

Gujarat Maritime Board

Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard



Final Master Plan Report

February 2026

Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

Final Master Plan Report

prepared for Gujarat Maritime Board

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SYMBOLS AND ABBREVIATIONS

Symbols and abbreviations used are generally in accordance with the following list.

1

Proper names and organisations

AADA	Alang Area Development Authority
BMT India	BMT Consultants (India) Private Limited
CPWD	Central Public Works Department
GIDC	Gujarat Industrial Development Corporation
GETCO	Gujarat Energy Transmission Corporation Limited
GEPIL	Gujarat Environment Protection Infrastructure Ltd
GMB	Gujarat Maritime Board
PGVCL	Paschim Gujarat Vij Company Limited
IMO	International Maritime Organisation
IRCS	Indian Red Cross Society
MoEFCC	Ministry of Environment, Forest and Climate Change
SRIA	Ship Recycling Industrial Association
ILO	International Labour Organization
ISO	International Organization for Standardization

2

Other abbreviations

BM	Dense Bituminous Macadam
CD	Chart Datum
CRZ	Coastal Regulation Zone
DP	Development Plan
DPR	Detailed Project Report
EIA	Environmental Impact Assessment
EU	European Union
EU SRR	European Union Ship Recycling Regulation
ETP	Effluent Treatment Plant
GCL	Geosynthetic clay liner

HDPE	High Density Polyethylene
HT/LT	High Tension / Low Tension
HKC	Hong Kong Convention
HTL	High Tide Line
IHM	Inventory of Hazardous Materials
LAAR	Land Acquisition, Rehabilitation and Resettlement
LA	Land Acquisition
LPG.....	Liquefied Petroleum Gas
M.....	Million
MEP	Mechanical, Electrical & Plumbing
MSL	Mean Sea Level
MRI	Magnetic Resonance Imaging
NPV	Net Present Value
NRSC.....	National Remote Sensing Centre
OPD	Outpatient department
PPE.....	Personal Protective Equipment
PPP.....	Public Private Partnership
PVC	Polyvinyl Chloride
RFID	Radio Frequency Identification
SCADA	Supervisory Control and Data Acquisition
SOPs	Standard Operating Procedures
SPT	Standard Penetration Test
SoR.....	Schedule of Rates
SRP	Ship Recycling Plan
STP	Sewerage Treatment Plant
TMT	Thermo-Mechanically Treated
TSDF	Treatment, Storage and Disposal facility
URDPFI	Urban and Regional Development Plan Formulation and Implementation
ULCC	Ultra Large Crude Carriers

3

WPR Work Participation Rate

XLPE..... Cross-Linked Polyethylene

Units of measurement**Length, area and volume**

mm millimetre(s)

m metre(s)

km kilometre(s)

mm²..... square millimetre(s)m²..... square metre(s)km²..... square kilometre(s)

ha hectare(s)

m³..... cubic metre(s)**Time and time derived units**

s second(s)

min minute(s)

hr..... hour(s)

Mass, force and derived units

kg kilogram(s)

g gram = kg x 10⁻³t tonne = kg x 10³

Mt..... Million Tonnes

Mtpa Million Tonnes per annum

TPD..... Ton Per Day

DWT..... Dead Weight Tonne, the total mass of cargo, stores, fuels, crew and reserves with which a vessel is laden when submerged to the summer loading line. (Although this represents the load carrying capacity of the vessel it is not an exact measure of the cargo load).

LDT Light Displacement Tonnage, Light Displacement Tonnage (LDT) is the weight of the ship including permanent equipment but not cargo.

Executive Summary

The Alang-Sosiya Ship Recycling Yard, located on the Gulf of Khambhat in Bhavnagar district, Gujarat, is globally recognised as the largest ship recycling hub. Spread over 10 km with 150 demarcated recycling plots (of which 128 are active), the yard has dismantled more than 8,600 ships, yielding nearly 69 million LDT of recycled steel to date. With its natural topography gentle seaward slopes and significant tidal range, Alang-Sosiya Ship Recycling Yard remains ideally suited for beaching-based dismantling, a method foundational to its growth. However, to maintain global relevance and comply with modern environmental, safety, and labour regulations, the yard is undergoing a strategic transformation.

For upgradation and expansion of ship recycling yard, a master plan for the existing yard facility and further expansion of additional 10 km towards south has been undertaken to increase the total capacity to match future market.



Existing yard area is under Alang Area Development Authority, and a development plan (DP) is in place for the development of the existing facility. And the proposed master plan has been prepared integrating the development plan including the expansion of yard.

Baseline assessment and current conditions

The master plan exercise began with a comprehensive baseline assessment of the yard's existing conditions to determine the infrastructural and regulatory gaps. This included:

- **Connectivity:** While connected to NH-51 via Trapaj through SH-37, internal roads and last-mile access remain underdeveloped.
- **Land use & spatial growth:** Significant industrial densification has occurred since 2010, especially around Manar and Sosiya. Villages such as Bharapara and Mathavada remain underdeveloped but are potential nodes for future growth.
- **Environmental constraints:** The area is heavily regulated under CRZ norms, with parts under CRZ-IA and forest land. These areas demand statutory clearances and re-zoning for development.
- **Social & demographic profile:** A dominant male migrant labour force characterises the region, coupled with limited and under-utilised labour housing and healthcare services.
- **Physical infrastructure:** The yard is supported by a TSDF, health facilities, and limited public services—necessitating augmentation for scale and compliance.
 - **Roads:** A single north–south spine road connects all the existing ship recycling plots to SH-37 and serves as the primary access road for the yard. Currently, there is no road connectivity to the proposed stretch.
 - **Stormwater and sewerage network:** A stormwater drain has been developed along the north–south spine road to prevent ingress of stormwater into the plots within the existing stretch. No sewerage network exists at Alang
 - **Water supply:** GWSSP supplies water to various water tanks at Alang through its source at Trapaj, for which Gujarat Maritime Board (GMB) pays the applicable tariff on a monthly basis. GMB, in turn, supplies water to all ship recycling plots and other facilities within the yard.
 - **Electricity:** Electricity is supplied to the Alang ship recycling yard from the Manar 66 kV substation by Paschim Gujarat Vij Company Limited (PGVCL) through an overhead cable network, catering to all plots and associated facilities.
 - **Solid waste management:** A dedicated Treatment, Storage, and Disposal Facility (TSDF) with Secured landfill, Incinerator and Effluent Treatment Plant (ETP) operated and maintained by Gujarat Environment Protection Infrastructure Ltd (GEPIL) on behalf of GMB facilitates handling of all the solid waste generated across the yard facility including handling of hazardous waste.
- **Social infrastructure:** Key social infrastructure at Alang supporting the ship recycling yard includes a worker training institute, a multi-specialty hospital, and a labour housing colony, in addition to primary schools and PHC's in and around Alang.

In conclusion, the existing conditions at Alang reflect a mature yet evolving industrial ecosystem, with clear needs for modernization, environmental compliance, and infrastructure expansion to support its growth into a globally competitive ship recycling hub.

Policy framework and regulatory alignment

A comprehensive policy review was undertaken to assess the implications of the Ship Recycling Act, 2019, which brings Indian regulations in line with the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships

(HKC). In parallel, the EU Ship Recycling Regulation (EU SRR) was studied for its more stringent environmental and labour compliance requirements.

The planning team conducted:

- Comparative benchmarking of Indian and international regulations, identifying overlaps and divergences.
- Technical consultations with domain experts and regulatory authorities to evaluate on-ground implications of compliance.
- Gap assessments to determine infrastructure upgrades needed at the yard level—particularly in hazardous waste management, worker safety, and environmental protection.

