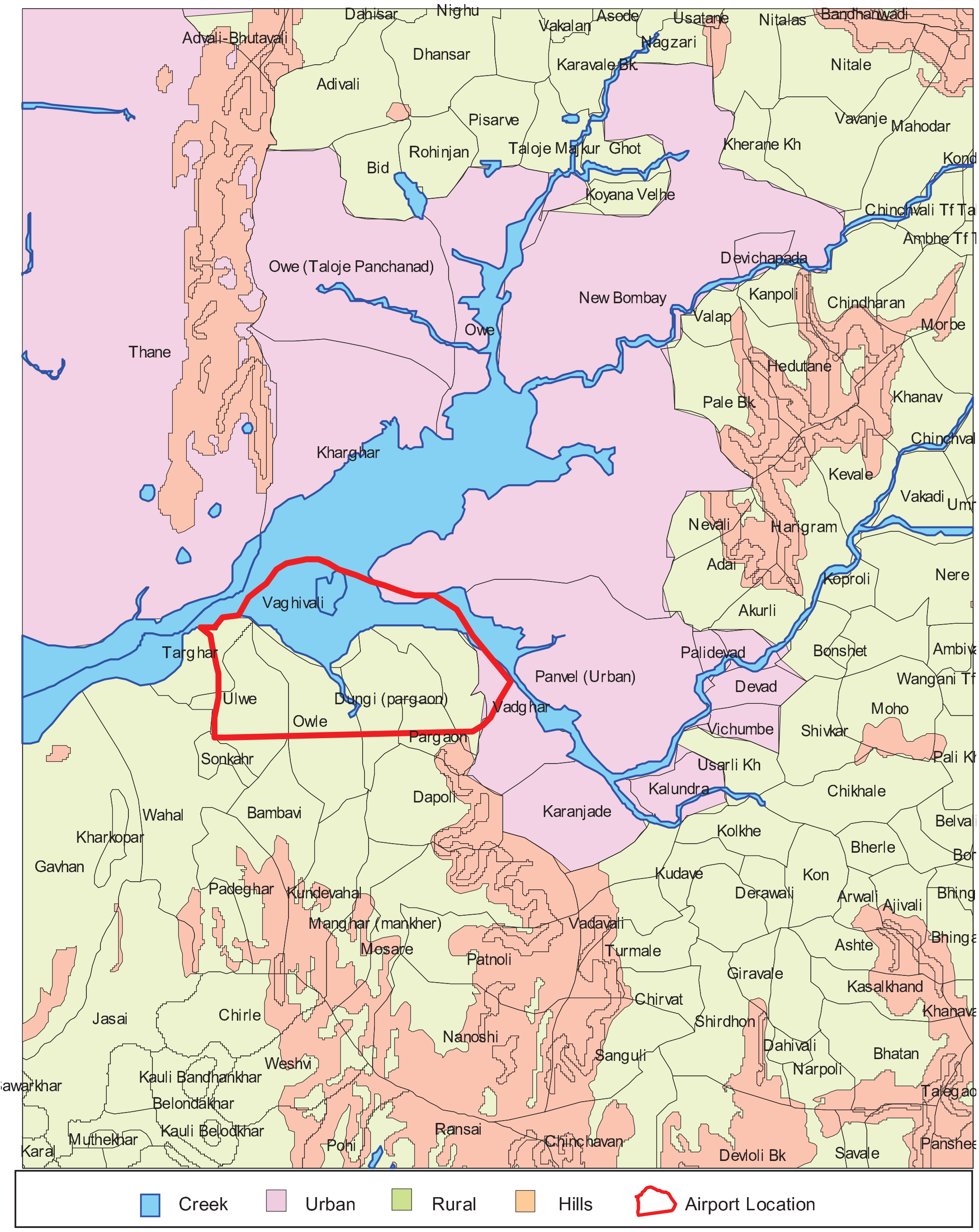
Hydrometeorology

i) Climate: The Climate experienced throughout the year is generally hot and humid. The maximum day temperature ranges in between 28^0C to 32^0 C. while the minimum temperature ranges in between 17^0C to 27^0C. The relative humidly remains in between 44 % to 76% throughout the year.

ii) Rainfall : Rainfall is the only source of recharge to groundwater. The study area fall in the High Rainfall Zone of Konkan, ranging between 2072 mm to 2741 mm. It receives rainfall between June to September i.e. monsoon period. Some amount of rainfall is also received during non-monsoon period. In the study area, rainfall is measured at 3 taluka stations. i.e. (a) Panvel, (b) Uran & (c) Thane

a) Panvel Hydrometeorological Station : The data is available from 1989 up to 2009. The IMD normal rainfall is 2741 mm. The 21 year data reveals that for 12 years, the rainfall received is above normal by 0.44 % to 50.89 %. For 9 years the rainfall received is below normal and it ranges from 2.30 % to 33.27 % (Table-1a)

Fig-1 : Location map of study area showing proposed site of Navi Mumbai International Airport



b) Uran Hydrometeorological Station. : The data is available from 1989 to 2009. The IMD normal rainfall is 2072 mm. The 21 years data reveals that for 12 years the rainfall received is above normal by 7.58 % to 70.08 %. For 9 years the rainfall received is below normal and it ranges from 0.14 % to 56.18 % (Table-1b)

c) Thane Hydrometeorological Station. : The data is available from 1989 to 2009. The IMD normal rainfall is 2446 mm. The 21 years data reveals that in 11 years the rainfall received is above normal by 1.84 % to 63.08 %. For 10 years the rainfall received is below normal and it ranges from 1.02 % to 36.92 % (Table-1c)

Geographic features

(i) Physiography : Broadly the Konkan is divided into 2 main divisions (i) Coastal region (ii) Inland division or Sahyadri Range. The study area falls in coastal region. It is adjoining the Panvel creek. It has plain area as well as rugged & uneven topography. The main Sahyadrian scarp form the eastern horizon. These ranges send westwards several transverse subsidiary hills many of which with varying heights almost reach the coastline to form headlands. It is important to know that the mountains in the Deccan Trap or peninsula are mostly of the relict type i.e. they are not mountains in the true sense of the term but are mere outstanding portions of the old plateau that have escaped, for one reason or another. The weathering phenomenon has cut out all the surrounding parts of the land and they are huge blocks or tors of the old plateau More prominent elevation is in the southern portion about 20 km distance of the study area i.e. Karnala 475m. high.(Fig-2a and Fig-2b)

Fig-2a : Geomorphology of study area

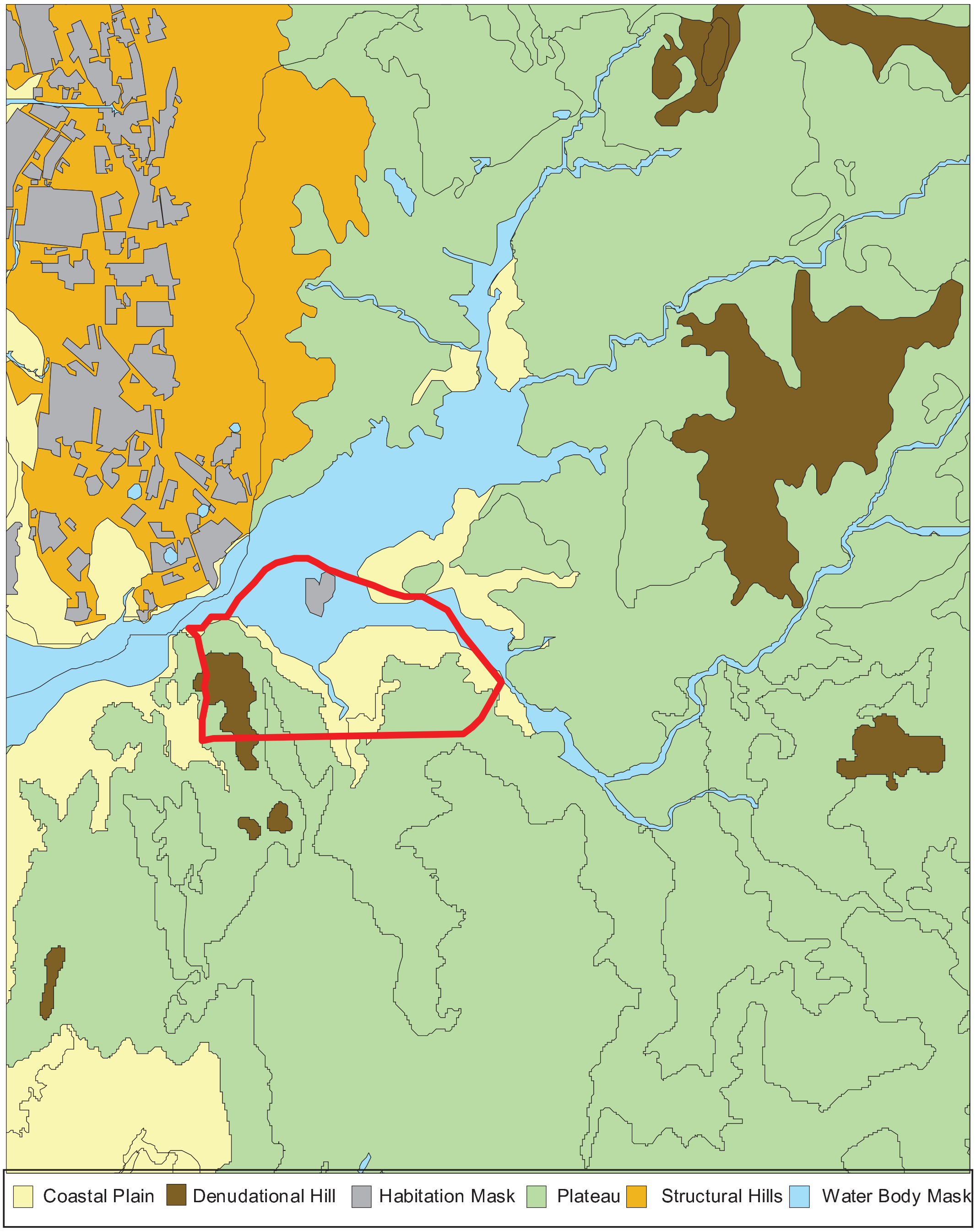
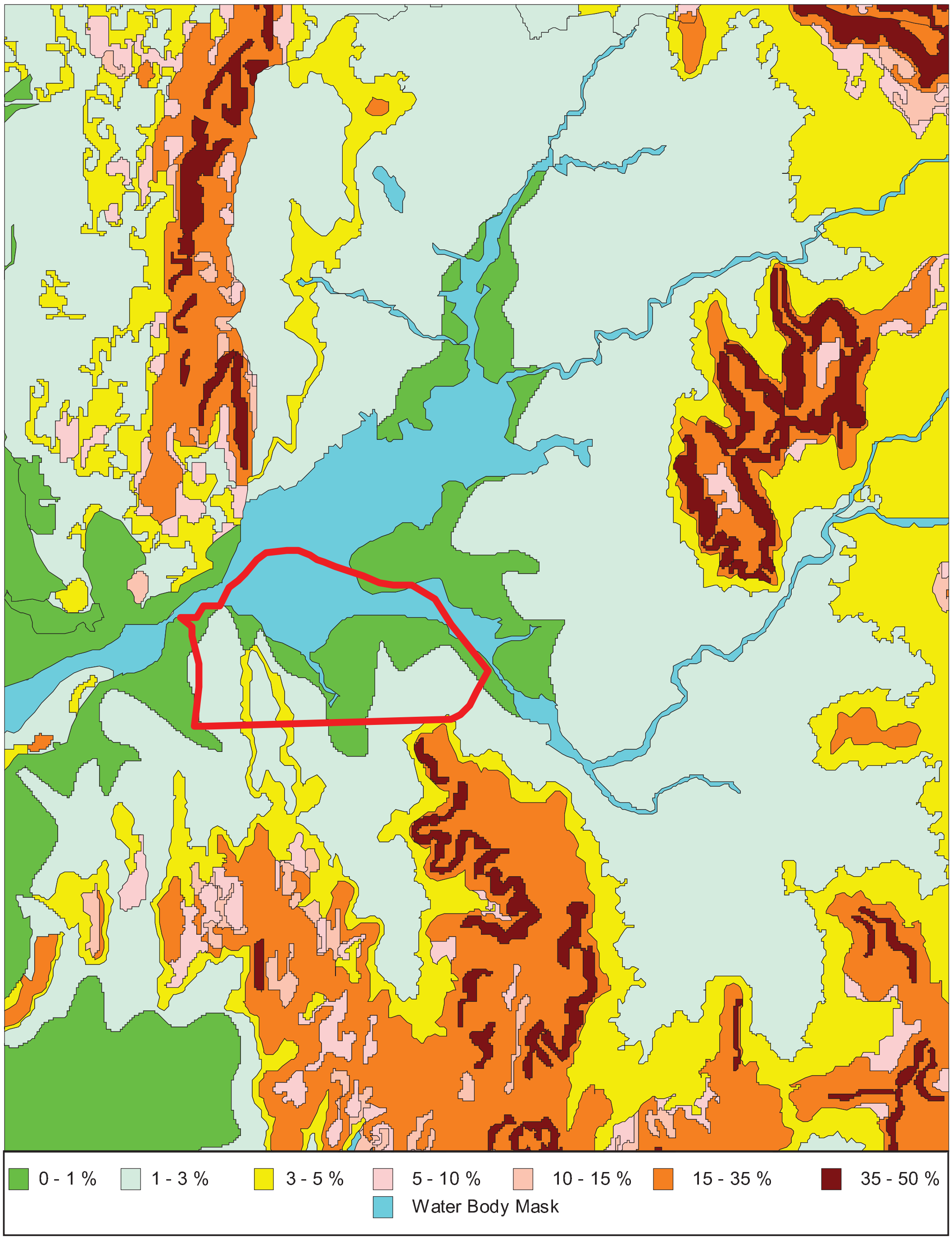


Fig-2b :Slope of study area



(ii) Drainage : The Sahyadrian scarp is the birth place of all westerly flowing rivers. 5 main rivers drain through the study area. Taloja Nadi and Navdi nadi in the North, Kalundri and Kolkhewadi river in the west and Ulwe nadi in the south. Taloja nadi and Navdi Nadi join together to form Panvel Creek

Kalundri and Kolkhewadi river join together to form Gadhi river meeting the Panvel Creek at village Waghvali.

Garada nala and other streams form Ulwe river which joins Panvel Creek in the south near village Dungi. (Fig-3)

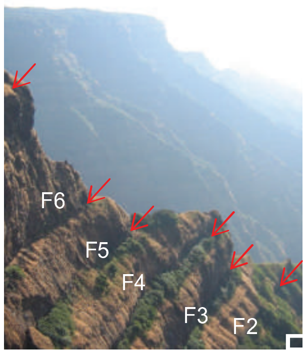
Geology

The geological formations of the entire study area consist of dark coloured volcanic lava flows, basaltic in composition and is intruded by large no. of dykes. (Fig-4a)

(i) Basaltic rocks: The lava flows were poured out of long and narrow fissures in the earths crust, during the Upper Cretaceous to Lower Eocene period approximately, 80 to 100 million years ago. These are spread out in the form of horizontal sheets or beds and constitute the innumerable spurs, hills and hill ranges, bold flat topped ridged, lofty peaks and plateaus with impressive cliffs. These hill ranges and plateaus form a part of Western Ghats. In the plains and valleys the lava flow occurs below a thin blanket of soil of variable thickness. A characteristic feature of these flows is their horizontal disposition and considerable lateral extent with almost incredible uniformity in their composition and appearance.

These lava flows are also termed as plateau basalts, because of their dominantly basaltic composition and the tendency to form flat topped plateau. Since these basaltic lava flows cover an extensive region in the Deccan and frequently present step like appearances to the hills and ridges they are commonly termed as "Deccan Traps" the word trap in Swedish meaning stairs or steps.

The traps attain a thickness of nearly 760m in the east of study area i.e. around Matheran plateau. The individual flows vary greatly in thickness from a few meters to as much as 75 m or even more. In a single hill, a number of flows sometimes as many as 10 to 20 could be seen resting horizontally one above the other. Vertical, inclined, prismatic and columnar jointing are commonly found in the hard and compact basalts. These rocks wither by exfoliation into massive spheroidal boulders which are usually seen on hill slopes and foot hills.



Petrologically the lava flows in the study area are extraordinary uniform in their composition and texture, corresponding to a dolerite or basalt with an average specific gravity of 2.9. These basalts are composed of abundant labrodorite, feldspar, enstatite, augite and interstitial glass. Magnetite is the most common accessory mineral though at times a fair amount of Olivine is also present.

Fig-3 : Drainage in the study area

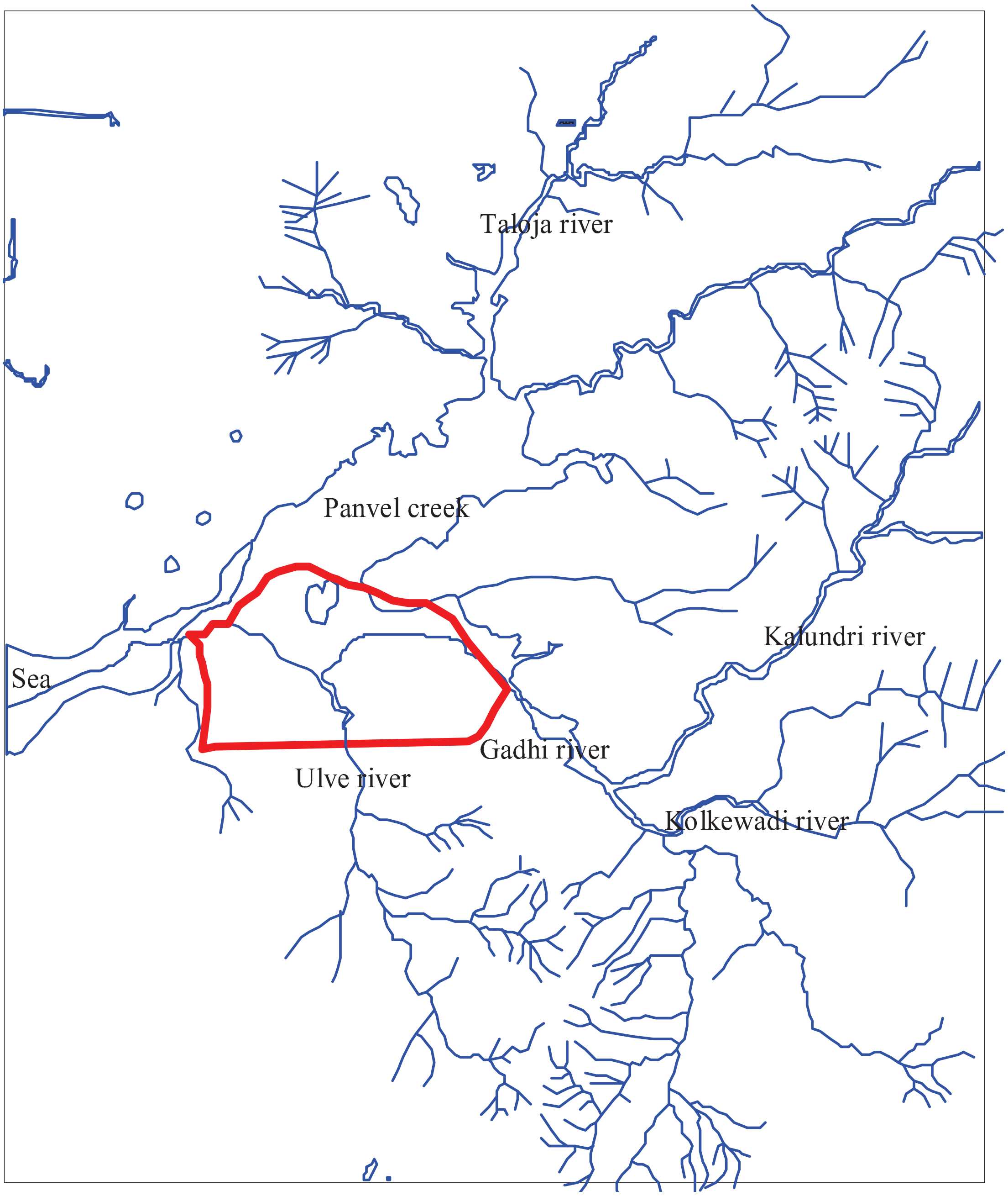


Fig-4a : Geology and dykes

The basalts are usually dark gray and bluish gray in colour and are hard, compact and tough. The texture is fine to medium grained.

A single lava flow can be divided into mainly two parts, the lower part is called massive basalt while the upper part through which gases come out during cooling is called vesicular basalt. Sometimes these vesicles are filled with secondary minerals like calcite, zeolites and variety of secondary quartz like agate, jasper, chalcedony etc.

The geological section in the dugwell and borewell observed in the study area is given in Fig 4b

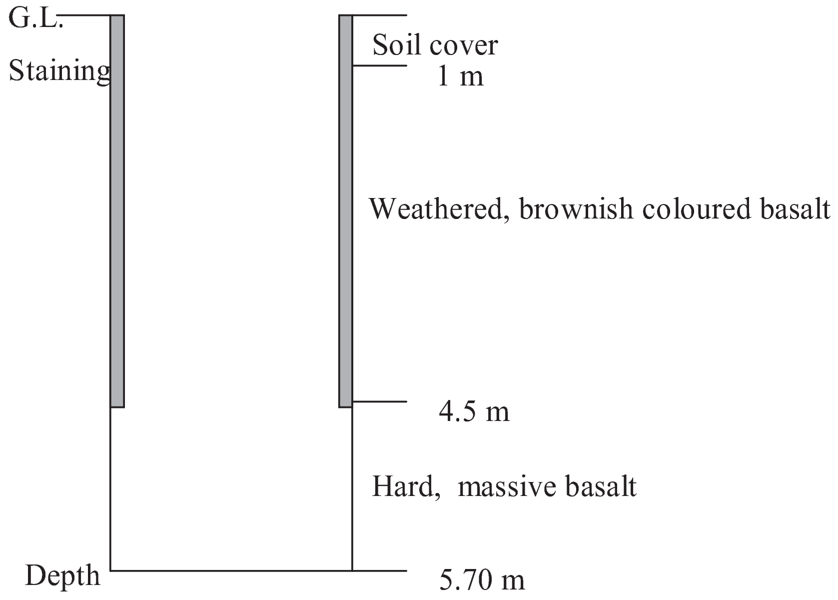
ii) Dyke: A large number of dykes intrude the lava flows. These dykes trend N15°E – S15°W, NE – SW, N85°E and S85°W and NE-SW. The dykes are more abundant in Panvel area. Majority of the dykes range in width from 2m to 4m. Branching and multiple injections are also noticed in few dykes in the area South East of Panvel. The contact between the dykes and the host basalt flow are invariably sharp (Fig-4a).

iii) Panvel Flexure : Panvel Flexure has been noted for more than a century (Bladford 1867, Wynne 1886). These workers have described the flexure as a simple monoclinal fold (bending) of the lava flows. Some workers have linked the origin of the flexure to the west-coast rifting, subsidence and uplift of Western Ghats. The flexure is north-south and extends from Gujrat to Murud Jangira. Many have doubted the very nature of this Panvel structure as a flexure. Many theories are put up but they are still inadequate.

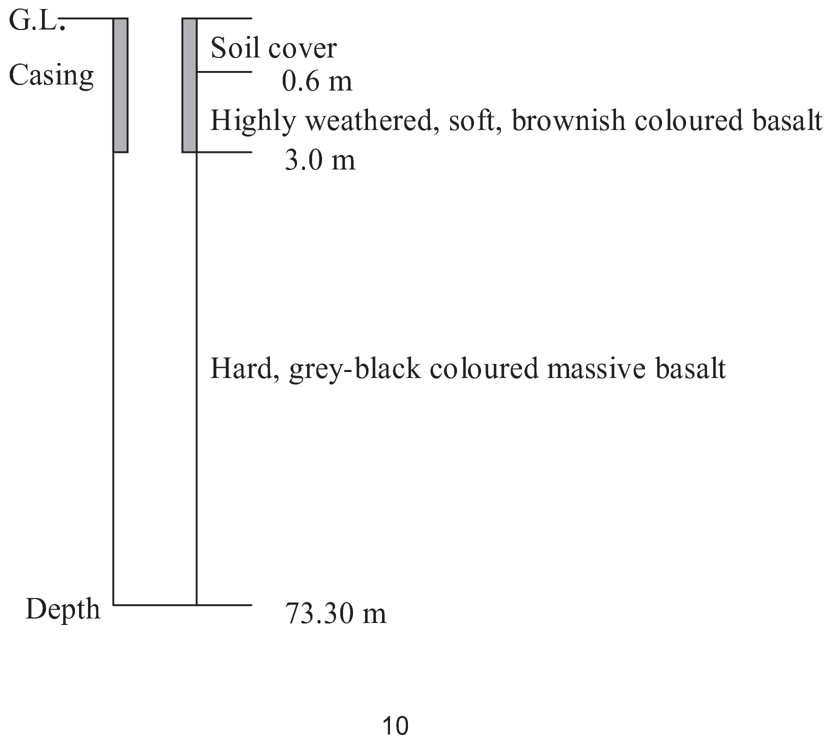
During the hydrogeological study in this area, it is observed that there is no effect on groundwater regime. Also the drainage is not controlled by structures. The water levels in the whole area behave in a normal way and no evidences are observed that there is control of any structure.

Fig-4b : Geological section

Section of dugwell : Village-Nandgaon, Taluka – Panvel, Dist.- Raigad



Section of borewell : Village – Manghar, Taluka – Panvel, Dist.-Raigad



Delineation of watersheds

The occurrence, movement and distribution of groundwater can be better understood and studied in smaller units called watersheds. On the basis of physiography and drainage, GSDA has divided the whole State into 1505 Elementary Watersheds.

The study area falls mainly in 3 westerly flowing (WF) watersheds i.e.

(i) WF 40, (ii) WF 42, (iii) WF 36 (Fig-5a)

The major portion of the study area is covered in WF40 watershed.

These watersheds are again sub-divided into mini watersheds as given below. (Fig-5b)

a) **WF 40 -** This watershed covers Panvel city and comes under Raigad district. It is divided into 9 mini watersheds and are named as WF 40/1, 40/2, 40/3, 40/4, 40/5, 40/6, 40/7, 40/8 and 40/9.

The miniwatershed WF 40/7 covers the proposed airport site and is the main focus of our study. Whereas, the other mini watersheds partially cover the Impact Zone.

b) **WF 42 -** This watershed also comes under Raigad district. One mini watershed i.e. 42/1 falls in the study area.

c) **WF 36 -** This watershed comes under Thane district. One mini watershed 36/2 falls in study area. About 11 towns coming under Navi Mumbai Municipal Corporation are covered in this mini watershed. This mini watershed is located in the north of study area. Panvel Creek divides the watershed from the airport area.

Hydrogeology

Earlier Groundwater investigations were carried out by GSDA to locate feasible sites for drilling of borewells for Drinking Water purpose. Also systematic hydrogeological investigations were carried out in few villages to study the aquifer conditions and feasibility for new dugwells for irrigation purpose.

A special hydrogeological study was taken up in the villages falling in the study area- Reconnaissance survey and well inventory of dugwells and borewells was undertaken. 38 observation wells in 36 villages fixed for monitoring of pre & post monsoon groundwater levels (Table-2). The detailed well inventory reveals that the depth of dugwells varies from 2.5 to 11.1 m and the diameter varies from 2.2 to 6.3 m. All the wells are round in shape. The drinking water borewells have a depth range of 40m to 90 m. Post monsoon water level map is prepared and shown in Fig-6.

(i) Occurrence of Groundwater

There is no primary porosity in the rocks encountered in the study area. The lower massive basalt is compact and does not posses any porosity. The vesicular basalt in the only starta that can store groundwater to some extent, but does not possess appreciable permissibility as the vesicles are not inter connected.

The soil cover in the wells is very shallow. Hence the secondary porosity and permeability developed due to weathering and fracturing is limited and the wells yield less

Fig- 5a : Elementary watershed map

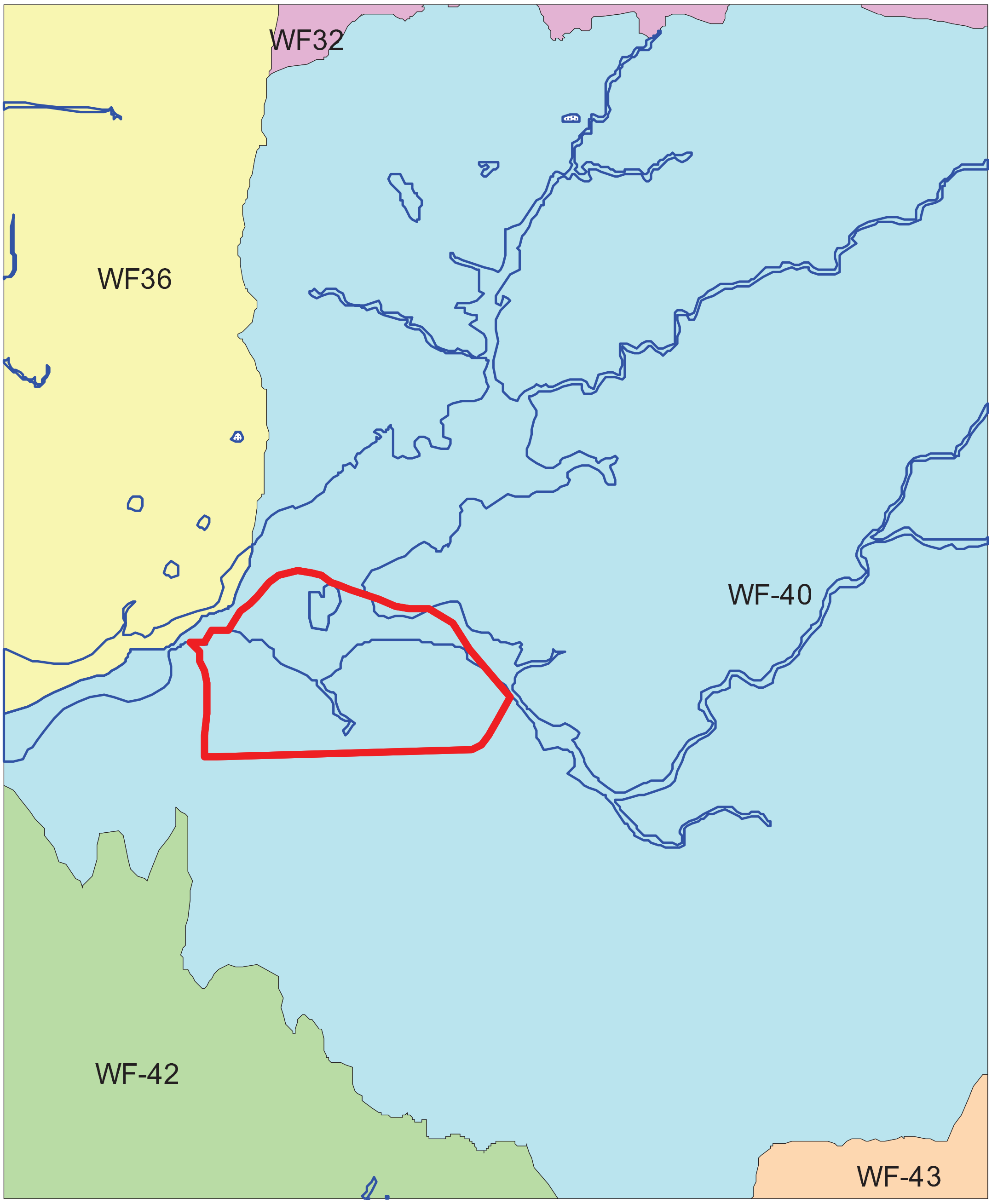


Fig- 5b : Mini watershed map

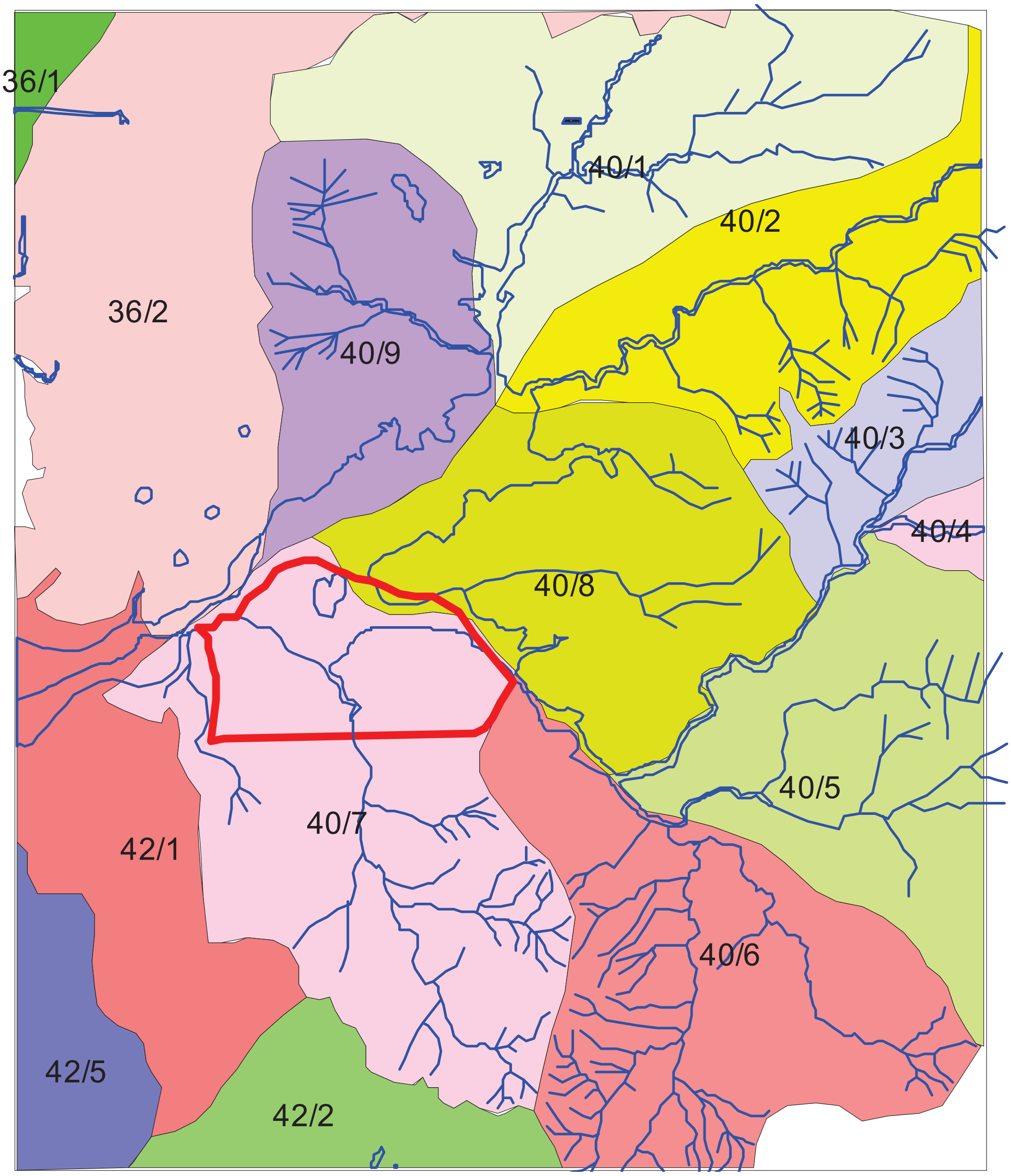
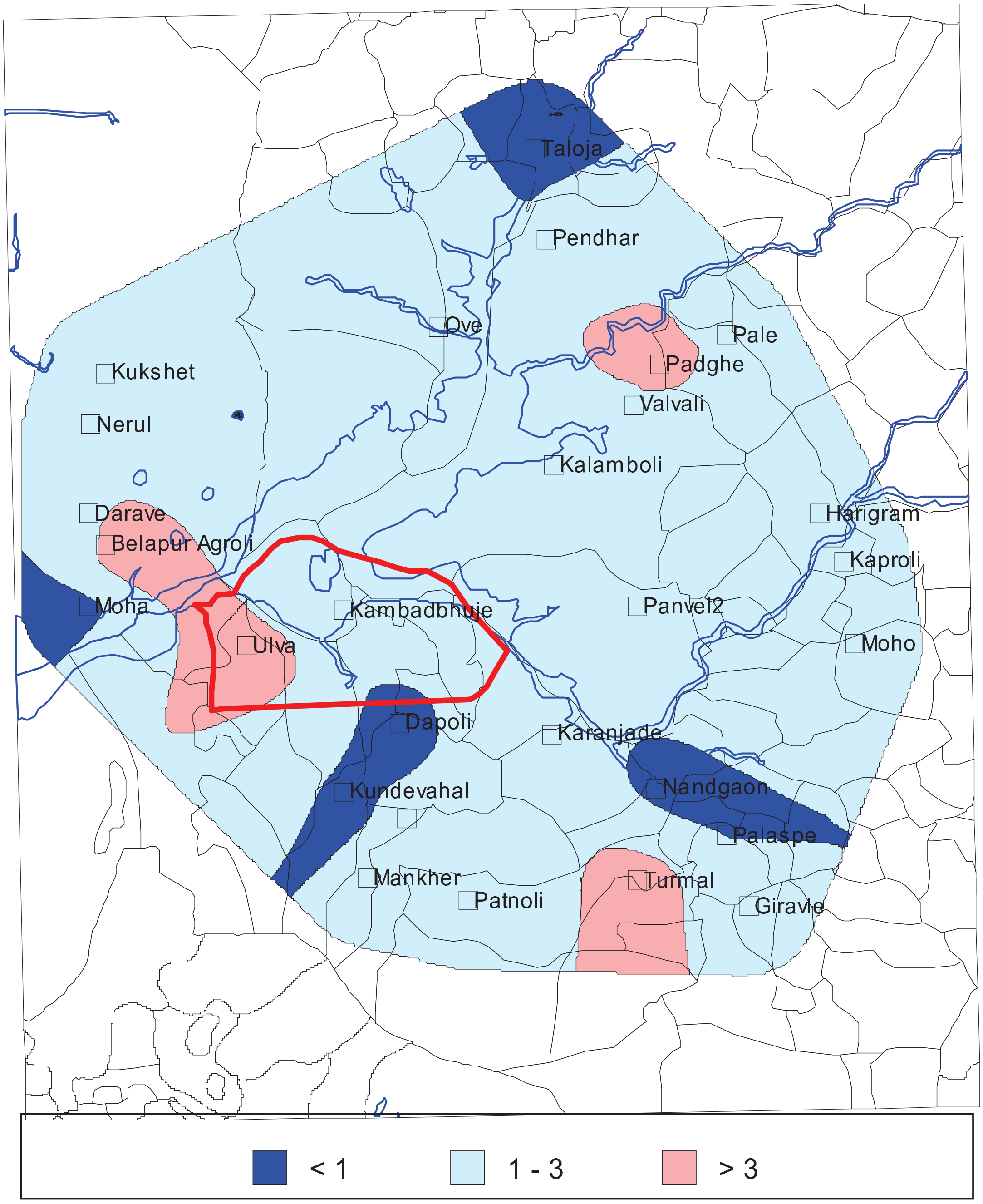


Fig- 6 : Post monsoon water levels (m) map



water. Due to massive rock the depth is restricted to 7 to 8 m. only and almost all wells dry or yield very little water in summer.