The master plan adopts a regulation-first strategy, embedding compliance requirements into the very structure of zoning and infrastructure planning. This includes:

- Designation of dedicated waste management and hazardous material handling zones.
- Provision of impermeable surfaces, containment structures, and oil-water separation systems to meet pollution control norms.
- Allocation of land for worker housing, training facilities, and medical infrastructure to comply with safety and welfare mandates.
- Incorporation of monitoring and emergency response systems to align with EU SRR protocols.

Plot optimization and capacity modelling

The objective of this assessment was to enhance the capacity of Alang-Sosiya Ship Recycling Yard to over 11 million LDT/year and above by 2040, while maintaining uninterrupted ongoing operations and ensuring regulatory compliance.

To meet the Gujarat Maritime Board's vision of doubling the yard's capacity, a data-driven strategy was adopted. This included a nine-year historical productivity analysis, benchmarking of high-performing plots, and scenario-based modelling under Business-as-Usual (BAU), Moderate, and Accelerated growth pathways. The plan also integrates infrastructure needs to comply with global standards such as the Hong Kong Convention (HKC), EU Ship Recycling Regulation (EU SRR), and Basel Guidelines.

Key steps included:

- Evaluation of existing plot performance and identification of inefficiencies
- Simulation of alternative layouts through “what-if” models to define ideal plot dimensions and configurations
- Formulation of a phased optimization and expansion roadmap, including a southward extension towards Mathwada

Key findings of the assessment were:

- Larger plots (215–300 m) were found to be more productive, consistent, and suitable for international compliance

- A Controlled Landing Method is proposed as a practical, regulation-compliant upgrade over traditional beaching
- Phase-wise transition is designed to add capacity while minimizing disruptions, with plot reconfigurations and selective consolidation of underperforming units
- Productivity analysis revealed:
 - **Estimated mean productivity** of the yard stands at **5.74 LDT/m²/year**, based on GMB's projected capacity of 4.5 million LDT/year.
 - **Higher actual potential** observed: mean and median of maximum productivity reach **6.786 and 5.78 LDT/m²/year**, respectively.
 - Over **50% of plots** in most width categories outperformed the projected yard average.
 - **Well-performing plots** (except 80–100 m category) show strong potential even during a market downturn.
 - **Smaller plots** (30–80 m) yield higher productivity per unit area but show greater variability.
 - **Larger plots** (100+ m) offer consistent performance and are suited for large vessels and regulatory upgrades.
 - Evidence of **diminishing returns** in very large plots underscores the need for optimal sizing and layout efficiency.
 - Findings support the case for **plot reconfiguration** and **controlled expansion** to improve capacity and compliance.

The recommended layout reconfiguration, backed by empirical evidence, is designed to meet GMB's capacity targets while allowing for flexible adaptation to market dynamics. The optimized strategy ensures a balanced use of land and labour, improved compliance, and readiness for next-generation shipbreaking operations.

Strategic vision and capacity expansion roadmap (2025–2040)

To position Alang–Soshiya as a globally competitive, regulation-compliant, and high-capacity ship recycling hub, a clear roadmap has been outlined for the period 2025 to 2040. This vision is anchored in data-driven projections, infrastructure optimisation, and regulatory alignment.

Strategic priorities

- Reallocate land use and upgrade infrastructure to unlock latent capacity.
- Reconfigure plot layouts and site logistics to align with Hong Kong Convention (HKC), EU Ship Recycling Regulation (EU SRR), and Basel Convention guidelines.
- Embrace technology-driven upgrades to enhance productivity, safety, and sustainability.

Projected growth metrics

Metric	Current state	Target by 2040
Annual capacity	approx.4.5M LDT/year	approx.11.3M LDT/year

Metric	Current state	Target by 2040
Worker productivity	0.66 to 1.71 LDT/worker/day	1.0 to 2.0 LDT/worker/day
Unit area productivity	4.5 to 9.6 LDT/m ² /year	6.0 to 11.0 LDT/m ² /year
Daily max output	approx.600 LDT/day	1,200 to 1,500 LDT/day

Key actionable recommendations

- Extend plots up to 215 m in length to enhance throughput and reduce congestion.
- Introduce parallel dismantling lines and optimise material flow with designated entry/exit points.
- Upgrade crane capacities and integrate automated cutting technologies for faster turnaround.
- Implement digital workflow management, including RFID tracking and performance analytics.
- Expand workforce productivity through training, safety, and partial automation.
- Improve waste disposal logistics and incorporate stormwater and oil separation systems within plots.

Preconditions for capacity realisation

Achieving a 2.5 x and above increase in capacity will require a convergence of supportive conditions:

- **Market support:** High global demand for scrap steel and consistent vessel availability.
- **Policy incentives:** Low import duties, financial support, and regulatory handholding by Government of India (GoI) and GMB.
- **Operational reforms:** Mechanisation, worker safety, and skilled labour development.
- **Global compliance:** Full alignment with HKC and EU SRR requirements.
- **Competitive edge:** Ability to outbid regional rivals (Pakistan, Bangladesh, Turkey) in ship acquisition.

Why larger plots are the future

Consolidating into larger ship recycling plots (240 m × 215 m or 300 m × 215 m) offers the following benefits:

- Better regulatory compliance with dedicated zones for hazardous waste, PPE, and crew safety.
- Efficient layout enables multiple vessel operations, better equipment mobility, and advanced process flows.
- Improved worker safety due to reduced congestion and better traffic separation.
- Future-ready design accommodates robotic dismantling, larger vessels, and sustainable waste segregation systems.

- Larger plots can integrate welfare infrastructure including dormitories, training blocks, and emergency response facilities.

Recommended ship recycling method and compliance strategy

To support the future expansion and regulatory compliance of the Alang–Soshiya Ship Recycling Yard, a comprehensive assessment of global ship dismantling methods was undertaken. The aim was to identify a viable, cost-effective, and regulation-aligned solution suited to Alang’s geographical, operational, and financial realities.

Comparative assessment of ship recycling methods

Method	Pros	Cons	Conclusion
Drydock	• high environmental compliance • containment of hazardous materials • suitable for large ships • meets HKC & EU standards.	• Extremely high capital & operational costs • engineering challenges due to tidal variations, strong currents and dredging needs.	• Negative viability due to technical, financial & geographical constraints.
Slipway	• Moderate environmental compliance. • lower cost than drydock, suitable for small to medium-sized vessels.	• Limited capacity for large vessels, affected by tides, additional costs for EU compliance.	• Less feasible for large size and scale dismantling needs.
Pier-Breaking	• Better environmental control • safer working conditions, improved material handling.	• High infrastructure costs, limited capacity for large vessels. • incompatible with Alang’s sloping beach.	• Not suitable for Alang’s landscape.
Airbag Method	• Low capital investment, flexible ship movement • better control than traditional beaching.	• Limited for very large vessels • risk of instability • moderate pollution containment challenges.	• Technically viable for smaller and medium ships but requires additional infrastructure.
Beaching Method (Traditional)	• Cost-effective • high throughput • well-suited to Alang’s geography.	• Poor containment of hazardous material • major environmental concerns • non-compliant with EU SRR.	• Existing method but needs environmental improvements for EU compliance.
Controlled Landing Method (Proposed Solution)	• Cost-effective • high throughput • adaptable for EU SRR compliance with modifications • builds on existing capabilities.	• Requires carefully engineered impermeable flooring, proper drainage, stricter pollution control.	• Most practical & economically viable for Alang’s future shipbreaking.

Controlled landing method for proposed plots

The Controlled Landing Method is proposed as the most feasible and future-ready dismantling approach. It draws from best practices at compliant yards (e.g., Aliaga, Turkey) and builds on Alang's operational strengths.

Key elements include:

- **Engineered sloped platforms:** Impermeable concrete flooring beyond high tide line
- **Enhanced drainage:** Oil-water separators, sediment traps, real-time pollutant sensors
- **Safe landing mechanisms:** Airbags, winches, reinforced slopes
- **Worker safety protocols:** PPE usage, emergency drills, medical response
- **Environmental containment:** Surface runoff collection and treatment
- **Recommended pilot project:** To validate design, performance, and EU compliance in Indian conditions

Regulatory alignment and infrastructure requirements

Regulation	Operational requirements	Infrastructure requirements/Upgrades
Hong Kong Convention (HKC) Compliance	SRFP, IHM management, hazardous waste handling, worker safety	ETPs, impermeable floors, storage with secondary containment, emergency zones
EU Ship Recycling Regulation (EU SRR) Compliance	Pollution monitoring, emissions control, fire safety, dismantling protocols	Cutting zones with containment, on-site pollution monitoring and safety infra
Indian Ship Recycling Act, 2019 (Mirroring HKC Standards)	Mirrors HKC; national legal backing for compliance	Infrastructure upgrades in line with HKC, safety and waste management

Strategic recommendations for ship recycling plots

- Adopt **Basel Convention zoning** (Zones A-F) for operational clarity and compliance segmentation
- Integrate **EU SRR environmental protocols** within plot layouts
- Align plot designs with **HKC-mandated safety and emergency standards**
- Allow for layout flexibility to accommodate plot-specific operational models
- Develop **demonstration plots** under a government-backed pilot to showcase compliance and attract international tonnage

The Controlled Landing Method offers the most pragmatic and cost-effective transition path for Alang's recycling yards, balancing global compliance, operational continuity, and local adaptability.

Integrated spatial development strategy for Alang

The proposed master plan for the Alang-Sosiya Ship Recycling Yard, outlines a phased and regulation-aligned spatial framework aimed at guiding sustainable industrial expansion, residential growth, and ecological preservation.

Zoning framework and land use integration

The master plan classifies land into clearly demarcated zones in line with the Alang Area Development Authority (AADA) Development Plan (DP), balancing industrial functionality with environmental and community needs. Key land-use categories include:

- Industrial zones (Industrial - A) dedicated to ship recycling and supporting activities.
- Additional space behind the existing road (Industrial - A) for tertiary, storage activities and other facilities for ship recycling plots
- Public housing and amenity reservations (Mixed industrial use (IZ7)), including land for public housing, utilities, open spaces, gardens are embedded within the master plan to ensure long-term service delivery and liveability.
- Recreational and agricultural zones, strategically preserved to maintain ecological continuity and green cover.

Road network planning and mobility strategy

A robust and context-sensitive road hierarchy is a key component of the plan. It integrates:

- Segregated roads for ship recycling traffic and secondary market access road for safety and efficiency.
- Alignment with existing DP road corridors.
- East-west connectivity to streamline access and internal circulation.
- Respect for natural terrain and water bodies, with bridges and drainage integrated into the alignment strategy.

Sustainability and zoning rationale

The zoning approach applies nuisance-based principles to mitigate land-use conflicts while encouraging vibrant mixed-use development. Key planning considerations include:

- Buffer zones and green corridors for CRZ and environmentally sensitive areas.
- Designated industrial expansion areas for future ship-recycling infrastructure.
- Reserved land parcels for future civic infrastructure such as housing, health centres, and public parks.

Conclusion

The master plan adopts a holistic and flexible development approach, accommodating current industrial operations while planning for long-term capacity enhancement and compliance. It balances regulatory mandates (such as CRZ and DP alignment),

infrastructure efficiency, and social inclusivity. This integrated spatial strategy positions Alang for resilient, sustainable growth over the next two decades.

Phased infrastructure and capacity expansion strategy (2025–2040)

The proposed development strategy for the Alang-Soshiya Ship Recycling Yard adopts a phased approach aligned with projected market growth, regulatory conditions, and population dynamics. This framework supports GMB's long-term vision of doubling yard capacity while simultaneously scaling infrastructure and services in a balanced and sustainable manner.

Phase-wise capacity expansion

To accommodate anticipated increases in shipbreaking throughput and maintain operational flexibility, the expansion is structured into three implementation phases. Enhancement of existing stretch will be taken up by GMB simultaneously as required.:

Phase	Timeline	Added capacity (M LDT/year)	Key actions
Current phase	2025-2039	Existing 4.5 MLDT	Ensuring all the plots in the existing stretch meet HKC Compliance and encourage EU SRR audit readiness & promote environmental and safety standard upgrades Upgradation of Physical and social infrastructure as and when required Encourage plot management to adopt various technological upgradation for efficient and safe recycling
Phase 1	2025 - 2027	4.5 MLDT	Expansion southwards towards Mathwada, developing 9 new proposed plots in the remaining CRZ II stretch in mathwada including associated backend infrastructure.
Phase 2	2028 to 2038	2.3 MLDT	Further expansion southwards after CRZ and forest clearance, adding 6 new plots of 240 m-300 m width as per the ship recycling market requirement.
Phase 3	2039 +	8.7 MLDT	Further expansion with additional plots as required after assessing the latest global ship recycling trends and potential market

This phased approach provides the flexibility to align investments with actual market conditions, while de-risking regulatory dependencies and ensuring uninterrupted operations.

Land acquisition

The proposals to expand the capacity of Alang-Soshiya Ship Recycling Yard required land acquisition for develop ship recycling plots and backend infrastructure. It is proposed to acquire entire area within the expansion of master plan to develop the facilities. Acquiring the land allows the authority to lease it to interested investors to develop proposed facility in coordination with the authority. Across the three phases, a total of 639.59 Ha land both private and government land including forest land is to be acquired to develop required facilities.

The current agricultural Jantri rate has been considered for the land acquisition cost of government land. For private land, four times the Jantri rate, as per the provisions of the

LARR Act, along with 100% solatium, has been considered in estimating the land acquisition cost.

Land ownership distribution and acquisition cost table

Phase	Type of land	Total area (Ha)	Acquisition cost in (Cr.)	Total acquisition cost (Cr.)
Phase 1	Government land	3.00	₹ 0.84	₹ 49.08
	Private land	138.0	₹ 48.94	
Phase 2	Government land	44.8	₹ 2.69	₹ 32.43
	Private land	123.63	₹ 29.74	
Phase 3	Government land	126.1	₹ 7.79	₹ 32.09
	Private land	100.5	₹ 24.3	
	Total area (Ha)	536.61	Total LA Cost (Cr.)	₹ 113.6

For the purpose of estimating land distribution and tentative land acquisition costs, all land parcels falling in between the master plan boundary have been treated as private land, in case they include a mix of government and private ownership and spatially cannot identify the mix. This assumption has been adopted for preliminary costing, and the actual ownership distribution may vary upon detailed verification.

Forest land conversion

Reserve forest area falls within the expansion stretch of the proposed master plan. And as per Forest Conservation Act, 1980, de-notification of the reserve forest area requires GMB to provide compensatory afforestation land and Compensatory Afforestation (CA). The same has been considered in the cost estimates for forest land conversion.

As per the revised Net Present Value (NPV) for Eco Class-I, a rate of ₹16 lakh per hectare has been considered. Additionally, a cost of ₹50 lakh per hectare has been adopted for compensatory afforestation land and ₹12 lakh per hectare for compensatory afforestation activities to arrive at the tentative total cost of forest conversion.