(ii) Water Table Aquifer

Groundwater occurs under water table conditions within a depth of 4 to 5 m below ground level. Weathering and fracturing of upper basalt has resulted into water table aquifer. In the plain region there is hydraulic continuity in this zone. However in the higher elevation in isolated plateaus, small gorges and valleys the occurrence of groundwater is highly localized, which does not reflect the regional picture. The depth to water level in the inventoried wells ranged between 0.2 m to 5 m bgl. in Jan 2010.

The dug wells near the creek have sweet water up to 5 m to 6 m but below this depth there is brackish water. Hence the depth of dug wells is restricted to 5 to 6 m. only.

The water table aquifer wells dry up in March. Some wells are perennial but the groundwater availability is meager.

In general the potential from water table aquifer is not significant. Even through the rainfall is heavy, the massive basalt does not allow vertical percolation. Hence there is more runoff.

(iii) Confined Aquifer

Groundwater occurs under confined conditions below the depth of 30m. where the fracture porosity is insignificant. Here the weathered flow contacts are completely cut off from the upper aquifer on account of intervening highly impermeable massive basalts and red boles. The recharge to these aquifers is through major shear zones intersecting several flows. The confined aquifer is tapped through bore wells drilled for drinking water purpose. The depth ranges from 20m to 90 m and are normally 150mm in diameter. The piezometeric levels in these bore wells are observed to range from 2 m to 5 m in post monsoon.

(iv) Hydrograph network for observation wells

Groundwater Surveys and Development Agency has established 3920 observation wells in the state for monitoring the long term trend in the Groundwater levels. Out of these 4 observation wells fall in & around the study area.

i) Village Panvel Taluka Panvel, District - Raigad
ii) Village Nere, Taluka Panvel, District - Raigad
iii) Village Uran, Taluka Uran District - Raigad
iv) Village Kopar Khairane Taluka Thane District - Thane.

Data from these wells is collected 4 times a year i.e. January, March, May & October.

(a) Observation well at Panvel Dist-Raigad

The observation well at Panvel is located in watershed WF 40 which is very close to the proposed airport site.

The depth of the well is 8.05 m bgl. The 20 years data is taken for analysis i.e. from 1980 to 2009.

The pre-monsoon hydrograph shows that the groundwater level trend is rising. It ranges from 0.4m to 2.10 m. This is attributed to many factors. First factor is the rainfall. Second factor is that the use of groundwater is minimized, due to which withdrawal is less and hence the groundwater levels show rising trend. The 3rd factor is urbanization. It is possible that there is decrease in agriculture and subsequently the use of groundwater is reduced.

The post monsoon hydrograph also shows rising trend. The twenty year data reveals that the post monsoon groundwater level range in between 0.10 m bgl to 0.9 m bgl. This indicates that the aquifer is replenished every year. (Table-3a)

(b) Observation well at village Nere Taluka Panvel Dist-Raigad

The observation well at Nere is located in watershed WF 40 and is close to 10 sq.km impact zone. The depth of the well is 7.9 m bgl. The data available is from 1989 to 2009.

The premonsoon groundwater level shows a steady pattern. It ranges between 5.20m to 7.10m. Withdrawal of groundwater is observed draining the aquifer in the month of May. The aquifer is limited, due to underlying massive basalt.

The post monsoon hydrograph shows the rising trend in groundwater levels. This indicates that the aquifer is replenished every year. Groundwater level ranges from 0.25m to 1.90m. (Table-3b)

(c) Observation Well at Jasai, Taluka Uran, District Raigad.

The observation well at Jasai is located in watershed WF 42 and is due SW of the airport site in the 10 sq.km impact zone. The depth of the well is 5.5 m bgl. The data available is from 1991 to 2009.

The pre-monsoon hydrograph shows slight declining trend. The groundwater levels range in between 0.60m to 4.85m bgl. It is observed that the use of groundwater is increased since 2003. That is the reason for draining the aquifer.

The post monsoon hydrograph reveals the rising trend. The groundwater levels range in between 0.10m to 1.20m bgl. This indicates that the whole aquifer is recharged every year. (Table-3c)

(d) Observation well as Kopar Khairane, taluka and Dist-Thane.

The observation well is located in watershed WF 36 and is little far away from the 10 sq.km. Impact zone. The depth of the well is 4.7 m bgl. The data available is from 1991-2009.

The pre-monsoon hydrograph shows slight declining trend. The pre-monsoon groundwater level ranges from 1.05m to 2.80m bgl. This indicates that there is no groundwater withdrawal, as all the villages are urbanized.

The post monsoon hydrograph shows increasing trend, indicating that the aquifer is replenished every year (Table-3d)

Drinking Water Supply

Almost all the villages coming under Impact Zone are supplied drinking water through pipe water supply schemes. Previously these villages were dependent on bore wells for drinking water. Due to urbanization there is greater demand for pipe water supply schemes. After implementation of pipe water supply schemes, the use of dug wells and bore wells (Hand pumps) is diminished and they are in disuse state. The details of drinking water bore wells is given in Table 4

Assessment of Groundwater Resources

Government of India has framed GEC-97 guidelines for carrying out groundwater resources assessment. Groundwater recharge is worked out for monsoon and non-monsoon also. Groundwater table fluctuation between pre and post monsoon, specific yield are important parameters for computing monsoon recharge, while in non-monsoon recharge seepages from canals, surface water irrigation, tanks, ponds, groundwater irrigation and water conservation structure are considered.

The groundwater draft is calculated from all the existing abstraction structures. The groundwater assessment is carried out for the whole watershed. Stage of groundwater development and categorization of watershed is defined as safe, semi critical, critical and over exploited. In general when the stage of development is less than 70% then the watershed is considered safe. When the stage of development is in between 70 to 90% then the watershed falls in semi critical category. When the stage of development is in between 90% to 100% then the watershed falls in critical category and when the development is above 100%, then the watershed is categorized as over exploited watershed. Any further groundwater development in critical and overexploited watershed is restricted as per Maharashtra Groundwater Act 1993.

Groundwater assessment carried out in 2009 reveals that the stage of development in watershed WF 40 is 27.57% and falls in safe category. Similarly in watershed WF 42 and WF 36, the stage of development is 13.82% and 5.81% respectively. Both of them fall in safe category (Table – 5).

Groundwater quality

The quality of water is related to its use. Human consumption, livestock watering or irrigation supply each has different requirement to the properties of water. Water suitable for livestock is totally unfit for human consumption. For the study purpose, quality of groundwater used for human consumption is taken into account. We have restricted to physical and chemical properties only. Biological parameters depend on human pollution and unsafe sanitation, hence it is not considered for study purpose.

About 49 water quality network stations are fixed for water sampling and analysis. Out of these 28 stations are from Panvel taluka, 11 station from Uran taluka and 10 stations from Thane taluka (Table – 6a). The water samples collected are from shallow aquifer (i.e. dug wells) as well as from deep aquifers (i.e. Bore wells). Some samples are collected from creek, river, and pond.

The methods adopted for physical and chemical analysis are given in Table–6b.

Drinking water specifications as per ISO 10500:1991 are given in Table-6c.

Water Quality Analysis

The water samples collected from different sources are analysed by adopting the methods given in the table. The results are compiled and are given in Table -6d.

The talukawise analysis results are described in terms of Piper and Wilcox diagram.

i) Taluka- Panvel

Trilinear Piper Diagram : The result is presented in Piper diagram after convertion of all the values of parameters in mg/l to meg/l. The diagram is divided into 8 groups, 4 for different cation and 4 for different anion dominant samples and it is known as facies.

Wilcox Diagram : Represent the salinity hazards in terms of Sodium Adsorption Ratio versus conductivity in micro siemens/cm SAR is calculated as

$$SAR = \frac{Na+}{\sqrt{\frac{Ca + Mg}{2}}}$$

All the values are expressed in mili equivalent / lit. In the study area almost all samples are having SAR value more than 10, Sample No. 26 and 32 are having SAR value in between 10 to 18. Most of the samples are having conductivity in between 250 to 2250 usimens/cm, so the samples are in S1C2 and S1C3 class of Wilcox diagram. (Fig – 7a)

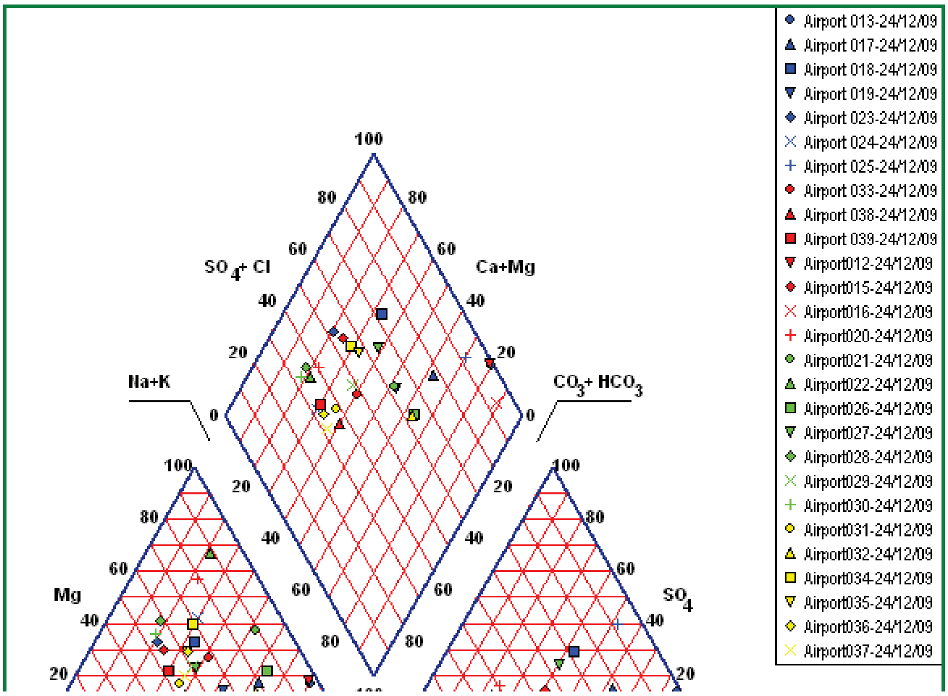
ii) Taluka – Uran

Trilinear Piper Diagram : Taluka Uran has facies Ca+Mg, Na+K, CO_3+HCO_3, Cl+SO_4

Wilcox Diagram : SAR value > 10 and conductivity is in between 250 to 750 u-siemens/cm. Water is good for irrigation purpose. (Fig – 7b)

Fig – 7a : Samples from Taluka – Panvel, Dist. Raigad

Piper Diagram



Wilcox Diagram

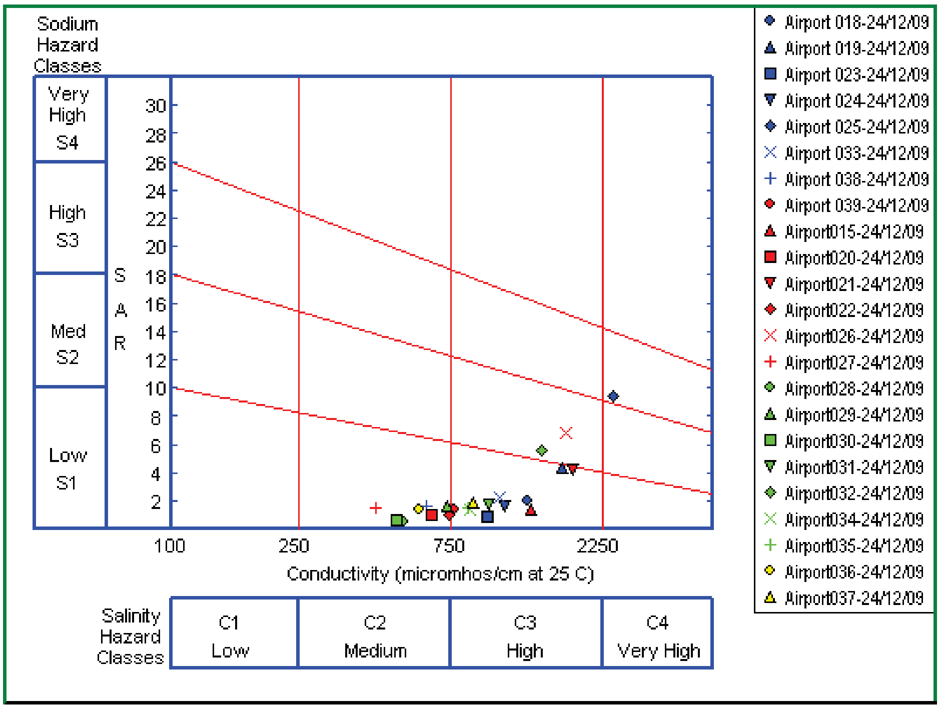
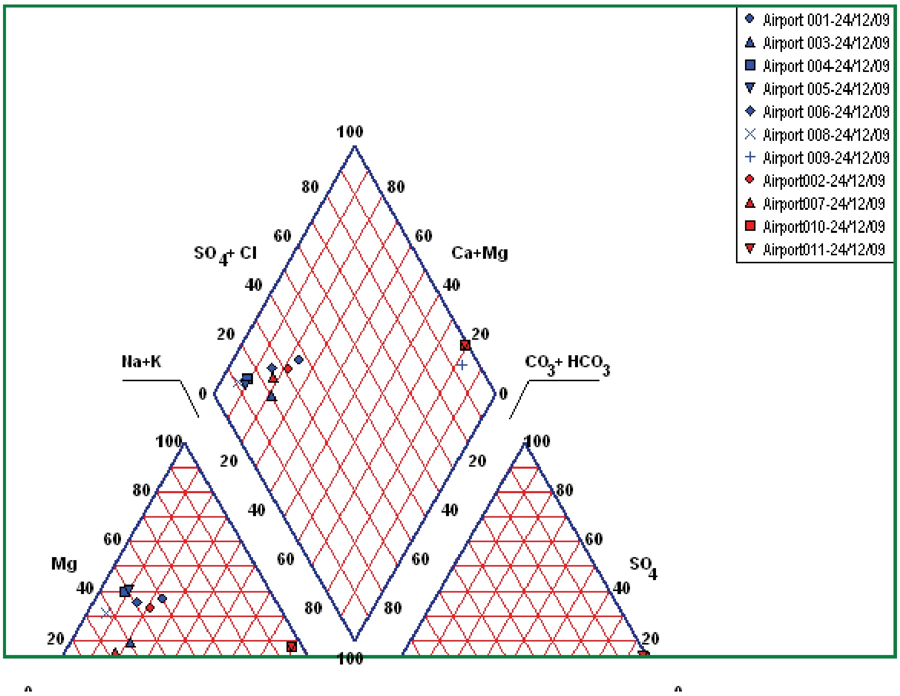
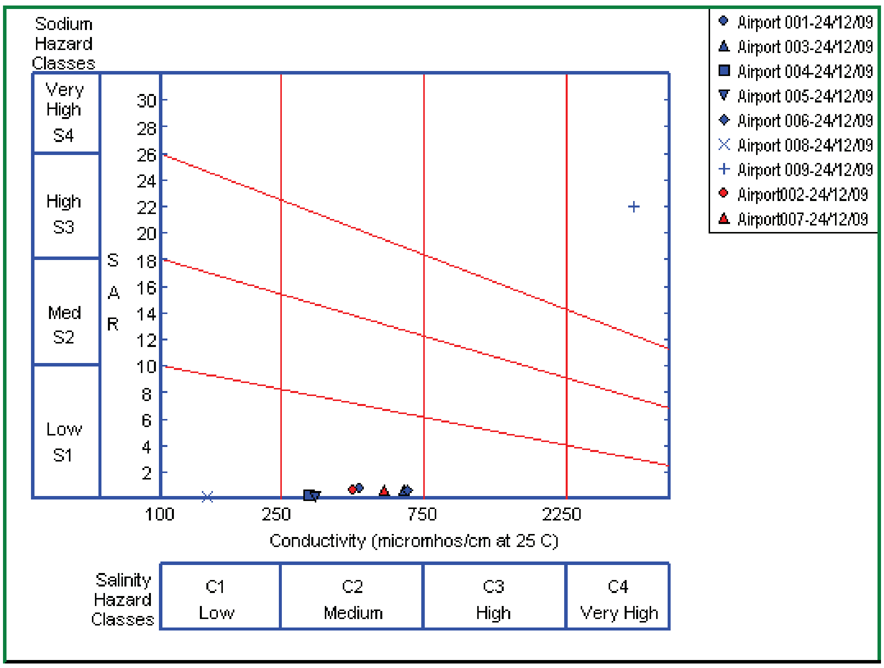


Fig-7b : Samples from Taluka – Uran, Dist. Raigad

Piper Diagram



Wilcox Diagram



iii) Taluka – Thane

Trilinear Piper Diagram : Taluka Thane has facies Ca+Mg, Na+K, Cl+SO_4 , HCO_3+CO_3.