Forest area distribution and cost table

Phase	Type of land	Total area (Ha)	Forest conversion cost (in Cr)	Total cost (in Cr)
Phase 2	Reserve forest	20.45	₹ 15.95	₹ 80.66
Phase 3	Reserve forest	82.96	₹ 64.71	

Infrastructure development

The infrastructure roadmap aligns with population and industrial growth through 2040, targeting a serviced community of 59,741 people including existing and expansion of shipyard. Development is broken into physical and social infrastructure categories, scaled in tandem with each phase. Key elements within the expansion of the facility include:

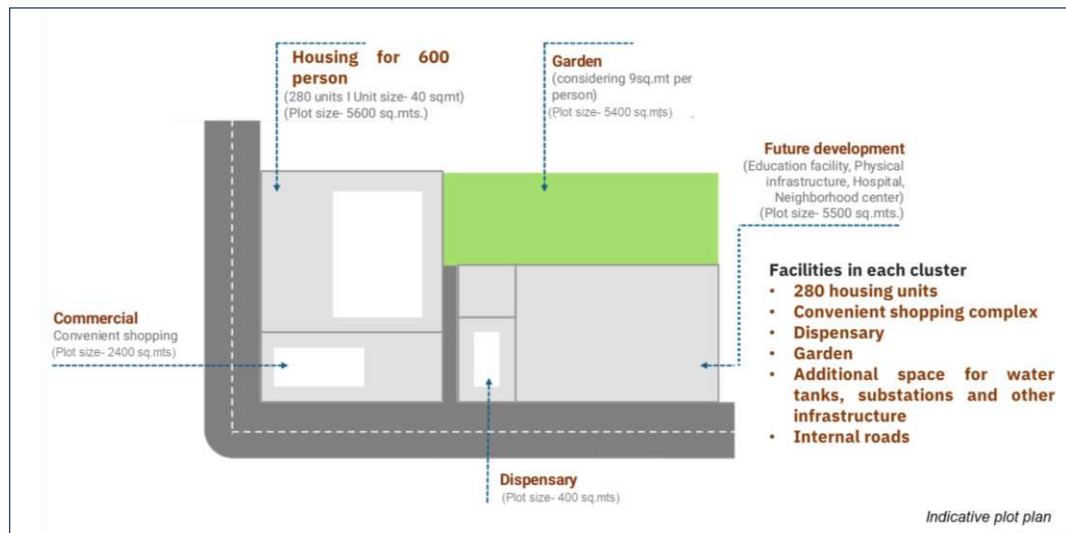
- **Road network** – A total of 22.71 km of road stretch in the expansion side across three phases

- **Power infrastructure** – 4 no of CSS with a capacity's of 2000 kVA & Utility duct to carry electricity cables and scope for other fibre cables in future.
- **Water storage reservoirs** - Designed for 15 M Liters capacity demand including 10% surplus capacity for 2-day water requirement. Includes ESRs, GSRs, and pump stations
- **Sewerage system** – 6 MLD STP and decentralised pumping stations.
- **Industrial waste management (TSDF)**
 - Central ETP to handle contaminated water using advanced treatment.
 - Secured landfill and phased incineration capacity.
 - Contaminated oily water transfer through pipe network and treatment at CETP
- **Gas supply**
 - Gas supply network to the proposed ship recycling plots
- **Housing clusters provisioning**

All the housing requirement for the workers are expected to be met by the housing developed by ship recycling plot management within their back-up yard provided. Across the master plan few parcels of land have been identified for cluster development where housing for limited workers can be developed by GMB.

The following clusters shall have additional space for future development, any physical infrastructure to be developed such as water storage tanks, compact substations, STP's etc.

GMB housing & amenities cluster



Housing & amenities cluster proposal

Facility	Phase 1	Phase 2	Phase 3
Housing & amenities cluster	2	1	3

Apart from the above proposals, additional recommendations for enhancement of existing facility have been provided which the authority can develop parallel to the phases proposed as required.

- **Other social infrastructure**

Facilities such as 50 bedded multi-speciality hospital and upgradation of training institute is proposed to enhance the health infrastructure and productivity of workforce in Alang.

Cost estimates

The cost estimates for the proposed expansion of master plan at Alang have been comprehensively assessed across core and support infrastructure over a 15-year phasing horizon (2025–2040). These estimates serve as a budgeting tool and reflect concept-stage engineering designs, subject to a $\pm 30\%$ variation. The figures have been structured around major infrastructure heads, implementation phases, and stakeholder responsibilities. This cost does not include cost of projects within enhancement of existing facility.

Key Highlights:

- **Total development cost:** ~ ₹ 1,223.55 Cr (inclusive of all core infrastructure, across all the phases for GMB).
- **Land acquisition cost** (including forest conversion): ~ ₹ 194.25 Cr (across all the phases for GMB).
- **Costing methodology:**
 - Government land has been calculated based on agricultural jantri rates and private land at four times the jantri rate
 - Based on 2024 base year prices and GMB/CPWD/NH SoRs.
 - Designed as block-level estimates using conceptual layouts, unit rate derivations, and URDPFI norms.
 - Includes flat escalation (12%), and physical contingencies (5%).

Stakeholder-wise cost responsibility allocation

The total project cost has been allocated among two principal stakeholder groups, based on their respective roles and responsibilities in the development and operations:

- **Ship recycling plot owners**
 - Responsible for the development of individual ship recycling plots, including construction of internal pavements, operational buildings, utility installations, and internal services. These costs will be borne directly by the plot allottees.
 - Individual plot owners are responsible to develop the backup yard as per their requirements including land development which include cutting/ filling as per the site.
- **Gujarat Maritime Board (GMB)** - GMB will be the principal agency for delivering common infrastructure required for the yard's functioning. This includes two broad components:
 - **Basic Infrastructure:** Development of the core yard and physical infrastructure including earthwork and land levelling for recycling plots,

development of the road network (internal and regional), and provisioning of trunk services such as water supply, sewerage, stormwater drainage, and electrical distribution.

- **Public housing & amenities cluster:** GMB will develop multiple housing clusters which include housing, shopping centre and parks, catering around 10 % of total expected workers coming to Alang spread across the ship recycling yard.

Cost categories and estimates for GMB

- Road infrastructure ~INR 243.12 Cr
- Physical infrastructure ~INR 385.55 Cr
- Multi-speciality hospital & upgradation of training institute ~ INR 19.60 Cr
- GMB housing and utility cluster ~ INR 198.88 Cr
- Land development for ship recycling plots ~ INR 260.16 Cr
- Land development for secondary scrap market ~ INR 79.74 Cr
- Soft dredging on the shore ~ INR 36.50 Cr

Phase-wise cost summary – GMB

Table: Phase wise acquisition cost

	Description	Phase 1	Phase 02	Phase 03
1	Land requirement (in Ha)	141.01	188.73	309.46
2	Land acquisition cost (In cr.)	₹ 49.08	₹ 32.43	₹ 32.09
	Forest conversation cost (in cr.)	-	₹ 15.95	₹ 64.70
	Total cost (in cr.)	194.25		

Total cost of acquisition of both private and government land requires **₹ 194.25 Cr.** across all three phases.

Table: Phase wise infrastructure development cost

	Description	Phase 1	Phase 02	Phase 03
1	Roads	₹ 116.40	₹ 33.13	₹ 93.58
2	Physical infrastructure	₹ 136.79	₹ 76.21	₹ 172.55
3	Multi-speciality hospital & upgradation of training institute		₹ 19.60	
4	GMB housing & amenities cluster	₹ 63.25	₹ 30.51	₹ 105.12
5	Land development for ship recycling plots	₹ 78.69	₹ 49.75	₹ 131.73
6	Land development for secondary scrap market	₹ 40.12	₹ 39.62	-
7	Soft dredging	₹ 12.36	₹ 24.14	-
	Total cost (in crores)	₹ 447.61	₹ 272.96	₹ 502.98

Basic infrastructure (roads, and utilities) requires **₹ 1,223.55 Cr** across three phases.

Table: Total project cost

	Description	Phase 1	Phase 02	Phase 03
1	Total Infrastructure cost (In cr.)	₹ 447.61	₹ 272.96	₹ 502.98
2	Total acquisition & forest conversation cost (In cr.)	₹ 49.08	₹ 48.38	₹ 96.79
	Total cost (in crores)	₹ 1417.80		

The total project cost comes is around **₹ 1418 Cr.**

Exclusions / Caveats to the cost estimates

Cost estimates provided are exclusive of the following:

- GST and other statutory taxes
- CRZ de-notification has not been considered in the estimate.
- Costs for statutory clearances
- Supply and installation of heavy mechanical/electrical equipment unless explicitly mentioned
- O&M costs and future recurring charges

Following caveats and limitations are applicable:

- Estimates are based on concept-stage layouts; no BOQs or GFC drawings are available
- Accuracy limited to $\pm 30\%$ due to early-stage assumptions, with future refinement expected at DPR stage
- Escalation has only been included up to 2025 (12%); no provision beyond this timeframe

- Not suitable for tendering or contractual commitments without DPR validation
- Assumptions for soft costs include provision for DPR, EIA/EIZ, PMC, and further technical investigations have been considered.

This structured cost framework provides financial clarity to support phased implementation, prioritised infrastructure delivery, and targeted investment planning. It will be revisited at the DPR stage with detailed design inputs, site-specific geotechnical data, and BOQ-based rate analysis.

Conclusion

The proposed master plan envisages a phased enhancement of the ship recycling yard's capacity in line with projected demand, while promoting sustainable and environmentally safe recycling practices. The plan aims to strengthen Alang's position as the **world's largest and most sustainable ship recycling hub** through strategic planning and infrastructure integration.

Key outcomes of the proposed masterplan,

- EU SRR-compliant ship recycling plots to attract higher-value international recycling markets and improve global competitiveness.
- wider and larger plot configurations enabling multiple working bays and accommodating larger vessels.
- Operational efficiency improvements targeting around 1.5 times productivity enhancement through optimized layouts and higher-capacity equipment.
- Doubling the capacity from the existing 4.5 million LDT to 9.0 million LDT by 2027.
- Further expansion planned to achieve 11.3 million LDT recycling capacity by 2038, with provision for additional future growth based on market demand.
- Development of worker-centric backend infrastructure, including distributed housing and utility clusters integrated across the facility.
- Upgradation of the training institute to support workforce upskilling and adoption of international best practices in ship recycling operations.

The proposed ship recycling plots are meticulously designed to address key bottlenecks experienced in the existing yards, particularly in terms of capacity augmentation, operational efficiency, and seamless integration with supporting infrastructure. From the perspective of competent authorities, the master plan facilitates improved compliance, streamlined operations, and adoption of green recycling practices.

Further, the master plan emphasizes enhancement of worker productivity and welfare through upgradation of the existing training institute, development of housing and amenities clusters, and a focused approach towards improving workers' living standards and skill development. In addition, the provision of modern physical infrastructure, such as underground utility corridors, a comprehensive sewerage network, and underground contaminated water lines significantly upgrades the overall facility.

These interventions collectively enhance the operational efficiency, environmental performance, and global competitiveness of Alang in comparison with other international ship recycling facilities. Further, detailing of these proposals shall be undertaken at the Detailed Project Report (DPR) stage, with implementation proposed in a phased and structured manner to ensure effective execution.

1

1.1

Introduction

Background

Alang is the largest ship recycling yard (cluster) in the world, spanning over approximately 10km along the western coast of the Gulf of Cambay, near Alang-Soshiya village in the Bhavnagar district of Gujarat. The Gujarat Maritime Board (GMB) aims to enhance the capacity of the yard, which plays a crucial role in the nation's economy by generating up to 3.5M tonnes of re-rollable steel annually without tapping the natural resources. It also provides significant employment opportunities and contributes positively to the environment.

Currently, Alang-Soshiya Ship Recycling Yard has 150 ship recycling plots with 128 plots in active use. Over the years, the yard has recycled 8,681 ships, generating a total Light Displacement Tonnage (LDT) of 69 M. The ship recycling yard also contains supporting facilities such as administrative offices, a notified area office, a safety training institute, hospital, and a fire station.

Considering a positive outlook for ship recycling sector, GMB plans to expand Alang's capacity from 4.5M LDT to 9.0 M LDT. This expansion involves creating additional plots adjacent to the existing ones, extending southwards towards Mathawada village as also necessary augmentation and development of supporting infrastructure.

As a part of this initiative, GMB has appointed BMT Consultants (India) Pvt. Ltd. (Merizen) to undertake preparation of the Master Plan for Capacity Enhancement and Expansion of Alang-Soshiya Ship Recycling yard.

1.2

Purpose of report

The purpose of this report is to provide a comprehensive master plan aimed at guiding the development and expansion of Alang-Soshiya ship recycling yard. This report outlines key strategies and recommendations to achieve the following objectives:

- **Capacity enhancement:** To identify and propose measures for enhancing the capacity of existing infrastructure, ensuring it meets future demand projections and industry best practices.
- **Compliance and standards:** To propose new ship recycling plots adhering to EU SRR, Hong Kong Convention and other relevant national and international regulations
- **Sustainable development:** To promote sustainable development practices that balance economic growth with environmental stewardship, social responsibility, and resource management.

1.3

Format of report

The report is organised into the following chapters:

1. Chapter 01: Introduction – Provides background, objectives, and scope of the report.
2. Chapter 02: Site Characteristics – Analyses current site conditions and context of the study area.

3. Chapter 03: Ship Recycling Plots – Reviews existing ship recycling plots and operational practices.
4. Chapter 04: Proposed Ship Recycling Plots – Suggests optimal plot sizes and layout configuration based on study findings.
5. Chapter 05: Proposed Master Plan – Presents a conceptual layout and plan for the ship recycling facility including development proposals.
6. Chapter 06: Engineering Feasibility – Provides engineering design criteria for the project components in the proposed ship recycling plot
7. Chapter 07: Phasing and Development Strategies – Outlines a stepwise approach for implementing the master plan.
8. Chapter 08: Cost Estimates – Presents broad cost estimates of all the project components from the master plan
9. Chapter 09: Conclusion and Recommendations – Summarizes key findings and recommendations of the report.

2

Site Characteristics

2.1

2.1.1

Project location

Existing ship recycling yard

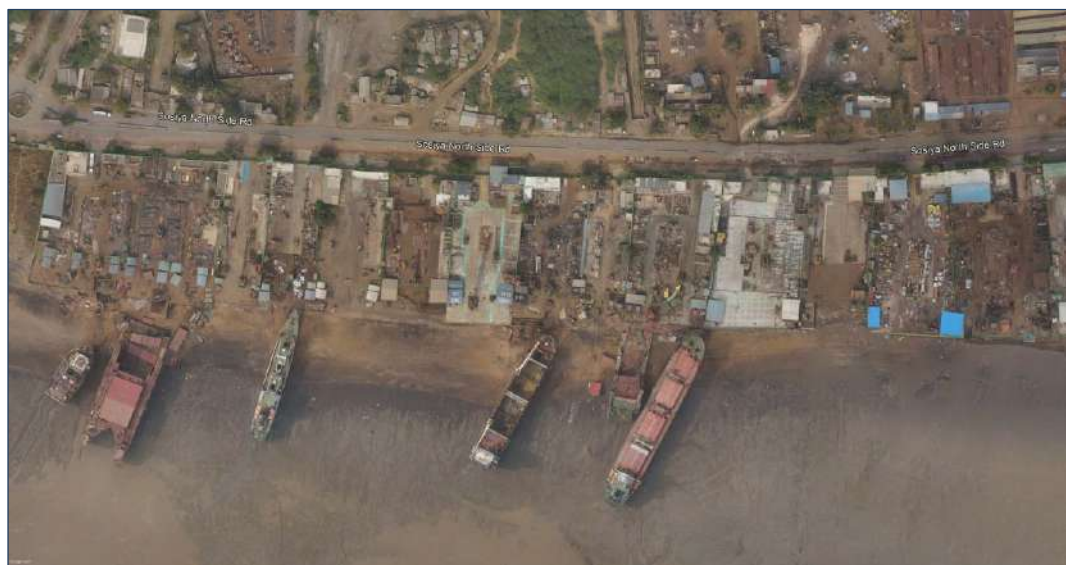
Alang-Sosiya Ship Recycling Yard is located on the west coast of India, in Bhavnagar district of Gujarat state, at latitude 21°23'48.04"N and longitude 72°10'42.43"E. The nearest town, Trapaj which is connected through National Highway NH 51, about 9 km from Alang ship recycling yard.