Wilcox Diagram : SAR value > 10 and conductivity is in between 250 to 2250 u-siemens/cm. Water is good for irrigation purpose. (Fig – 7c)

Iso TDS map with creek samples:

The map reveals that Panvel town has more concentration of TDS which is > 14000 ppm. Further the surrounding villages around Panvel i.e. Kamothe, Karanjade also have high TDS ranges from 2000 to 14000 ppm. Village Moha is also having high TDS value above 14000 ppm where as the villages Kombad Bhuje, Ulve are having TDS >14000 ppm and village Taloja is having TDS ranging from 2000 to 14000ppm. (Fig-7d)

Iso Chloride map:

On the basis chemical analysis Iso-Chloride map is prepared. All Creek water samples of Panvel, Taloja ,Moha and Kombad Bhuje fall in hazardous limit i.e. >20000 mg/l. All dugwell water samples fall in allowable limit. Pond water sample is also in allowable limit. In village Turbhe, Kamothe, Kharghar area chloride concentration is in range of 1000 to 10000 mg/l which is above permissible limit (Fig-7e).

Iso Sulphate map:

On the basis of chemical analysis Iso-Sulphate map is prepared. As per drinking water standards (IS :10500) allowable limit is 0-200 ppm and hazardous limit is > 400 ppm.

All Creek water samples of Panvel, Taloja ,Moha and Komad Bhuje fall in hazardous limit (>400ppm). All dugwell water samples fall in allowable limit. Pond water sample is also in allowable limit. In village Turbhe Kamothe Kharghar area Sulphate concentration is in medium range (permissible limit). (Fig-7f)

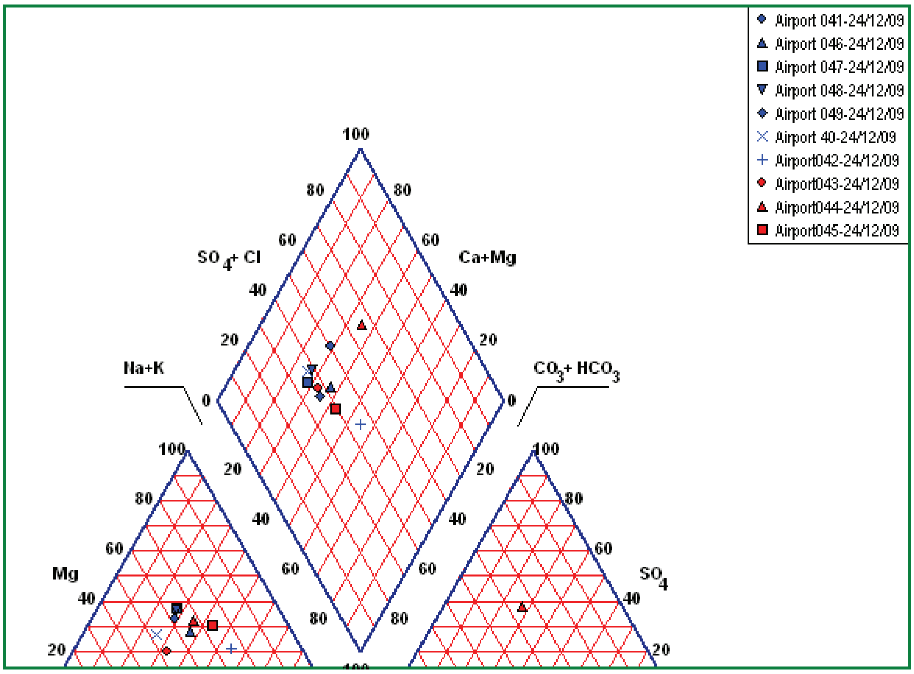
Iso Hardness map:

On the basis chemical analysis Iso-Hardness map prepared as per drinking water standards (IS :10500) where allowable limit is 0-300 ppm, permissible limit is 300-600 ppm and hazardous limit is > 600 ppm.

All Creek water samples of Panvel, Taloja ,Moha and Komad Bhuje fall in hazardous limit (>600ppm). All dugwell water samples are falls in allowable limit. Pond water sample is also in allowable limit. It is found that lower range of Total Hardness (allowable limit) is observed in all part of project area while sample located near Panvel city, Kombad, Bhuje Moha and Taloja Total Hardness show higher range (hazardous limit) (Fig-7g).

Fig-7c : Samples from Taluka – Thane, Dist. Thane

Piper Diagram



Wilcox Diagram

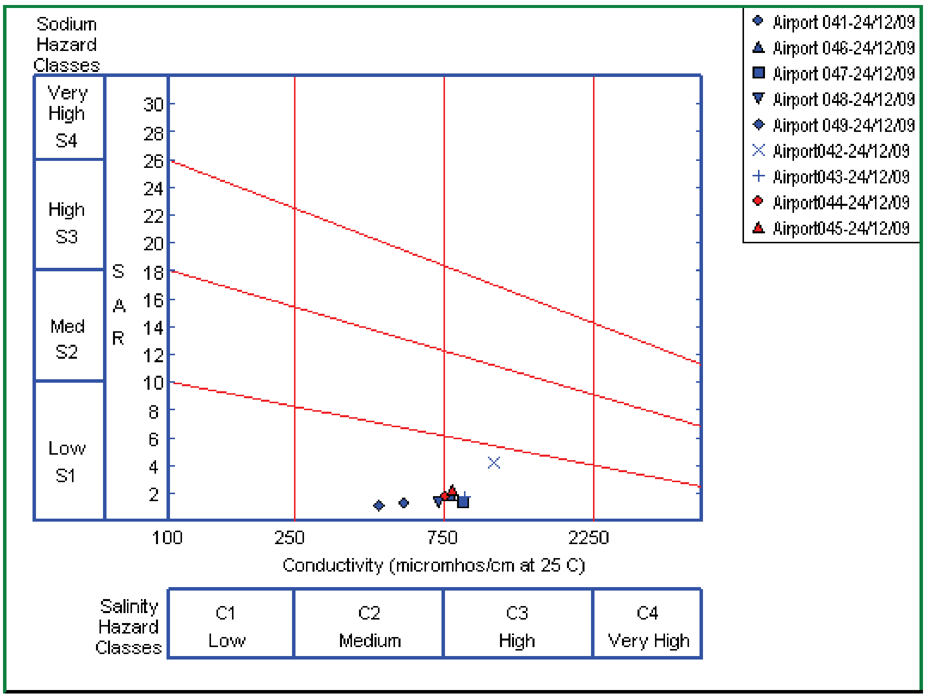


Fig- 7d : Iso-TDS (ppm) (with creek samples) map

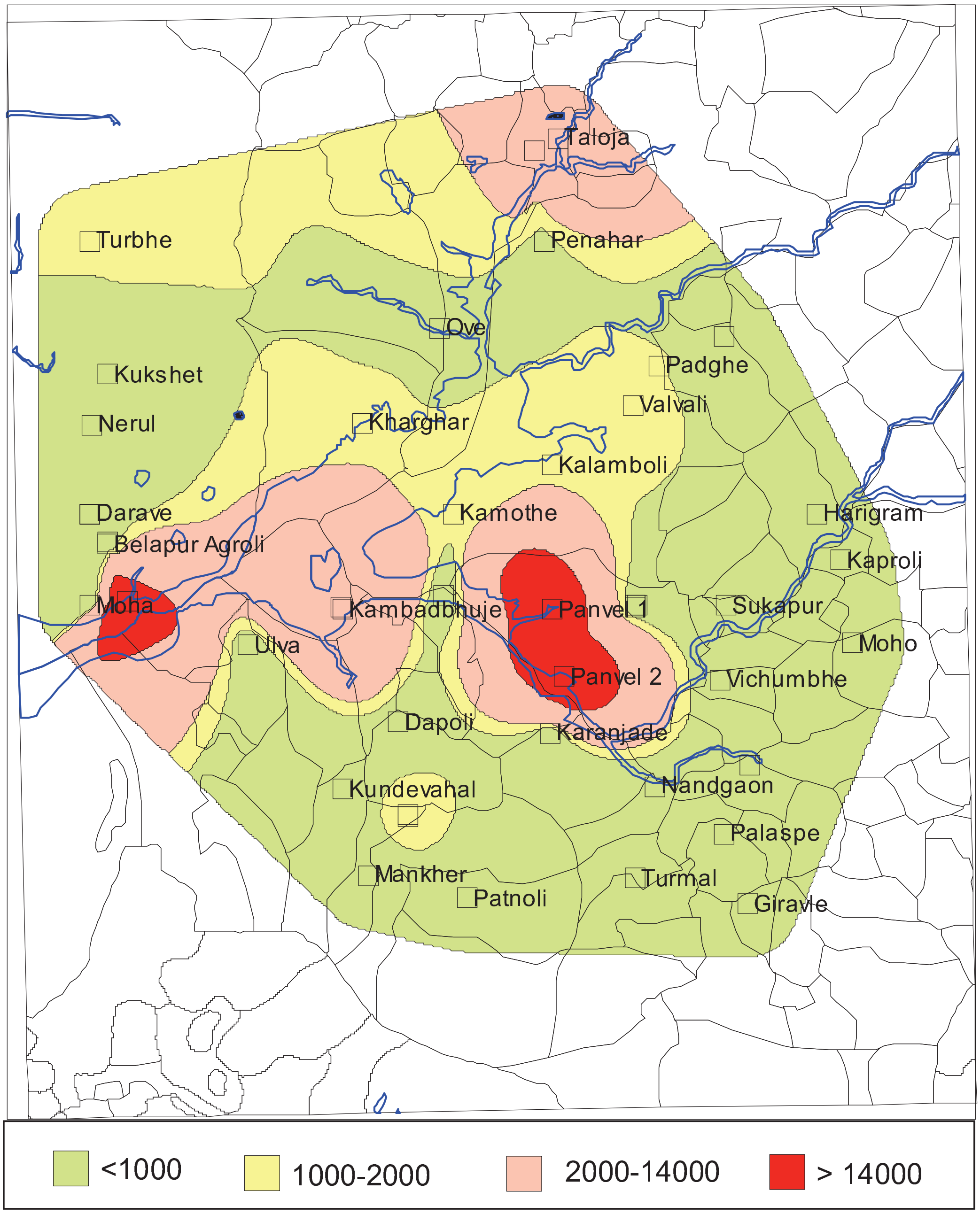


Fig- 7e : Iso-Cloride (ppm) (with creek samples) map

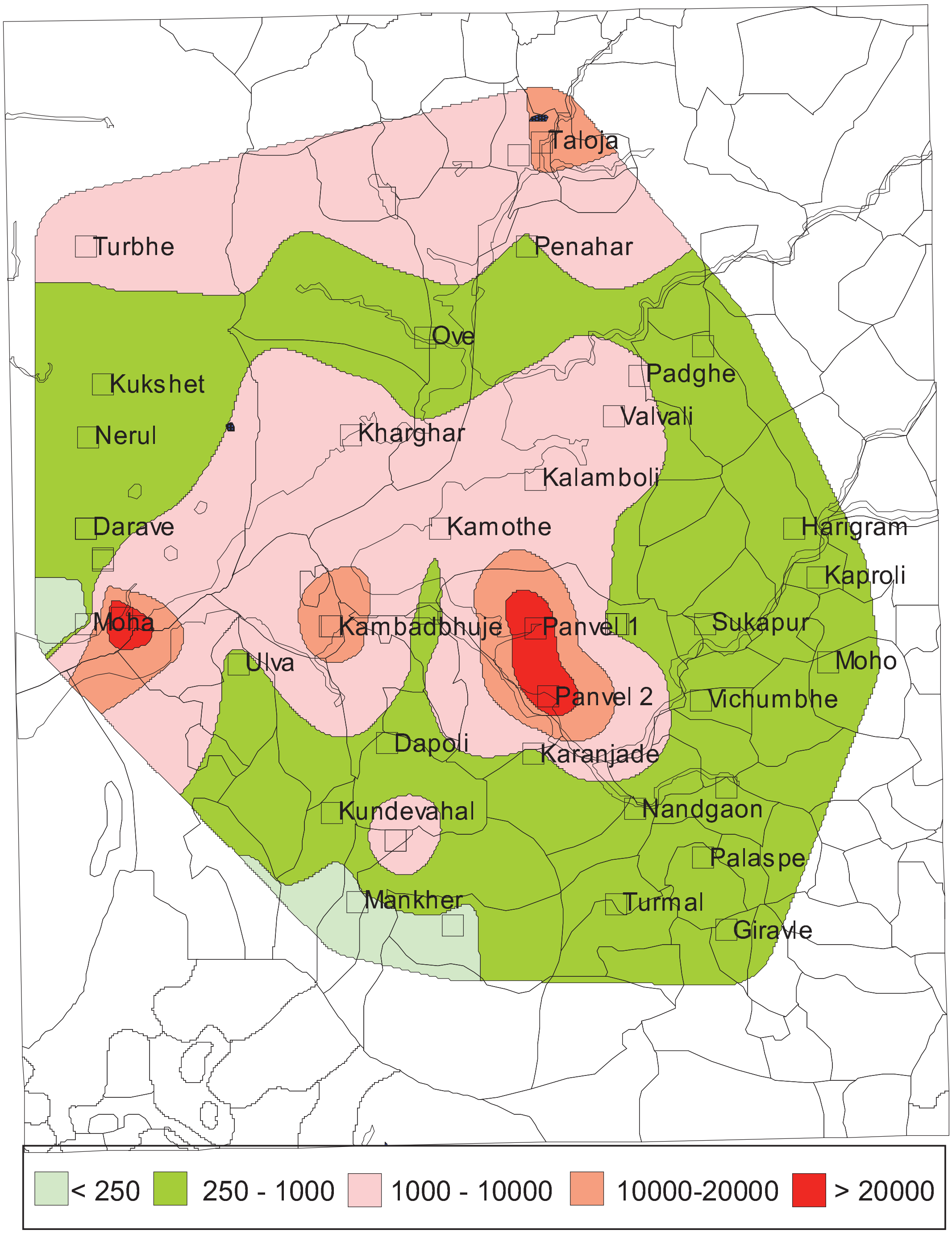


Fig- 7f : Iso-Sulphate (ppm) (with creek samples) map

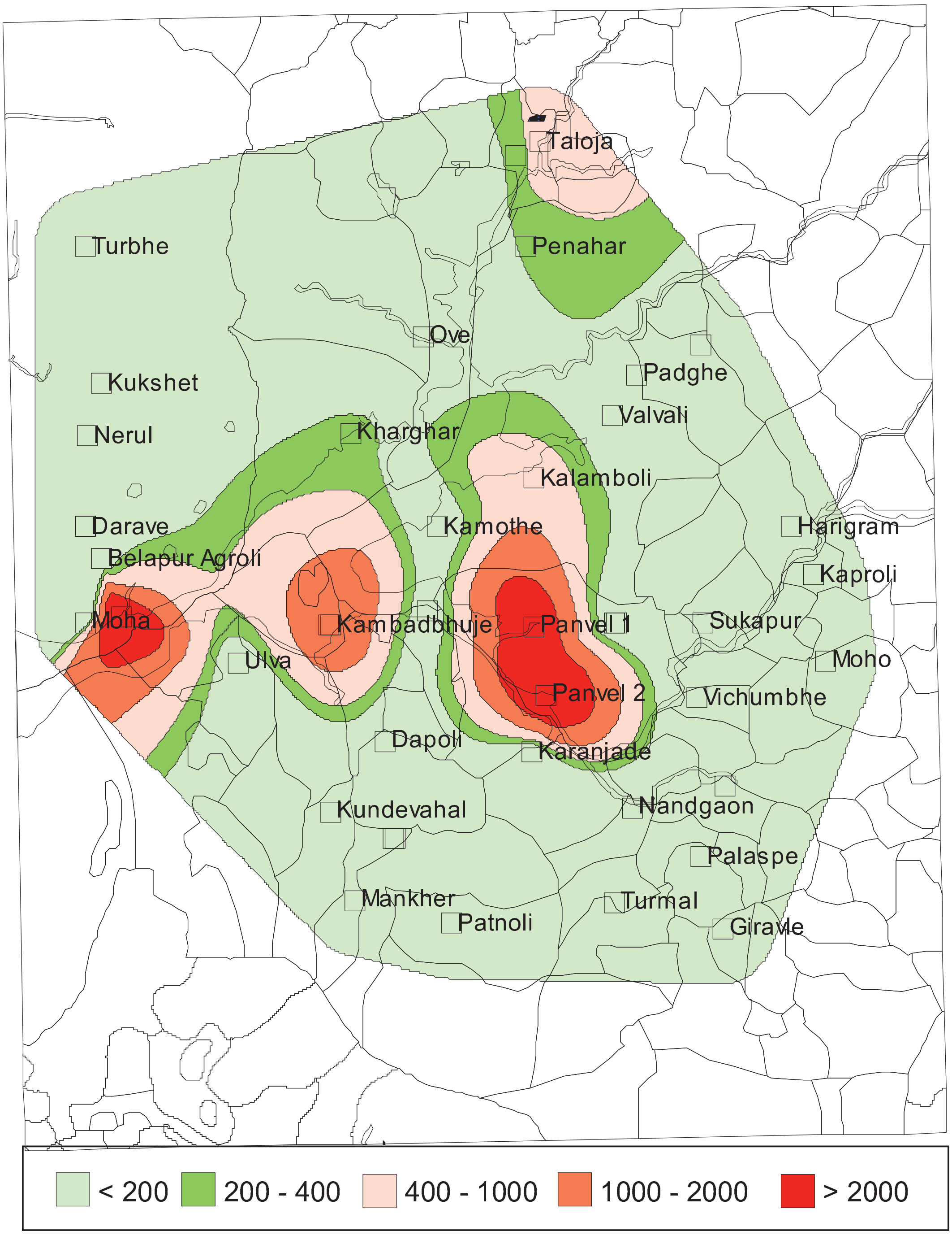
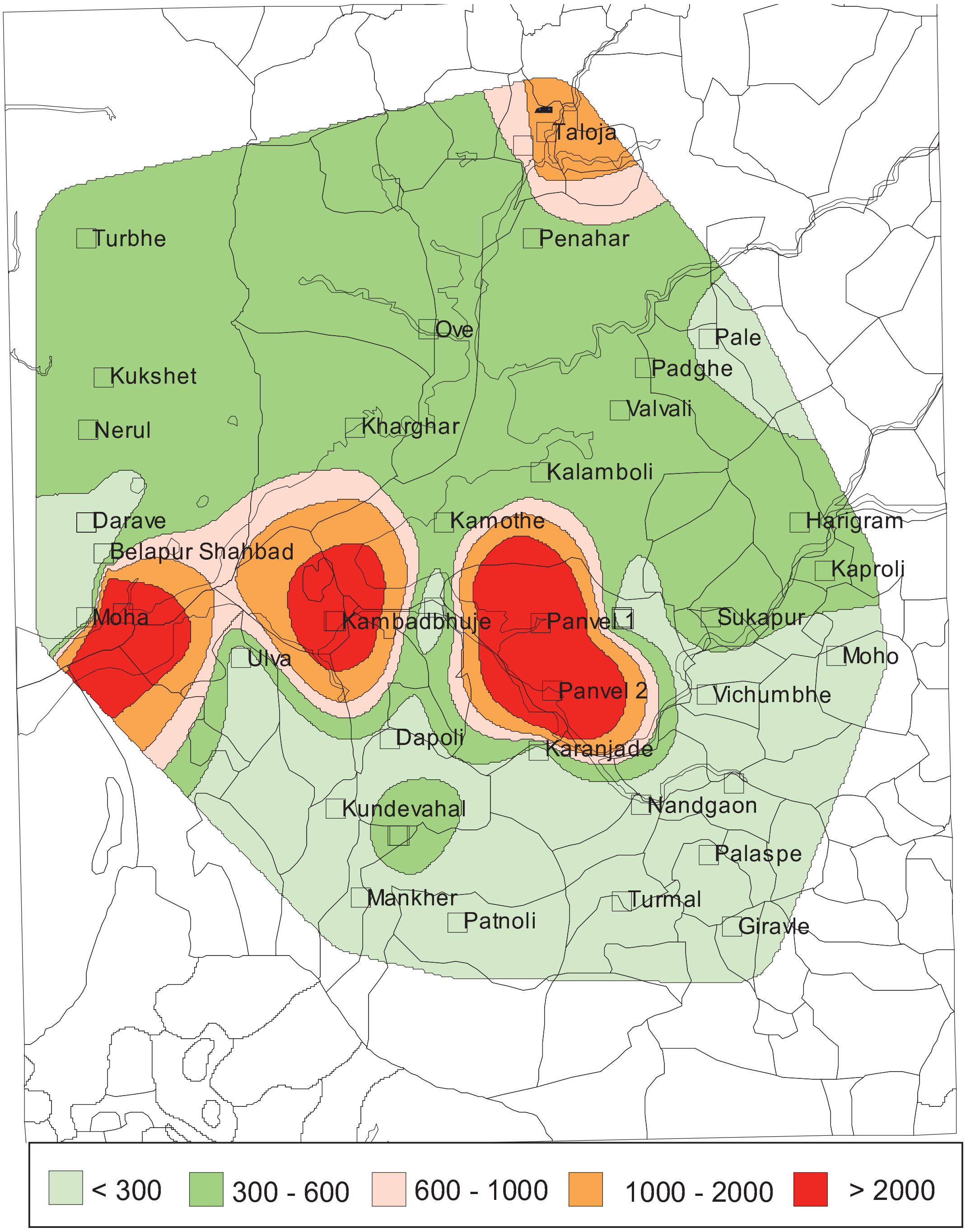