Figure 2-1: Location of Alang Sosiya ship recycling yard



The facility is around 10 km long spanning across villages Bharapara, Alang, Manar, Sosiya and Jaspara. The geography of Alang makes it an ideal location for ship recycling. The beach is low shallow, and the tides are high. The ship recycling industry was set up in Alang in 1982, and by 1990 over 100 ships started landing up in Alang each year. The yard currently has 150 recycling plots for ship recycling out of which 128 are operational. It has beached total of 8681 ships till date generating 69 M LDT.

Figure 2-2: Ship recycling plots



2.1.2 Proposed expansion

Along with existing 10 km stretch of ship recycling yard, expansion of the yard is also envisaged for another 10 km towards south of existing yard spanning across Mathvada, Chopda, Padari and Tarsara.

Figure 2-3: Location of proposed master plan study area



The master plan is proposed to be developed for the entire 20-kilometre stretch (including 10 km existing plots and 10 km proposed expansion). The study area for master plan extent has been considered to extend approximately 500 metres on the landward (north-west) side of the existing road and about 1000 metres towards the seaward side.

The final delineation of the master plan boundary shall be undertaken within this study extent based on the evolving planning concept and established planning rationale.

2.2 Met-ocean characteristics

2.2.1 Meteorology

There are three primary seasons in Gujarat: winter, from December through February, summer from March through May, and the monsoon season from May/June through September. October is considered as a transition month.

Alang has a hot semi-arid climate with three distinct seasons. The area experiences hot summers and almost no rain falls outside the monsoon season. The average annual temperature is 27.5 °C with summer temperature reaching 32 °C. The monsoon season (June to September) brings heavy rainfall, contributing to the region's annual precipitation.

2.2.2 Temperature

The average temperature in this location is around 27.5 °C. The month of June experiences the highest temperature with an average value of 32 °C and January is the coldest month of the year, with average temperature of 22.1 °C. The average temperatures vary during the year by 10 °C.

2.2.3 Seasons

Alang experiences a tropical climate with three distinct seasons:

1. **Summer** (March to June): Summers in Alang are hot and dry, with high temperature. The heat can be intense, especially during April and May.
2. **Monsoon** (June to September): The monsoon season brings moderate to heavy rainfall to Alang, resulting in reduced temperatures. Most precipitation falls in July and August, with an average of 203 mm. This area also experiences high humidity during this period.
3. **Winter** (October to February): Winters are mild and pleasant. This is the most comfortable season, making it ideal time for outdoor activities.

2.2.4 Rainfall

Alang receives About 687 mm of precipitation falls annually. Rainfall is seasonal with most of the rain occurring during the southwest monsoon. In July, the precipitation reaches its peak with an average of 203 mm.

The month with the highest number of rainy days is July (14 days). The month with the highest relative humidity is August (80.67 %) and extremely low level of relative humidity at only 31.95 percent in March.

2.2.5 Tides

Table 2-1: Tide measurements

Tidal Datums (m)	On Harmonic Analysis	w.r.t. LAT
Highest Astronomical Tide, HAT	10.770	11.130
Mean High Water Springs, MHWS	9.004	9.364
Mean High Water Neap, MHWN	7.390	7.750
Mean Sea Level, MSL	5.318	5.678
Mean Low Water Neap, MLWN	3.047	3.407
Mean Low Water Springs, MLWS	1.195	1.555
Lowest Astronomical Tide, LAT	-0.360	0.000

Source: Site survey report

2.2.6 Currents

The currents in the deeper waters beyond the intertidal are largely shore parallel along the primary axis of the Gulf of Kachch, driven by the high tidal range and have maximum values of 1.5 – 2.0 m/s as per the EIA report of 2016 (Mecon Ltd.). The Naval Hydrographic Chart 208 for the Gulf of Kachch provides tidal stream information 10 km offshore from Alang with spring tide values in the range of 2.5m/s.

2.2.7 Waves

Waves that enter the Gulf of Kachch primarily are generated from waves approaching from the Arabian Sea and local winds and thus have a direction along the axis of the Gulf of Kachch. Merizen has run their calibrated Gulf of Kachch wave model to generate wave climate descriptions at 14m water depth close to Alang. The results are provided below in Figures and Tables below. As can be seen, the predominant directions are parallel to the shore and thus waves approaching the shore will have low energy due to refraction of the waves and breaking in the shallower intertidal zones of Alang.