Fig- 7g : Iso-Hardness (ppm) (with creek samples) map



Geophysical Investigations

Electrical Resistivity Surveys are important to study the changes in resitivities both vertically and horizontally and will help in understanding the geometry of the subsurface. Existing geophysical data is used to prepare two sections.

i) The section A-A′ represent Moho, Panvel, and Chinchpada,

ii) Section B-B′ represent Shirdon, Chirvat, Varoli and Panvel.

Section A-A′:

The high resistivity value of the 2nd layer is pinched beyond Panvel, started from Chinchpada, this layer is acting as a barrier between Chinchpada and Moho. The low resistivity layer at Moho i.e. 2nd layer having less thickness is extended up to Chinchpada, which is pinched at Chinchpada. The third high resistivity layer at Moho is pinched at Panvel. An inclined low resistivity layer is observed from Moho to Chinchpada. The last or fourth layer is having moderate resistivity is extending from Moho to Chinchpad. (Fig-8a)

Section B-B′:

The section B-B′ contains the villages from Shirdon to Panvel. The high resistivity 2nd layer observed at Varoli is pinched at Villages Panvel and Chirvat. A very low resistivity layer observed at Shirdon is pinched at Varoli, which can be interpreted as loose overburden or morum. This layer is overlain by high resistivity layer observed from Shirdon to Chirvat as a top layer. Third layer resitivity values moderate low, the resitivity values are 40-56 ohm-m, which is interpreted as highly weathered zones, having a sufficient thickness observed at Panvel. The resistivity values are showing very high is pinched at Chirvat and having sufficient thick at Panvel, this layer is interpreted as 4th layer. (Fig-8b)

Geophysical Observations:

1) The high resistivity values in A-A′ section is 2nd layer acting as barrier between Chinchpada beyond Panvel.
2) Similarly the 3rd high resistivity layer observed at Moho is pinched at Panvel.
3) The 2nd low resistivity layer and the trend of resistivity values are from Moho to Chinchpada.
4) The 3rd low resistivity layer extending from Shirdon to Panvel showing same trend as in point 3.

The sections A-A′ & B-B′ further require series of vertical electrical soundings (data gaps) to understand and to establish the continuity in vertical and horizontal directions (Fig-8c to Fig-8g).

Fig- 8a : Geoelectrical cross section from Chinch pada to Moho

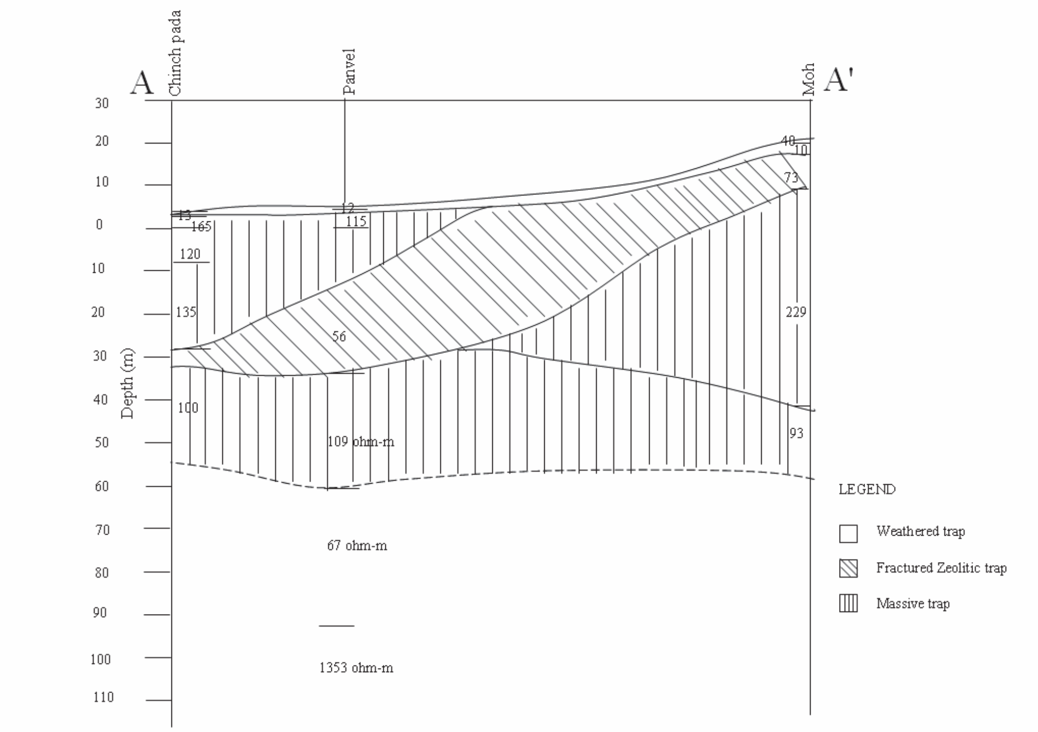


Fig- 8b : Geoelectrical cross section from Shirdhon to Panvel

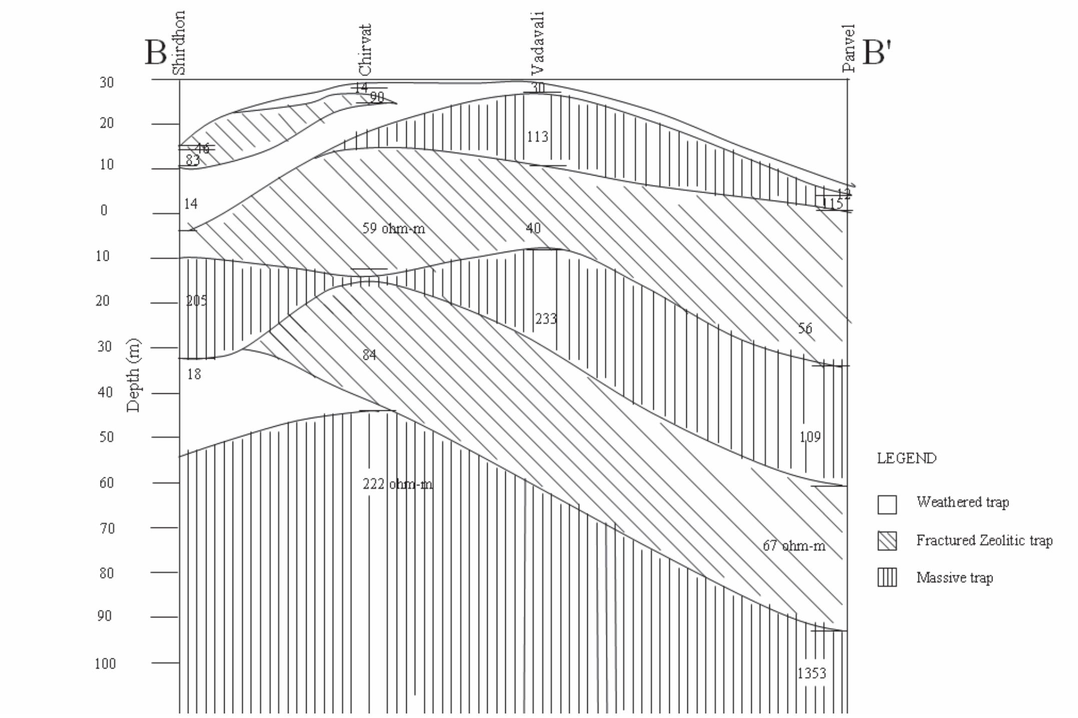


Fig- 8c : Sounding curveat – Panvel

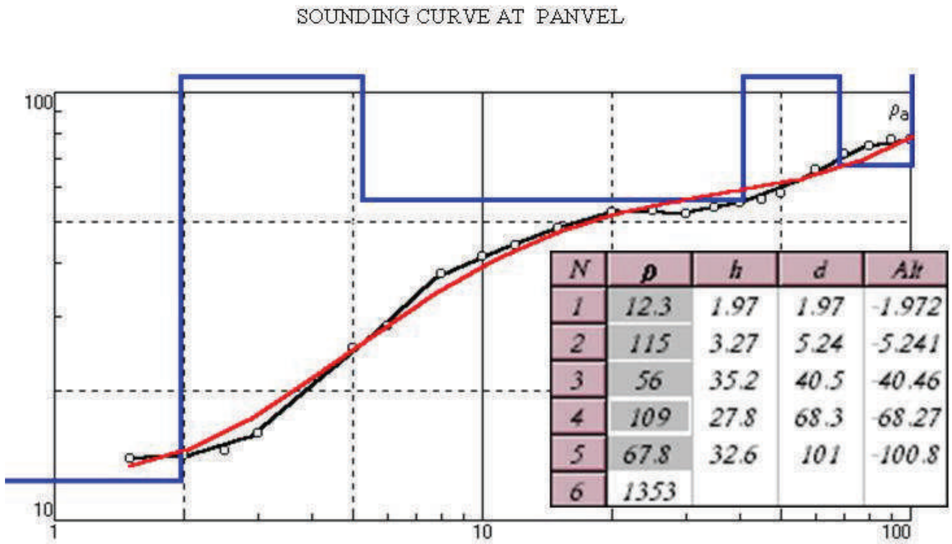


Fig- 8d : Sounding curveat – Moh

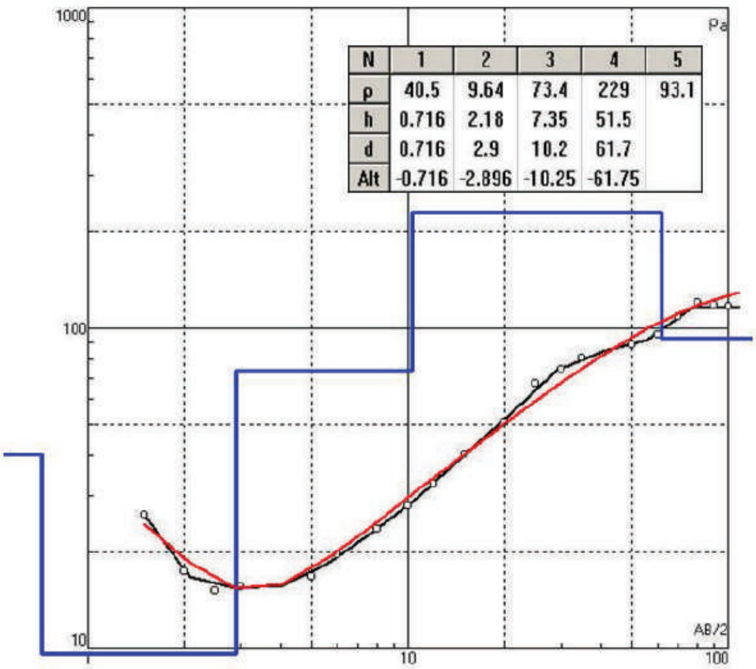
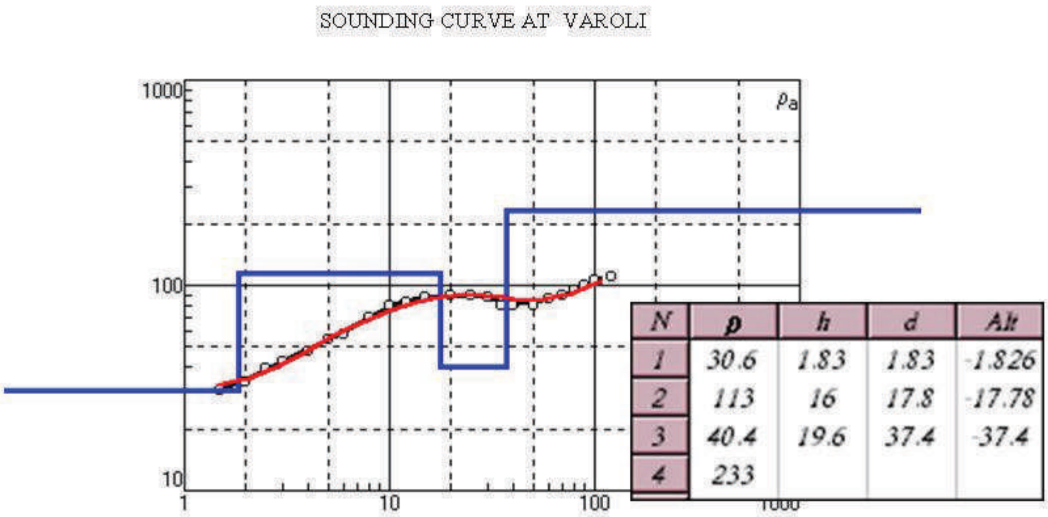
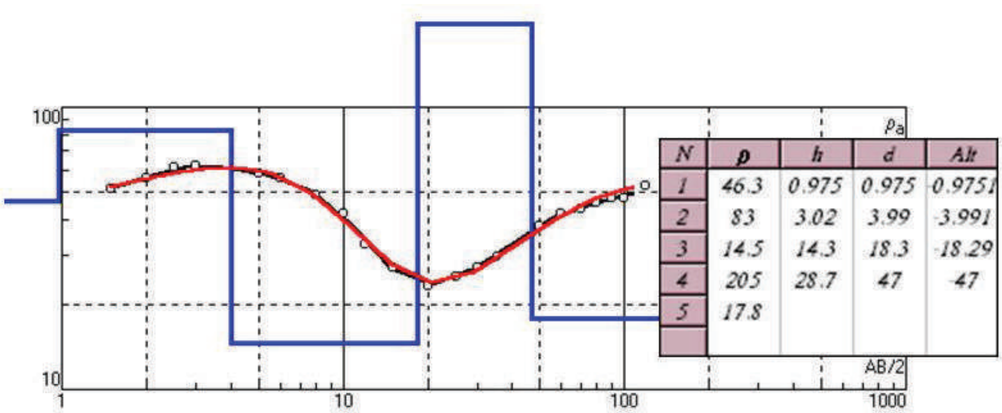


Fig- 8e : Sounding curveat – Vadavali



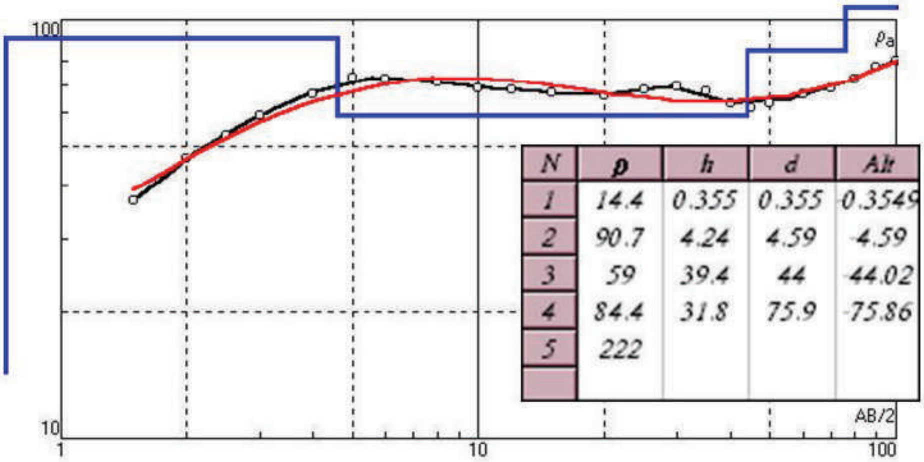
N	ρ	h	d	Alt
1	30.6	1.83	1.83	-1.826
2	113	16	17.8	-17.78
3	40.4	19.6	37.4	-37.4
4	233			

Fig- 8f : Sounding curveat – Shirdhon



N	ρ	h	d	Alt
1	46.3	0.975	0.975	0.9751
2	83	3.02	3.99	-3.991
3	14.5	14.3	18.3	-18.29
4	205	28.7	47	-47
5	17.8			

Fig- 8g : Sounding curveat – Chirwat



Conclusions and Recommendations

(i) Diversion of Ulve River

River Ulve forms the main drainage in mini watershed WF 40/7. The different streams originating around the hills of village Garada join together to form the river Ulve. The river has different names at different places. It passes through village Garada, Balewadi, Nanoshi, Patnoli, Mosare, Manghar, Bhangarpada and finally joins the creek at village Dungi.