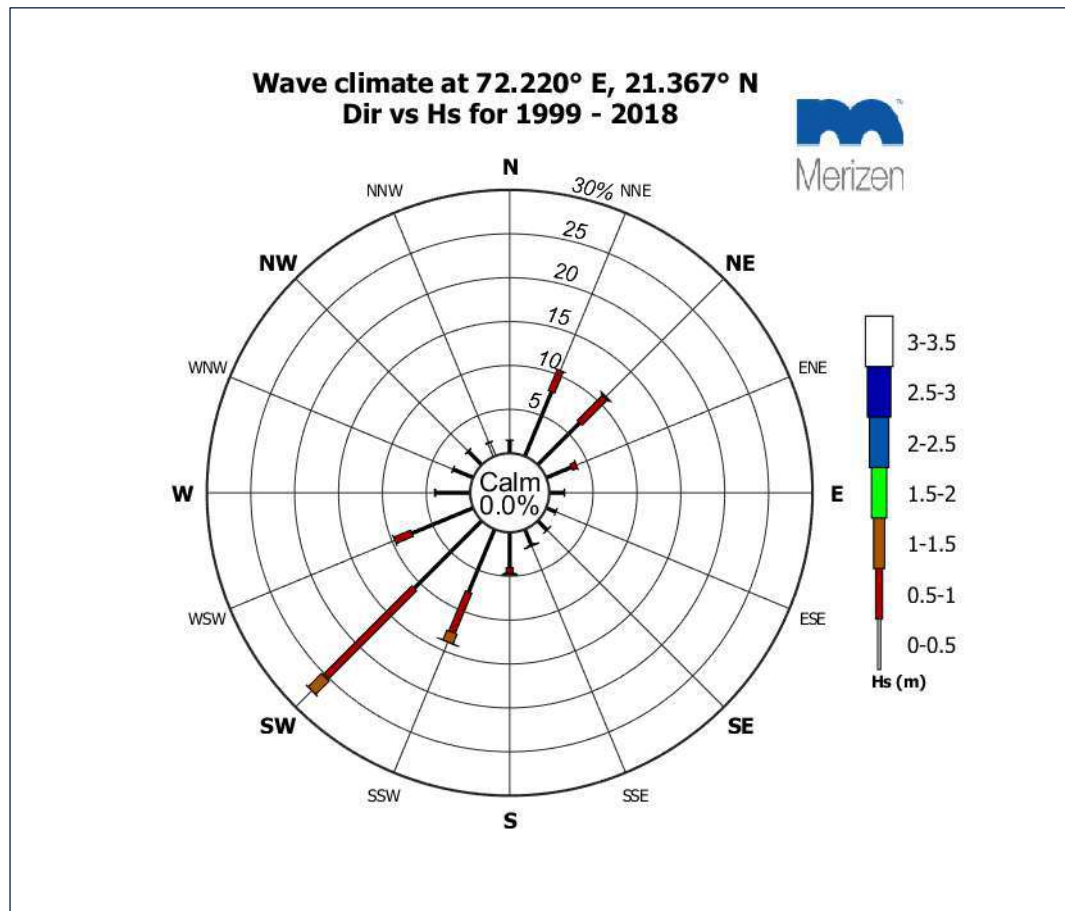
Figure 2-4: Hs roseplot at 14m CD

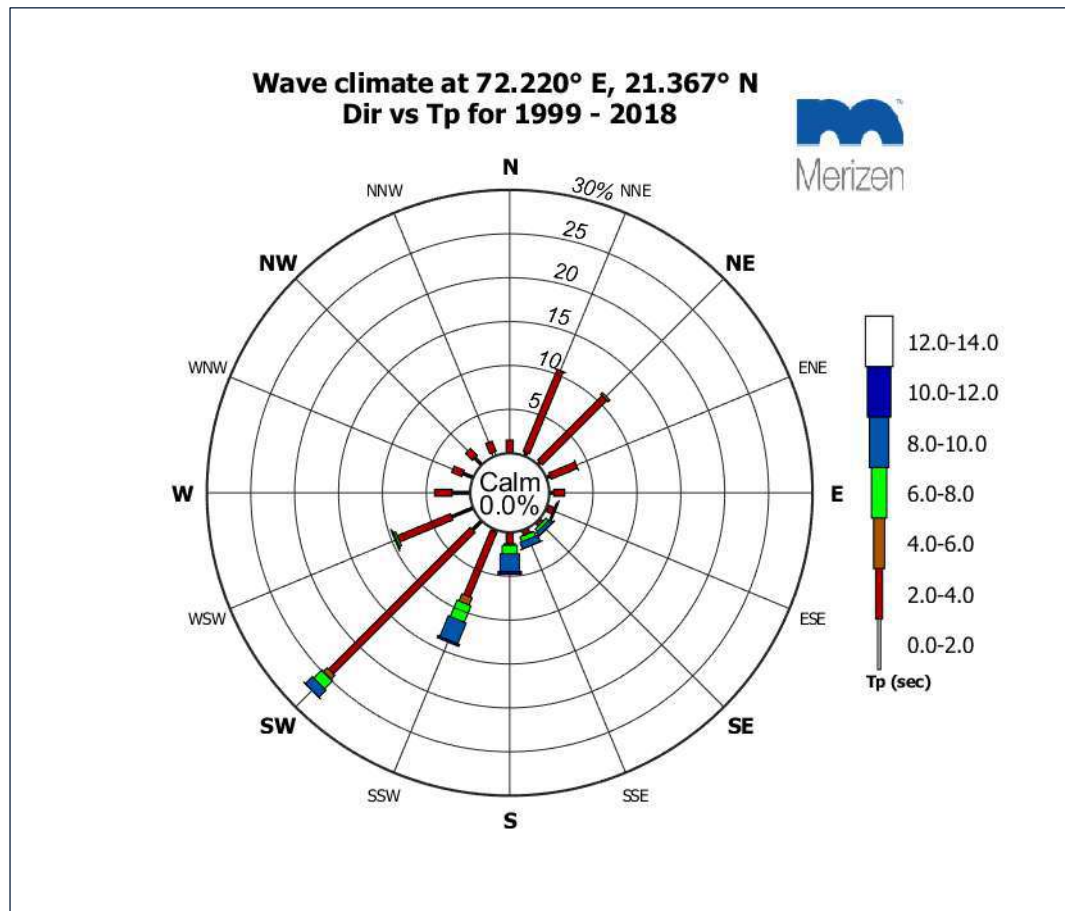
Figure 2-5: Tp roseplot at 14m CD

Table 2-2: Joint Probability Distribution for Hs(m) vs Direction at 14m CD

JP Table: Hs vs Direction - Offshore_pt																	
Location: 71.500° E 20.000° N Depth: 200.0 m																	
Hs\Dir	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	% Occurrence
0.0-0.5	0.02	0.01	0.01	0.01	0.02	0.02	0.04	0.11	0.64	1.04	0.48	0.21	0.13	0.08	0.04	0.02	2.88
0.5-1.0	2.13	1.75	1.07	0.97	0.80	0.78	0.75	1.18	3.51	8.82	8.13	8.84	5.92	3.03	1.77	1.58	51.02
1.0-1.5	0.65	0.78	0.32	0.11	0.07	0.02	0.02	0.06	0.15	0.69	5.41	6.82	1.41	0.58	0.20	0.14	17.43
1.5-2.0	0.02	0.04	0.03	0.01	0.01	0.00	0.00	0.00	0.02	0.08	3.75	5.51	0.11	0.01	0.01	0.00	9.59
2.0-2.5	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.04	2.49	6.15	0.00	0.00	0.00	0.00	8.72
2.5-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	1.38	5.19	0.00	0.00	0.00	0.00	6.65
3.0-3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.44	2.60	0.00	0.00	0.00	0.00	3.07
3.5-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.50	0.00	0.00	0.00	0.00	0.55
4.0-4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.07
4.5-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
5.0-5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
5.5-6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Occurrence	2.82	2.58	1.44	1.11	0.91	0.82	0.81	1.36	4.34	10.77	22.14	35.89	7.57	3.69	2.01	1.74	100.00

Table 2-3: Joint Probability Distribution for Hs(m) vs Tp(s) at 14m CD

JP Table: Hs vs Tp - Offshore_pt									
Location: 71.500° E 20.000° N Depth: 200.0 m									
Hs\Tp	0.0-2.0	2.0-4.0	4.0-6.0	6.0-8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	% Occurrence
0.0-0.5	0.00	0.00	0.20	1.50	1.12	0.07	0.00	0.00	2.88
0.5-1.0	0.00	0.00	12.46	26.93	10.77	0.86	0.00	0.00	51.02
1.0-1.5	0.00	0.00	3.20	10.38	3.76	0.09	0.00	0.00	17.43
1.5-2.0	0.00	0.00	0.09	4.33	5.10	0.08	0.00	0.00	9.59
2.0-2.5	0.00	0.00	0.00	1.68	6.66	0.38	0.00	0.00	8.72
2.5-3.0	0.00	0.00	0.00	0.21	6.05	0.39	0.00	0.00	6.65
3.0-3.5	0.00	0.00	0.00	0.00	2.81	0.26	0.00	0.00	3.07
3.5-4.0	0.00	0.00	0.00	0.00	0.44	0.11	0.00	0.00	0.55
4.0-4.5	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.07
4.5-5.0	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
5.0-5.5	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
5.5-6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Occurrence	0.00	0.00	15.95	45.01	36.77	2.26	0.00	0.00	100.00