Mini watershed WF 40/7 is of prime importance, because the airport site is located in this mini watershed (Fig-9).

The average depth of dugwells in the above mentioned villages is 6 to 7 m below ground level. The present Groundwater level ranges from 1.30m to 2.5m bgl. It is observed that the wells go dry in from the month of March or yield very little water in summer.

This area is underlain by hard massive basalt below 5.00m which is impervious with no primary porosity. Hence the weathered portion is limited. The water holding capacity of the aquifer is limited to weathered portion only. Due to this there is no irrigation during Rabi Season. Few farmers cultivate vegetables on the limited available groundwater.

Few drinking water Borewells have been drilled upto the depth of 60 to 75 m. bgl. Very few borewells are successful, but the quality of borewells is not potable. Below 30m the confined aquifer is brackish. At village Garada, which is located in the hills, it is observed that the borewell is yielding brackish water. This indicates that the sea water intrusion has taken place in the confined aquifer. As the sweet water is less dense than brackish water, it has formed lenses upto certain depths.

The geology is not favorable for dugwells as well as borewells hence it is observed that these is no scope for irrigation in this mini watershed.

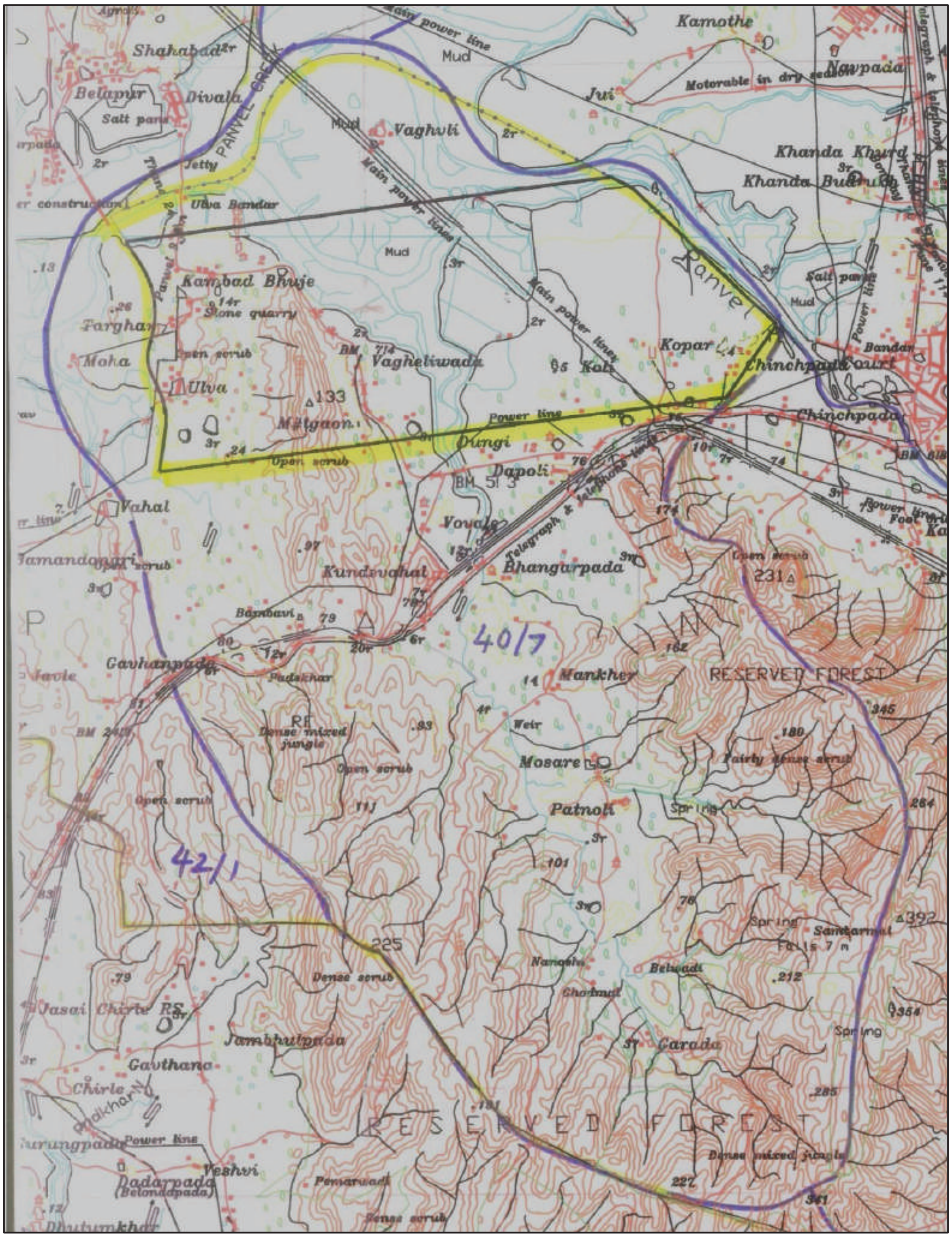
To have sustainable and continuous flow of groundwater, it is necessary to have non monsoon recharge through water conservation structures. These structures if constructed on the stream at regular intervals will recharge the groundwater naturally during non monsoon period.

Another advantage of water conservation structures is that they will reduce the surface water runoff that is reaching the creek near airport site. The diversion of this stream will not have any adverse impact on the groundwater regime in the mini watershed. Few K.T. weirs are recommended in the forest area of Garada and Belewadi villages and also along the river upto Bhangarpada. The locations will be given after detailed verification in phase II of the survey work.

(ii) Training of Gadhi River

Kalundri river and Kolkhewadi river meet in the southern part of Panvel city and further it meanders and meets Panvel Creek. The river in this part is renamed as Gadhi or Panvel River. The tidal water reaches the upstream of this river as well as the upstream of Kalundri and Kolkhewadi rivers. The training of Gadhi river will have no effect on the groundwater regime in the mini watersheds WF40/5 and WF 40/6.

Fig- 9 : Map of mini watershed – WF 40 / 7



(iii) **Recommendations**

The development of groundwater potential by means of dugwells and borewells is severely restricted in view of the rugged and hilly nature of the terrain in the Eastern & Southern part of study area. The plains in the West of study area are covered with mud land and creek water After due observations, following conclusions and recommendations are made.

i) **Rising water table:** From the pre monsoon and post monsoon groundwater levels of 4 observation wells it is observed that there is a rising trend which indicates that optimal usage of groundwater for agriculture is not done. The stage of development indicates that there is further scope for groundwater usages. Due to urbanization, drinking water is supplied through pipe water supply schemes hence the dependency on groundwater is reduced. The density of wells in these elementary watersheds is just 1.7 well per sq.km.

ii) **Groundwater quality** is the main issue in Panvel city and Taloja Industrial area. The unconfined aquifers are yielding sweet water, but in some cases the deeper confined aquifers are polluted, due to sea water intrusion and industrial waste.

iii) **Water conservation Structures:** The dugwells, though fully saturated during monsoon are not sustainable and dry up in early summer due to geological constraints. To make these wells sustainable, additional non monsoon recharge is essential so that continuous recharge will take place against withdrawal. This can be achieved only through construction of water conservation structures, on the existing drainage. Ulve river, Kalundri river, Kolkhewadi river and Taloja river and Navadi river are best suitable for this purpose. The type of structure can be recommended after detailed survey in Phase II. These structures will also help in reducing surface run off, which otherwise this will have some impact on the proposed site.

iv) **Desilting of Panvel creek and Gadhi river, Navadi river and Taloja river** : Through the years Gadhi river and its tributaries Taloja river and its tributaries have deposited large amount of silt near the confluence of these two rivers. It is observed that due to silting, the water spread area has increased converting the land into mud plains. It is suggested that desilting of Panvel creek upto Gadhi and Taloja river will reduce water spread area in the proposed airport site. The desilting will also have no adverse impact on the groundwater regime in all the mini watersheds. In fact it will create more space for the accommodation of freshwater in the surrounding areas.

v) **Rowing Channel**: The Gadhi river after training at the proposed location will be suitable for International Standard Rowing Channel of length 2300m, width 110m and height 3.5m. If this is considered then Rowing channel will be ready with no extra cost. Further Rowing channel will have no adverse impact on Groundwater regime in the mini watersheds.

Need for Phase II Survey

One complete Hydrological cycle should be considered for complete understanding of hydrogelogical processes in nature. In the present study, post monsoon data has been collected and analyzed. For completion of the cycle pre-monsoon data will be required to be collected and analyzed. Further to study aquifer parameter, Aquifer performance tests are to be conducted, pre- monsoon water quality data, geophysical data and location of water conservation structures are required to be finalized. Hence phase II survey is very much essential.

Table - 1a : Rainfall received at station - Panvel, District- Raigad (in mm)

Year	Total	% Departure from Normal (2741)
1989	2830	3.25
1990	2898	5.73
1991	4136	50.89
1992	2569	-6.28
1993	2978	8.65
1994	3272	19.37
1995	2076	-24.26
1996	2308	-15.80
1997	2351	-14.23
1998	2753	0.44
1999	2203	-19.63
2000	2770	1.06
2001	2572	-6.17
2002	1829	-33.27
2003	2760	0.69
2004	2678	-2.30
2005	3411	24.44
2006	3611	31.74
2007	2833	3.36
2008	3024	10.32
2009	2007	-26.78

Table – 1b : Rainfall received at station - Uran, District- Raigad (in mm)

Year	Total	% Departure from Normal (2072)
1989	2713	30.94
1990	2457	18.58
1991	3524	70.08
1992	1991	-3.91
1993	2734	31.95
1994	2232	7.72
1995	1704	-17.76
1996	2069	-0.14
1997	2722	31.37
1998	2235	7.87
1999	1287	-37.89
2000	2562	23.65
2001	908	-56.18
2002	1202	-41.99
2003	1837	-11.34
2004	2049	-1.11
2005	2229	7.58
2006	2324	12.16
2007	2354	13.61
2008	2576	24.32
2009	1005	-51.50

Table – 1c : Rainfall received at station - Thane, District – Thane (in mm)

Year	Total	% Departure from Normal (2446)
1989	2102	-14.06
1990	3102	26.82
1991	1882	-23.06
1992	1902	-22.24
1993	2421	-1.02
1994	3989	63.08
1995	1543	-36.92
1996	3622	48.08
1997	3494	42.85
1998	2367	-3.23
1999	2015	-17.62
2000	2897	18.44
2001	2225	-9.04
2002	1895	-22.53
2003	2523	3.15
2004	2491	1.84
2005	3459	41.41
2006	3131	28.00
2007	3106	26.98
2008	2710	10.79
2009	2081	-14.92

Table – 2 : Details of observation wells and depth to water level (Post monsoon)

Sr. No.	Name of Village	Taluka	Mini watershed no.	Type of source	Depth in m. (bgl)	Dia in m.	Parapet in m.	DWL in m. (bgl)
1	2	3	4	5	6	7	8	9
1	Turbhe	Thane	36/2	Dugwell	2.50	2.40	0.80	0.60
2	Darave	Thane	36/2	Dugwell	7.20	3.20	0.90	1.30
3	Kukshet	Thane	36/2	Dugwell	6.50	5.10	0.80	1.50
4	Nerul	Thane	36/2	Dugwell	5.65	3.30	0.85	2.65
5	Karave	Thane	36/2	Dugwell	5.30	3.30	1.00	0.20
6	Belapur	Thane	36/2	Dugwell	5.70	4.50	0.60	1.60
7	Belapur(Agroli)	Thane	36/2	Dugwell	7.60	6.20	0.50	3.70
8	Pendhar	Panvel	40/1	Dugwell	6.00	3.20	0.80	1.60
9	Padgha	Panvel	40/2	Dugwell	8.00	5.50	0.00	5.00
10	Pale BK	Panvel	40/2	Dugwell	5.90	3.80	0.80	1.90
11	Harigram	Panvel	40/3	Dugwell	6.50	3.30	1.00	2.65
12	Kaproli	Panvel	40/5	Dugwell	6.00	2.20	0.80	2.60
13	Moho	Panvel	40/5	Dugwell	7.90	6.10	0.80	2.40
14	Kolkhe	Panvel	40/5	Dugwell	6.10	3.60	0.80	0.70
15	Chichpada	Panvel	40/6	Dugwell	4.90	3.30	1.00	1.30
16	Nandgaon	Panvel	40/6	Dugwell	5.90	4.30	0.90	0.80
17	Palaspe	Panvel	40/6	Dugwell	11.10	3.60	0.50	1.00
18	Turmal	Panvel	40/6	Dugwell	9.30	3.30	0.70	3.40
19	Girwale	Panvel	40/6	Dugwell	7.30	6.10	0.90	2.00
20	Karanjade	Panvel	40/6	Dugwell	5.20	2.90	0.60	1.80
21	Kopar	Panvel	40/7	Dugwell	5.30	3.10	0.80	1.30
22	Moha	Panvel	40/7	Dugwell	3.30	3.10	0.80	0.90
23	Ulve	Panvel	40/7	Dugwell	6.30	5.30	0.60	3.60
24	Kombad Bhije	Panvel	40/7	Dugwell	6.60	6.30	0.80	1.50
25	Owale (Waghilipada)	Panvel	40/7	Dugwell	6.90	5.30	0.60	2.50
26	Kundevahal	Panvel	40/7	Dugwell	3.80	10.30	0.90	0.90
27	Bhangharpada	Panvel	40/7	Dugwell	5.50	2.60	0.80	1.20
28	Mankher	Panvel	40/7	Dugwell	6.15	3.35	0.95	2.40

Table – 2 : Details of observation wells and depth to water level (Post monsoon)

Sr. No.	Name of Village	Taluka	Mini watershed no.	Type of source	Depth in m. (bgl)	Dia in m.	Parapet in m.	DWL in m. (bgl)
1	2	3	4	5	6	7	8	9
29	Patnoli (Mashere)	Panvel	40/7	Dugwell	5.70	3.50	1.00	1.70
30	Dapoli	Panvel	40/7	Dugwell	7.20	3.90	1.00	0.80
31	Valavali	Panvel	40/8	Dugwell	6.90	3.20	0.80	2.20
32	Kalamboli	Panvel	40/8	Dugwell	7.10	5.80	0.90	2.40
33	Jui	Panvel	40/8	Dugwell	6.25	3.60	0.85	1.25
34	Panvel	Panvel	40/8	Dugwell	5.00	3.10	0.70	1.90
35	Kharghar	Panvel	40/9	Dugwell	4.10	3.20	0.70	2.10
36	Kharghar	Panvel	40/9	Dugwell	4.20	4.60	0.70	1.30
37	Owe	Panvel	40/9	Dugwell	7.55	3.10	0.85	2.95
38	Taloja	Panvel	40/9	Dugwell	3.30	2.70	0.80	0.60

Table – 3a : Post monsoon water level data of observation well Panvel, Taluka – Panvel, District - Raigad

Year	Water Level (m bgl)			
	Jan	Mar	May	Oct
1990	-	-	1.00	0.40
1991	1.00	1.90	2.10	0.70
1992	1.40	1.45	1.20	0.90
1993	1.00	1.00	1.30	0.50
1994	0.95	1.00	1.35	0.70
1995	0.75	0.90	0.95	0.50
1996	0.95	0.95	1.00	0.30
1997	0.80	0.90	-	0.40
1998	0.30	0.20	0.60	0.30
1999	2.10	0.85	0.40	0.25
2000	0.60	0.50	0.40	0.30
2001	-	0.40	0.60	0.50
2002	0.70	0.70	2.90	0.35
2003	0.60	0.70	0.70	0.45
2004	0.40	-	1.00	0.70
2005	0.30	0.30	1.10	0.30
2006	0.45	0.30	0.63	0.10
2007	0.10	0.40	0.70	0.10
2008	0.50	0.60	0.70	0.10
2009	0.45	0.35	0.85	0.45

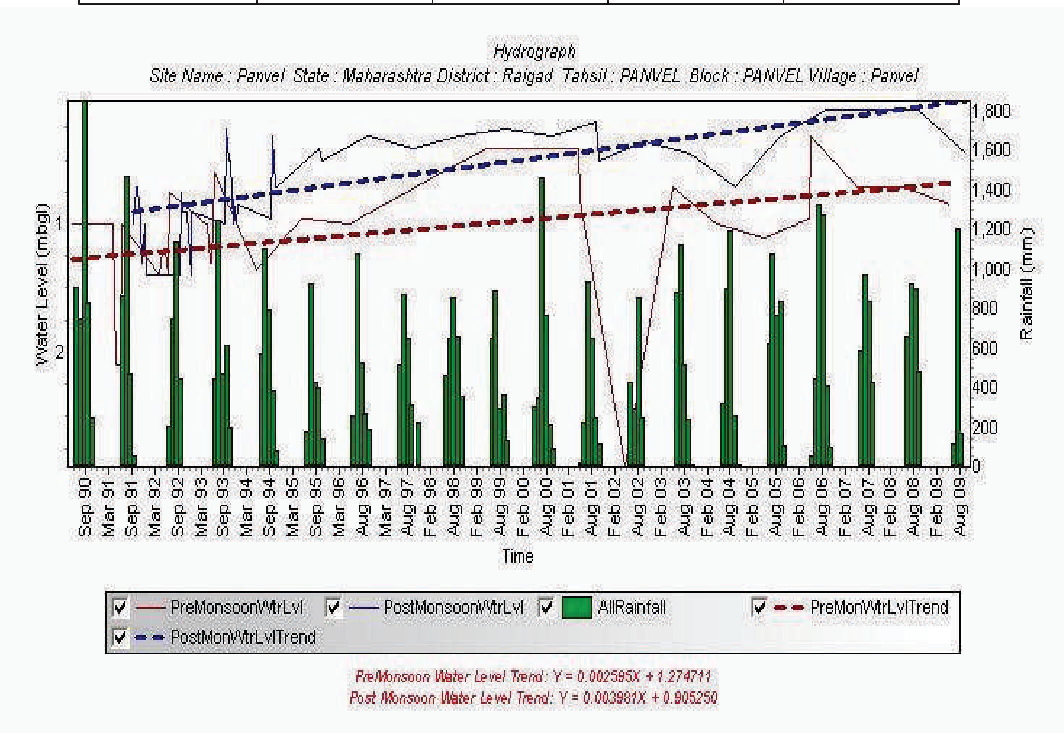


Table – 3b : Post monsoon water level data of observation well Nere, Taluka – Panvel, District - Raigad

Year	Water Level (m bgl)			
	Jan	Mar	May	Oct
1989	-	-	5.20	1.80
1990	-	-	6.30	0.40
1991	2.80	5.00	5.85	1.50
1992	3.70	4.45	6.30	1.80
1993	4.10	6.20	6.85	0.55
1994	-	5.30	7.00	1.90
1995	3.90	5.50	7.10	-
1996	3.50	3.90	7.10	0.90
1997	2.80	4.20	-	1.10
1998	2.50	4.30	5.75	0.30
1999	2.70	4.20	5.40	0.25
2000	3.20	4.80	5.80	0.40
2001	-	4.70	5.50	0.70
2002	3.20	4.60	5.50	0.90
2003	3.80	5.00	6.10	0.90
2004	3.30	-	6.20	0.40
2005	3.40	4.45	6.10	0.25
2006	3.15	4.50	5.50	1.00
2007	1.80	4.10	5.40	0.65
2008	3.20	4.30	5.50	0.40
2009	2.70	4.40	5.50	1.25

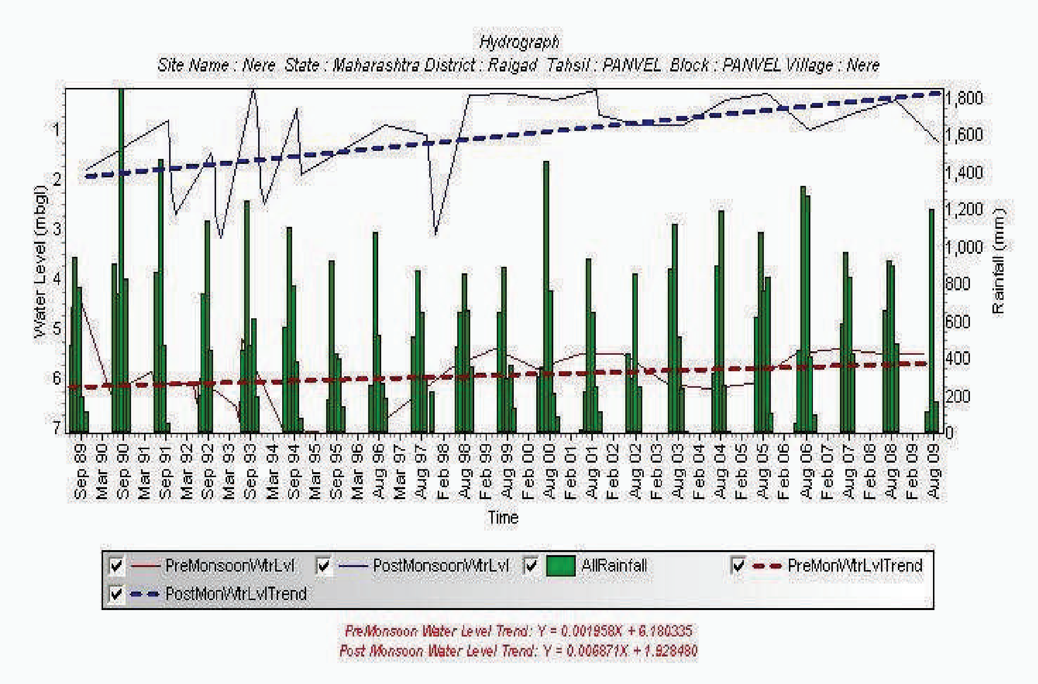


Table – 3c : Post monsoon water level data of observation well Jasai, Taluka – Uran, District - Raigad

Year	Water Level (m bgl)			
	Jan	Mar	May	Oct
1989	-	-	1.90	0.70
1990	-	-	1.90	0.30
1991	1.20	1.95	2.80	0.80
1992	1.70	1.90	2.05	1.20
1993	1.70	2.00	2.40	0.40
1994	-	0.75	2.70	0.40
1995	0.65	-	5.00	0.40
1996	0.75	4.00	4.90	0.30
1997	0.70	0.80	-	0.20
1998	-	-	0.90	0.20
1999	0.30	0.90	-	0.30
2000	0.20	0.40	0.60	0.20
2001	-	0.70	2.70	0.10
2002	1.90	2.30	2.50	0.40
2003	2.70	4.20	4.20	0.35
2004	1.65	-	4.30	0.05
2005	1.85	2.40	4.20	0.30
2006	2.70	3.70	4.45	0.55
2007	2.10	4.80	4.85	0.45
2008	2.00	4.10	4.30	0.40
2009	3.45	4.00	4.50	0.30

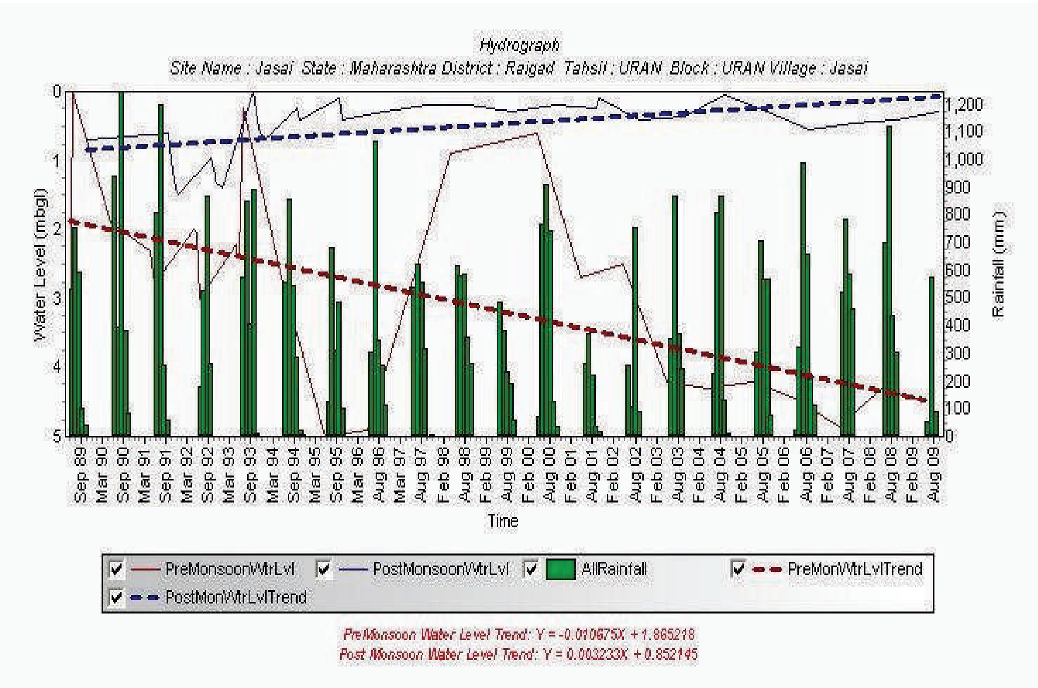


Table – 3d : Post monsoon water level data of observation well Kopar Khairane, Taluka – Thane, District - Thane

Year	Water Level (m bgl)			
	Jan	Mar	May	Oct
1991	1.40	1.50	2.00	1.10
1992	1.80	1.80	1.85	2.00
1993	1.60	1.60	1.90	0.90
1994	1.10	1.80	1.95	0.00
1995	1.80	1.90	1.95	1.10
1996	2.30	2.40	2.50	0.70
1997	1.90	2.30	2.60	0.80
1998	1.05	1.30	1.50	0.60
1999	1.20	1.50	1.70	0.60
2000	-	1.30	1.30	0.90
2001	1.55	-	2.70	0.75
2002	-	1.05	1.05	0.70
2003	-	1.50	2.15	1.00
2004	-	1.35	1.45	0.70
2005	1.60	1.65	1.75	0.70
2006	1.60	2.00	2.10	2.70
2007	2.90	2.05	2.10	0.80
2008	1.90	2.90	2.05	0.85
2009	1.90	2.80	2.80	0.80

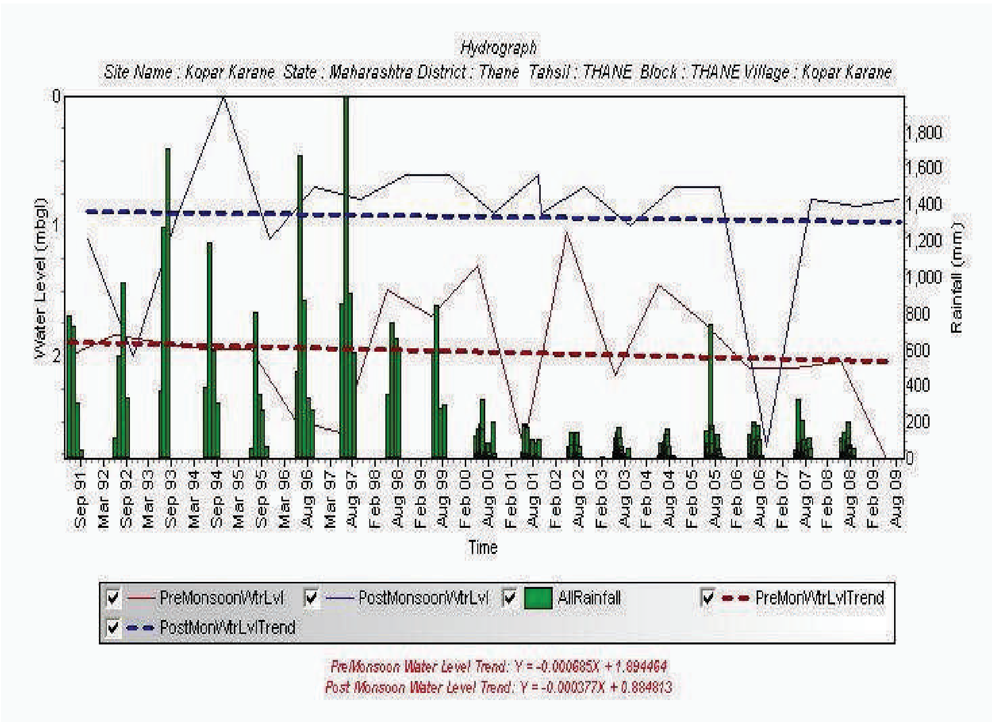


Table – 4 : Information of drinking water borewells

Borewell Data - Taluka Panvel

S.N.	Name of village	Mini watershed No.	No. of BW	Depth range (m)	Casing range (m)
1	Taloje Panchanand	40/1	3	25.00 - 6.10	3.05 - 6.10
2	Valap	40/2	5	43.28 - 65.00	6.10 - 10.00
3	Pale Bk.	40/2	5	55.00 - 68.60	6.09 - 7.62
4	Hedutane	40/2	1	36.6	7.3
5	Harigram	40/3	7	60.00 - 73.50	3.10 - 12.20
6	Nere	40/5	9	54.86 - 73.76	3.05 - 12.20
7	Kaproli	40/5	3	45.40 - 7.00	6.1
8	Devad	40/5	3	60.00-60.40	3.05-13.80
9	Chipale	40/5	4	61.00-80.20	6.10 - 9.14
10	Vihighar	40/5	5	60.00 - 94.30	3.10 - 6.20
11	Bonshet	40/5	5	60.00 - 76.20	6.10 - 9.15
12	Moho	40/5	13	51.80 - 93.20	2.74 - 6.40
13	Shivkar	40/5	6	55.40 - 61.40	6.10 - 12.20
14	Vichumbe	40/5	4	61.57 - 64.00	3.00 - 6.10
15	Usarli Kh.	40/5	3	48.77 - 62.20	6.1
16	Chikhale	40/5	8	60.00 - 63.80	3.05 - 6.15
17	Bherle	40/5	3	60.00 - 70.00	6.1
18	Kon	40/5	6	60.00 - 61.00	6.10 - 12.19
19	Kolkhe	40/5	2	60.00 - 62.10	3.05 - 6.10
20	Arivali	40/6	2	66.00 - 75.10	3.05
21	Derawali	40/6	5	55.46 - 76.80	3.05 - 12.20
22	Giravle	40/6	2	61.00 - 68.01	3.00
23	Kasalkhand	40/6	5	64.00 - 74.10	3.05 - 6.20
24	Kudave	40/6	5	45.00 - 80.75	3.05 - 6.10
25	Shirdhon	40/6	9	42.67 - 92.00	3.05 - 10.00
26	Chirvat	40/6	1	59.5	3.1
27	Chinchvan	40/6	7	49.00 - 90.00	6.10 - 12.80

Table – 4 : Information of drinking water borewells

S.N.	Name of village	Mini watershed No.	No. of bore well	Depth range (m)	Casing range (m)
28	Sangurli	40/6	4	47.24 - 85.94	3.05 -6.10
29	Karanjade	40/6	9	42.67 - 76.50	2.90 - 9.15
30	Vadghar	40/6	1	58	9.15
31	Devloli Bk.	40/6	4	55.00 - 61.00	6
32	Somatne	40/6	3	49.00 - 55.00	6.10 - 12.20
33	Turmale	40/6	5	55.47 - 68.00	3.05 - 9.14
34	Nanoshi	40/7	6	60.00 - 77.00	3.05 - 6.10
35	Patnoli	40/7	5	60.00 - 79.75	3.05 - 6.30
36	Mosare	40/7	3	61.00 - 61.50	6.1
37	Dapoli	40/7	4	56.40 - 85.95	6.1
38	Manghar	40/7	3	60.00 - 76.10	3.05 - 6.10
39	Kundevahal	40/7	2	64.40 - 84.50	3.05 - 6.00
40	Vahal	40/7	2	57.61 - 62.48	3.00 - 9.14
41	Ulwe	40/7	2	55.47 - 62.30	3.65 - 12.20
42	Bombavi	40/7	3	61.50 - 79.85	6.10 - 12.20
43	Owle	40/7	3	31.00 - 63.00	3.05 - 6.10
44	Pargaon	40/7	2	67.67 - 79.87	6.1
45	Kopar	40/7	2	55.47 - 79.86	6.1
46	Vaghiwali	40/7	2	61.25 - 61.85	2.70 - 3.05
47	Valavali	40/8	4	51.00 - 57.00	3.22 - 12.20
48	Tembhode	40/8	4	56.40 - 92.00	3.05 - 6.10
49	Asudgaon	40/8	3	60.70 - 70.60	3.05 - 6.10
50	Adai	40/8	12	50.00 - 71.63	3.05 - 7.67
51	Akurli	40/8	4	61.00 - 66.00	4.25 - 6.10
52	Pali Deval	40/8	3	41.15 - 48.00	12.19 - 15.24
53	Shilottar Raichur	40/8	2	33.90 - 61.57	3.05 - 33.90
54	Owe	40/9	11	18.00-79.86	4.00-8.40

Borewell Data - Taluka Uran

1	Chirle	42/1	4	60.00 - 67.00	6.10 - 7.65
2	Weshvi	42/2	2	41.76 - 61.00	6.09 - 6.60
3	Ransai	42/2	3	30.00 - 60.00	3.05 - 18.30

Table – 5 : Groundwater Assessment in elementary watersheds in the study area

Part I - Groundwater Resources Abstract

SR. NO.	WATERSHED NO.		TOTAL WS AREA (Hectares)	TYPE OF AREA	AREA SUITABLE FOR GW RECHARGE (Hectares)	TOTAL ANNUAL GW RECHARGE (Ham)	NATURAL DIS-CHARGE (Ham)	NET ANNUAL GW AVAILABI-LITY (Ham)	GROSS DRAFT (Ham)
1	2		3	4	5	6	7	8	9
1	WF	36	12747	NC	8295.00	1068.53	53.43	1015.11	59.01
2	WF	40	44560	C	274.00	88.24	8.82	79.41	36.27
3	WF	40	44560	NC	30927.00	4672.11	233.61	4438.51	1209.34
4	WF	42	24597	NC	15150.00	1681.70	84.09	1597.62	220.79

Note :- C - Command, NC - Non Command, PQ - Poor Quality

Part I - Groundwater Resources Abstract

SR. NO.	WATERSHED NO.		STAGE OF DEVEL. (%)	WATER TABLE TREND		CATEGORY OF	FOR YEAR 2025 DOME. + INDUS.		NET GW AVAIL. FOR WATERSHED IRRIGATION USE (Ham)
				PRE MON-SOON	POST MON-SOON		REQUI-REMENT	ALLO-CATION	
1	2		10	11	12	13	14	15	16
1	WF	36	5.81	RISING	RISING	SAFE	10.22	10.22	945.88
2	WF	40	27.57	RISING	RISING	SAFE	682.23	682.23	2590.07
3	WF	40							
4	WF	42	13.82	RISING	RISING	SAFE	71.32	71.32	1305.50

Part II Component wise Groundwater Recharge

SR. NO.	INDEX NO.	WATER-SHED NO.		TALUKAS INCLUDED	TYPE OF AREA	TERRAIN HECTARE	AREA IN	EXISTING IRRI. WELLS
1	2	3		4	5	6	7	8
1	1445	WF	36	Thane	NC	Hardrock	8295.00	143
2	1453	WF	40	Panvel	C	Hardrock	274.00	22
3	1453	WF	40	Panvel	NC	Hardrock	30927.00	648
4	1456	WF	42	Uran,Panvel	NC	Hardrock	15150.00	121

Note :- C - Command, NC - Non Command, PQ - Poor Quality

Part II Component wise Groundwater Recharge

SR. NO.	INDEX NO.	WATER-SHED NO.		RECHARGE IN Ham FROM						
				RAIN FALL	CANAL	SURFACE IRRG	G.WATER IRRG.	TANKS	CONSER. STR.	TOTAL
1	2	3		9	10	11	12	13	14	15
1	1445	WF	36	1055.06	0.00	0.00	13.48	0.00	0.00	1068.53
2	1453	WF	40	48.82	9.33	5.87	7.43	16.79	0.00	88.24
3	1453	WF	40	4408.09	0.00	0.00	218.70	6.72	38.61	4672.11
4	1456	WF	42	1632.32	0.00	0.00	46.28	0.00	3.10	1681.70

Table – 6a : Location and type of water samples collected in study area

S.N.	Taluka	Village	Location	Source
1	Uran	Ulva	Near marathi school	Dugwell
2	Uran	Kundevahal	North side gaothan	Dugwell
3	Uran	Bhangarpada	Bhangarpada to mankher road.	Dugwell
4	Uran	Mankher	North side gaothan	Dugwell
5	Uran	Patnoli	Near talav ,north side village	Dugwell
6	Uran	Dapoli	Near MIDC pipe line	Dugwell
7	Uran	Kamba-dbhuje	Gaothan	Dugwell
8	Uran	Moha	Gaothan	Dugwell
9	Uran	Bhangarpada	Near Bhangarpada Ulva River)	River
10	Uran	Kambadbhuje	Near Kambadbhuje	Creak
11	Uran	Moha	Moha gaothan	Creak
12	Panvel	Panvel 1	Panvel creak	Creak
13	Panvel	Panvel 2	Panvel creak	Creak
14	Panvel	Taloja	Taloja creak	Creak
15	Panvel	Kharghar	Sec 13 gaothan well	BW
16	Panvel	Ove	Grampanchayat well	Dugwell
17	Panvel	Taloja	Higway ,near gaothan	Dugwell
18	Panvel	Penahar	Near school	Dugwell
19	Panvel	Padghe	Mr. Bhoir well	Dugwell
20	Panvel	Pale	Mr. Patil bore well	Dugwell
21	Panvel	Valvali	Gaothan	Dugwell
22	Panvel	Sukapur	Mr.Bele bore well	Dugwell
23	Panvel	Harigram	Gaothan	Borewell
24	Panvel	Kaproli	Gaothan	Dugwell
26	Panvel	Kamothe	Higway	Dugwell
27	Panvel	Kopara	Gaothan	Borewell
28	Panvel	Moho	Grampanchayat well	Dugwell
29	Panvel	Vichumbhe	Mr. Dhundrecar bore well.	Borewell
30	Panvel	Nandgaon	Behind aaganwadi well	Dugwell
31	Panvel	Palaspe	Grampanchayat well	Dugwell
32	Panvel	Turmal	Mr. Bhagilval bore well.	Borewell
33	Panvel	Giravle	Grampanchayat well	Dugwell
34	Panvel	Kolkhe	Grampanchayat well	Borewell
35	Panvel	Karanjade	Mrs.Nagapal well	Dugwell
36	Panvel	Panvel1	Panchayatsam.	Borewell
37	Panvel	Panvel2	Grampanchayat well	Dugwell

Table – 6a : Location and type of water samples collected in study area

S.N.	Taluka	Village	Location	Source
38	Panvel	Panvel3	Near rular hospital	Talav
39	Panvel	Panvel4	Police quartar	Dugwell
40	Thane	Turbhe	Mr. Patil bore well	Borewell
41	Thane	Darave	Sec23 belapur road	Dugwell
42	Thane	Kukshet	Sec. 6 public well	Dugwell
43	Thane	Nerul	Near railway station	Dugwell
44	Thane	Karave	Sec. 38 karave village	Dugwell
45	Thane	Belapur (Amrutswal)	Ram mandir	Talav
46	Thane	Belapur	Gaothan	Dugwell
47	Thane	Belapur Shahbad	Shahabad Gaothan	Dugwell
48	Thane	Belapur Shahbad	Shahabad Gaothan near garrage	Dugwell
49	Thane	Belapur Agroli	Agroli Gaothan	Dugwell

Table – 6b : The methods adopted for physical and chemical analysis

Sr. No.	Test	Instrument
1	Temperature	Thermometer
2	P^H	P^H meter
3	Turbidity	Turbidity Meter
4	Electrical conductivity	Conductivity meter
5	Total Dissolved Solid	T.D.S. meter
6	Alkalinity	Titrimetric method
7	Hardness	Titrimetric method
8	Calcium	Titrimetric method
9	Magnesium	Titrimetric method
10	Carbonate	Titrimetric method
11	Bicarbonate	Titrimetric method
12	Chloride	Titrimetric method
13	Iron	Spectrophoto meter
14	Sulphate	Spectrophoto meter
15	Nitrate	Spectrophoto meter
16	Sodium	Flame Photometer
17	Potassium	Flame Photometer

Table – 6c : Drinking water specification as per ISO 10500 - 1991

Sr. No.	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit in the absence of alternate source
	Essential Characteristics		
1	Turbidity, NTU, Max	5	10
2	pH value	6.5 to 8.5	No relaxation
3	Total Dissolved Solid mg/l Max.	500	2000
4	Total Hardness (as $CaCO_3$) mg/l Max.	300	600
5	Iron (as Fe) mg/l, Max.	0.3	1
6	Chloride (as Cl) mg/l, Max.	250	1000
	Desirable Characteristics		
7	Calcium (as Ca) mg/l, Max.	75	200
8	Magnesium (as Mg), mg/l, Max.	30	100
9	Sulphate (as SO4) mg/l, Max.	200	400
10	Alkalinity mg/l, Max.	200	600

Table – 6d : Chemical analysis results

S.N.	Taluka	Village	Location	Source	Turb (NTU)	pH	Cond (uSi/cm)	TDS (ppm)	Na (ppm)
1	Uran	Ulva	Near marathi school	DW	0.1	7.8	456	292	25
2	Uran	Kundevahal	North of gaothan	DW	0.1	7.9	433	277	21
3	Uran	Bhangarpada	Bhangarpada to Mankher road.	DW	4.6	8.2	643	412	21.7
4	Uran	Mankher	North of gaothan	DW	0.1	8.1	308	197	6.3
5	Uran	Patnoli	Near pond ,North of village	DW	0.2	8	327	209	6.2
6	Uran	Dapoli	Near MIDC	DW	0.1	8	553	354	22.3
7	Uran	Kambadbhuje	Gaothan	DW	0.2	8.2	659	422	23.4
8	Uran	Moha	Gaothan	DW	0.1	7.9	142	91	3.5
9	Uran	Bhangarpada Utai	Ulva River)	River	0.2	9.2	3780	2419	1240
10	Uran	Kambadbhuje	Near Kambadbhuje	Creek	0.3	8.3	40700	26048	10740
11	Uran	Moha	Moha gaothan	Creek	0.1	8.3	42600	27264	10910
12	Panvel	Panvel 1	Panvel creek	Creek	0.23	8.5	36800	23552	10050
13	Panvel	Panvel 2	Panvel creek	Creek	0.2	8.4	37300	23872	10230
14	Panvel	Taloja	Taloja creek	Creek	0.3	8	21200	13568	5840
15	Panvel	Kharghar	Sec 13 gaothan well	BW	7.1	8.2	1788	1144	70.1
16	Panvel	Ove	Near GP well	DW	0.1	7.2	1340	858	69.7
17	Panvel	Taloja	Higway ,Near gaothan	DW	4.7	7.3	5050	3232	440
18	Panvel	Penahar	Near school	DW	0.2	7.4	1310	838	96.4
19	Panvel	Padghe	Mr. Bhoir's well	DW	0.2	7.4	1687	1080	200
20	Panvel	Pale	Mr. Patil 's bore well	DW	0.2	8.3	653	418	37.7
21	Panvel	Valvali	Gaothan	DW	2.8	8.3	1820	1165	205
22	Panvel	Sukapur	Mr.Bele's bore well	DW	0.1	8.3	736	471	47.8
23	Panvel	Harigram	Gaothan	Bw	0.1	8.3	977	625	38.1
24	Panvel	Kaproli	Gaothan	DW	0.2	8.3	1106	708	75.8
26	Panvel	Kamothe	Higway	DW	1.3	8.3	1717	1099	310
27	Panvel	Kopara	Gaothan	BW	0.1	8.3	435	278	41.3
28	Panvel	Moho	Grampanchayat well	DW	0.2	8.3	533	341	17.9
29	Panvel	Vichumbhe	Mr. Dhundrekar's bore well.	BW	0.2	8.3	734	470	48.9
30	Panvel	Nandgaon	Behind aaganwadi well	DW	0.1	7.2	506	324	20.8
31	Panvel	Palaspe	Grampanchayat well	DW	0.1	7.2	989	633	66.5
32	Panvel	Turmal	Mr. Bhagilval's bore well.	BW	0.1	7.4	1446	925	205
33	Panvel	Giravle	Grampanchayat well	DW	0.1	7.4	1060	678	88
34	Panvel	Kolkhe	Grampanchayat well	BW	0.1	8.3	861	551	55.2
35	Panvel	Karanjade	Mrs.Nagapal's well	DW	0.1	7.2	848	543	57.8
36	Panvel	Panvel1	Near panchayat samiti	BW	0.1	7.3	600	384	46.6
37	Panvel	Panvel2	Grampanchayat well	DW	2.4	7.7	887	568	69.9
38	Panvel	Panvel3	Near rural hospital	Pond	0.1	8.1	628	402	51.1
39	Panvel	Panvel4	Police quartar	DW	6	7.4	773	495	50.2

Table – 6d : Chemical analysis results cont…

S.N.	Taluka	Village	Location	Source	Turb (NTU)	pH	Cond (uSi/cm)	TDS (ppm)	Na (ppm)
40	Thane	Turbhe	Mr. Patil's bore well	BW	0.1	7.3	1654	1059	92
41	Thane	Darave	Sec23 Belapur road	DW	0.1	7.2	558	357	42
42	Thane	Kukshet	Sec. 6 public well	DW	0.2	7.7	1085	694	180
43	Thane	Nerul	Near railway station	DW	0.1	7.2	869	556	71.5
44	Thane	Karave	Sec. 38 Karave village	DW	0.2	7.6	757	484	68.9
45	Thane	Belapur (Amrutswal)	Near Ram mandir	Pond	0.1	7.6	801	513	85.7
46	Thane	Belapur	Gaothan	DW	0.1	7.5	783	501	77.9
47	Thane	Belapur Shahbad	Shahabad Gaothan	DW	0.2	7.3	858	549	62.3
48	Thane	Belapur Shahbad	Shahabad Gaothan near garrage	DW	0.1	8.3	723	463	57.4
49	Thane	Belapur Agroli	Agroli Gaothan	DW	0.2	7.5	462	296	28.2

Table – 6d : Chemical analysis results cont…

S.N.	Taluka	Village	Location	Source	K (ppm)	TH (ppm)	Ca TH (ppm)	Ca (ppm)	Mg (ppm)
1	Uran	Ulva	Near marathi school	DW	2.4	184	96	38	21
2	Uran	Kundevahal	North of gaothan	DW	1.5	172	100	40	17
3	Uran	Bhangarpada	Bhangarpada to Mankher road.	DW	0.4	180	136	55	11
4	Uran	Mankher	North of gaothan	DW	1.4	156	88	35	16
5	Uran	Patnoli	Near pond ,North of village	DW	3.2	160	88	35	17
6	Uran	Dapoli	Near MIDC	DW	3.3	240	196	79	11
7	Uran	Kambadbhuje	Gaothan	DW	1.9	296	172	69	30
8	Uran	Moha	Gaothan	DW	0.6	120	80	32	10
9	Uran	Bhangarpada Utai	Ulva River)	River	30	600	400	160	48
10	Uran	Kambadbhuje	Near Kambadbhuje	Creek	34	6080	1000	401	1224
11	Uran	Moha	Moha gaothan	Creek	36	6280	1000	401	1272
12	Panvel	Panvel 1	Panvel creek	Creek	29	5700	700	281	1205
13	Panvel	Panvel 2	Panvel creek	Creek	27	5500	800	321	1133
14	Panvel	Taloja	Taloja creek	Creek	15	1600	600	240	241
15	Panvel	Kharghar	Sec 13 gaothan well	BW	0.9	418	256	103	30
16	Panvel	Ove	Near GP well	DW	4	480	292	117	45
17	Panvel	Taloja	Higway ,Near gaothan	DW	35	604	320	128	68
18	Panvel	Penahar	Near school	DW	4.3	432	220	88	51
19	Panvel	Padghe	Mr. Bhoir's well	DW	5	400	280	112	29
20	Panvel	Pale	Mr. Patil 's bore well	DW	0.3	288	76	30	51
21	Panvel	Valvali	Gaothan	DW	20	440	100	40	82
22	Panvel	Sukapur	Mr.Bele's bore well	DW	0.4	400	56	22	83
23	Panvel	Harigram	Gaothan	Bw	0.5	320	188	75	32
24	Panvel	Kaproli	Gaothan	DW	3.8	400	160	64	58
26	Panvel	Kamothe	Higway	DW	10	396	160	64	57
27	Panvel	Kopara	Gaothan	BW	2.8	148	92	37	13
28	Panvel	Moho	Grampanchayat well	DW	0.7	184	92	37	22
29	Panvel	Vichumbhe	Mr. Dhundrekar's bore well.	BW	0.3	180	112	45	16
30	Panvel	Nandgaon	Behind aaganwadi well	DW	0.4	200	112	45	21
31	Panvel	Palaspe	Grampanchayat well	DW	4.2	260	192	77	16
32	Panvel	Turmal	Mr. Bhagilval's bore well.	BW	5	260	164	66	23
33	Panvel	Giravle	Grampanchayat well	DW	2.5	280	152	61	31
34	Panvel	Kolkhe	Grampanchayat well	BW	0.4	292	128	51	40
35	Panvel	Karanjade	Mrs.Nagapal's well	DW	6.2	270	152	61	27
36	Panvel	Panvel1	Near panchayat samiti	BW	1.5	212	120	48	22
37	Panvel	Panvel2	Grampanchayat well	DW	2.9	268	184	74	20
38	Panvel	Panvel3	Near rural hospital	Pond	3.1	172	136	55	9
39	Panvel	Panvel4	Police quartar	DW	0.6	256	176	71	19

Table – 6d : Chemical analysis results cont…

S.N.	Taluka	Village	Location	Source	CO3 (ppm)	Hco3 (ppm)	Cl (ppm)	SO4 (ppm)	No3 –N (ppm)	No3 (ppm)	Fe (ppm)
1	Uran	Ulva	Near marathi school	DW	0	192	41	4.2	1.95	8.6	0.04
2	Uran	Kundevahal	North of gaothan	DW	0	196	39	2.1	1.02	4.5	0.02
3	Uran	Bhangarpada	Bhangarpada to Mankher road.	DW	0	260	35	0.35	0.02	1	0.07
4	Uran	Mankher	North of gaothan	DW	0	160	12	2.8	0.15	0.7	0.34
5	Uran	Patnoli	Near pond ,North of village	DW	0	168	12	0.35	0.13	0.6	0.23
6	Uran	Dapoli	Near MIDC	DW	0	240	41	1.75	0.38	1.7	0.07
7	Uran	Kambadbhuje	Gaothan	DW	0	288	39	0.35	1.66	7.4	0.02
8	Uran	Moha	Gaothan	DW	0	128	6	0.35	0.07	1	0.04
9	Uran	Bhangarpada Utai	Ulva River)	River	176	24	1960	73.5	0.65	2.9	0.01
10	Uran	Kambadbhuje	Near Kambadbhuje	Creek	200	40	15170	3150	2.55	11.3	0.01
11	Uran	Moha	Moha gaothan	Creek	240	60	15621	3448	2.08	9.2	0.01
12	Panvel	Panvel 1	Panvel creek	Creek	176	24	14700	2646	1.79	7.9	0.01
13	Panvel	Panvel 2	Panvel creek	Creek	144	56	14347	3150	1.82	8.1	0.01
14	Panvel	Taloja	Taloja creek	Creek	0	800	7644	637	1.64	7.3	0.02
15	Panvel	Kharghar	Sec 13 gaothan well	BW	0	240	133	216	2.35	10.4	0.04
16	Panvel	Ove	Near GP well	DW	0	292	118	87.2	5.75	25.5	0.02
17	Panvel	Taloja	Higway ,Near gaothan	DW	0	316	588	204	3.28	14.5	0.03
18	Panvel	Penahar	Near school	DW	0	324	135	221	8.85	39.2	0.08
19	Panvel	Padghe	Mr. Bhoir's well	DW	0	288	269	74.2	2.11	9.3	0.05
20	Panvel	Pale	Mr. Patil 's bore well	DW	64	180	59	53.4	0.02	1	0.02
21	Panvel	Valvali	Gaothan	DW	80	320	294	94.5	10.11	44.8	0.02
22	Panvel	Sukapur	Mr.Bele's bore well	DW	192	8	69	8.05	2.52	11.2	0.02
23	Panvel	Harigram	Gaothan	Bw	40	200	59	15.1	9.83	43.5	0.01
24	Panvel	Kaproli	Gaothan	DW	192	136	102	7.7	0.27	1.2	0.01
26	Panvel	Kamothe	Higway	DW	88	268	392	63	0.79	3.5	0.02
27	Panvel	Kopara	Gaothan	BW	88	32	63	66.4	1.54	6.8	0.09
28	Panvel	Moho	Grampanchayat well	DW	32	140	35	27.4	0.01	1	0.08
29	Panvel	Vichumbhe	Mr. Dhundrekar's bore well.	BW	56	120	78	14.7	0.85	3.8	0.05
30	Panvel	Nandgaon	Behind aaganwadi well	DW	0	172	39	10.5	0.01	1	0.2
31	Panvel	Palaspe	Grampanchayat well	DW	0	240	94	14.4	0.02	1	0.04
32	Panvel	Turmal	Mr. Bhagilval's bore well.	BW	0	248	274	30.8	0.12	1	0.38
33	Panvel	Giravle	Grampanchayat well	DW	0	236	118	43.4	0.73	3.2	0.01
34	Panvel	Kolkhe	Grampanchayat well	BW	40	200	78	24.2	9.09	40.3	0.01
35	Panvel	Karanjade	Mrs.Nagapal's well	DW	0	220	78	20.3	9.44	41.8	0.01
36	Panvel	Panvel1	Near panchayat samiti	BW	0	232	59	7.7	0.23	1	0.01
37	Panvel	Panvel2	Grampanchayat well	DW	0	296	88	3.5	0.43	1.9	0.01
38	Panvel	Panvel3	Near rural hospital	Pond	0	220	67	2.45	0.66	2.9	0.01
39	Panvel	Panvel4	Police quartar	DW	0	284	78	4.2	0.39	1.7	0.01

Table – 6d : Chemical analysis results cont…

S.N.	Taluka	Village	Location	Source	CO3 (ppm)	Hco3 (ppm)	Cl (ppm)	SO4 (ppm)	No3 –N (ppm)	No3 (ppm)	Fe (ppm)
40	Thane	Turbhe	Mr. Patil's bore well	BW	0	340	161	1.05	0.73	3.2	0.01
41	Thane	Darave	Sec23 Belapur road	DW	0	196	55	2.1	5.37	23.8	0.01
42	Thane	Kukshet	Sec. 6 public well	DW	0	420	231	7	0.63	2.8	0.01
43	Thane	Nerul	Near railway station	DW	0	308	94	3.15	3.19	14.1	0.01
44	Thane	Karave	Sec. 38 Karave village	DW	0	220	94	193	0.85	3.8	0.01
45	Thane	Belapur (Amrutswal)	Near Ram mandir	Pond	0	288	120	7.7	0.54	2.4	0.01
46	Thane	Belapur	Gaothan	DW	0	328	102	12.3	5.42	24	0.28
47	Thane	Belapur Shahbad	Shahabad Gaothan	DW	0	328	88	5.25	2.88	12.8	0.01
48	Thane	Belapur Shahbad	Shahabad Gaothan near garrage	DW	64	236	80	11.6	2.33	10.3	0.01
49	Thane	Belapur Agroli	Agroli Gaothan	DW	0	180	55	4.9	0.21	1	0.01

GSDA -

In pursuit of excellence in sustainable groundwater management

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