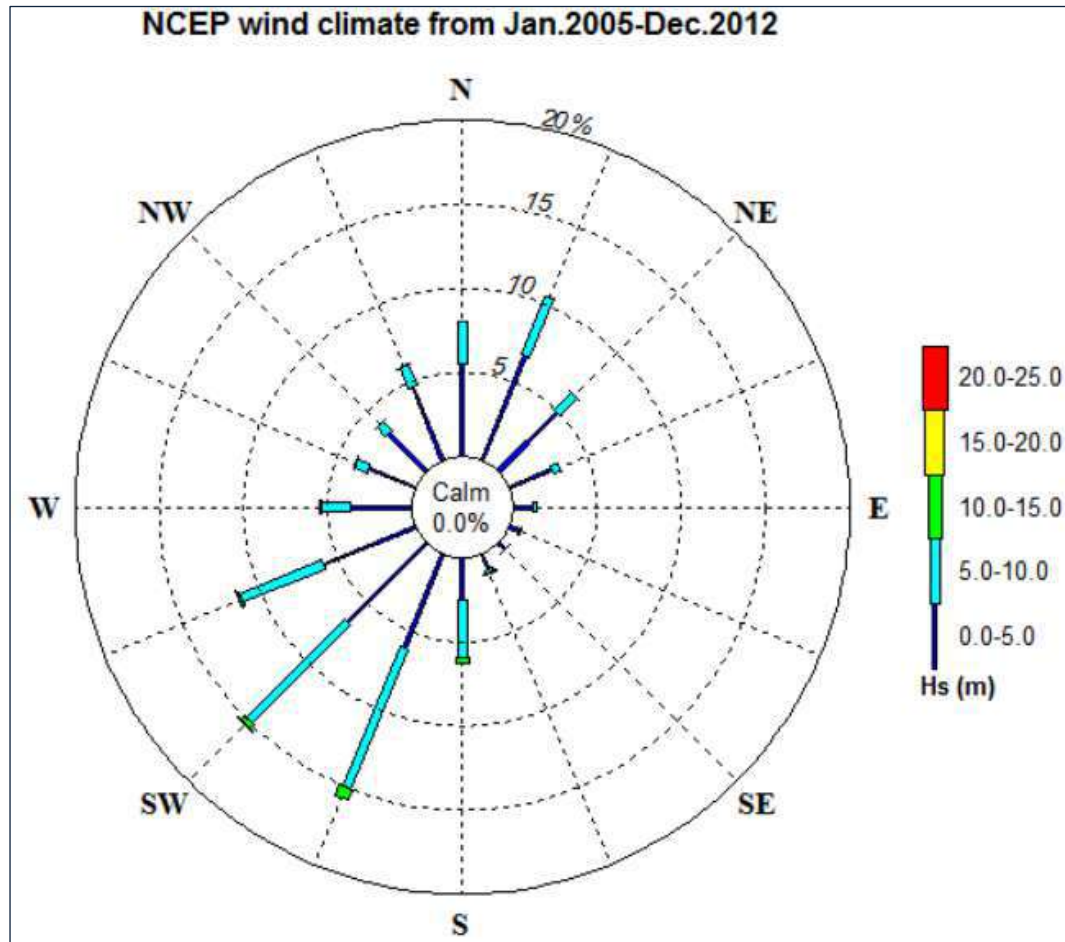
Table 2-4: Joint Probability Distribution for Tp(s) vs Direction at 14m CD

JP Table: Tp vs Direction - Offshore_pt																	
Location: 71.500° E 20.000° N Depth: 200.0 m																	
Tp\Dir	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	% Occurrence
0.0-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.0-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.0-6.0	2.21	2.07	1.06	0.59	0.33	0.10	0.02	0.01	0.01	0.01	0.06	1.46	3.22	2.31	1.26	1.22	15.95
6.0-8.0	0.61	0.50	0.38	0.52	0.57	0.72	0.77	1.17	1.76	2.80	9.07	19.16	4.33	1.38	0.75	0.52	45.01
8.0-10.0	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.18	2.46	7.08	12.02	14.99	0.02	0.00	0.00	0.00	36.77
10.0-12.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.88	0.99	0.28	0.00	0.00	0.00	0.00	2.26
12.0-14.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.0-16.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Occurrence	2.82	2.58	1.44	1.11	0.91	0.82	0.81	1.36	4.34	10.77	22.14	35.89	7.57	3.69	2.01	1.74	100.00

2.2.8

Winds

Wind data had been extracted previously from global databases by Merizen for a location near Ghogha. The wind directions are primarily along the axis of the Gulf of Kachch and are driven by the South-West and North-East monsoons. The wave rose plot shown below considers 30 sec wind averages. For 98% of the time, wind speed is less than 15m/s. Predominant and strongest wind generally are from 200° to 260° during south-west monsoon months



2.3

Demography

The demography of Alang, is influenced by its status as a major ship-recycling hub and its surrounding agricultural and coastal economy. The population in Alang primarily consists of workers in the ship-recycling industry, residents, and those who depend on related industries for their livelihood.

The demographic profile of Alang and its adjoining villages reflects distinct patterns shaped by industrial activity, particularly ship recycling, which has influenced population dynamics, labour participation, and social structures in the region.

The cluster of villages surrounding Alang in Talaja Taluka, Bhavnagar District, Gujarat, presents a semi-rural population pattern with moderate density.

As per the latest available data (census 2011), Alang has a population of 18,475, making it the most populous settlement among nearby villages, which include Tarasara, Padri,

Chopda, Mathavada, Bharapara, Trapaj, Alang, Manar, Sosiya, and Jaspara. The large population in Alang is attributed primarily to its status as a major industrial hub attracting both permanent and migrant workers.

The sex ratio in Alang stands at 226 females per 1,000 males, the lowest among all villages in the region. This significant gender imbalance is likely a result of the predominantly male migrant workforce engaged in the ship recycling plots. In contrast, villages such as Padri report a much healthier sex ratio of 1,046 indicative of more balanced resident populations.

Literacy levels across the region remain moderate, ranging from 55% to 65% in most villages. Alang slightly exceeds this range, with a literacy rate of 66%, reflecting the presence of better access to educational resources and NGO-supported literacy programs, especially targeted at adult workers and children of migrant families.

Alang exhibits a notably high Work Participation Rate (WPR) of 80.53%, the highest in the region. This contrasts with other villages where WPR ranges from 40% to 60%, consistent with their primarily agrarian economies and smaller working-age populations. The elevated WPR in Alang is largely driven by its industrial economy and the employment of a large migrant labour force in ship-breaking and associated sectors.

Alang's demographic profile is shaped by its industrial character, primarily driven by the ship-recycling industry. The town's high work participation rate and low sex ratio reflect a large, male-dominated migrant workforce. In contrast, nearby villages have more balanced populations and agrarian-based economies. These differences highlight the need for tailored development policies addressing the unique challenges of both industrial and rural communities in the region.

2.4 Coastal Regulation Zone for the location

The study area falls within the Coastal Regulation Zone (CRZ), a designated area under the Coastal Regulation Zone Notification by the Ministry of Environment, Forest and Climate Change (MoEFCC) on 18th January 2019. This regulation aims to protect the coastal environment by limiting industrial activities and development near the coastline.

As per latest approved CRZ maps (CRZ, 2011) the entire existing 10 km ship recycling yard stretch falls under CRZ II, which as per CRZ notification 2019, classified as developed land areas up to or close to the shoreline, within the existing municipal limits or in other existing legally designated urban areas, which are substantially built-up with a ratio of built-up plots to that of total plots being more than 50 per cent and have been provided with drainage and approach roads and other infrastructural facilities, such as water supply, sewerage mains, etc.

Towards the proposed expansion, an additional stretch of around 2.8 km adjoining existing yard in Mathvada also is under CRZ II, beyond that CRZ classification is as CRZ IA and CRZ III which are considered as environmentally critical (due to reserve forest, mangrove plantation etc.) and areas that are relatively undisturbed (viz. rural areas, etc.) respectively.

Figure 2-6: Coastal Regulation Zone at the study area

Initial stakeholder discussion feedback

An initial stakeholder consultation with assistance from GMB was carried out to understand the viability, potential usage of the concerned zones, and indicative timelines for their implementation. The key discussions and outcomes are summarized below:

CRZ: During discussions regarding the area currently classified as CRZ IA, the Environment Cell of GMB confirmed that they have approached the Coastal Zone Management Authority (CZMA) to request reclassification of the area to CRZ IB.

Reserve Forest: A meeting was held between the Forest Department, Bhavnagar and GMB to assess the feasibility and timeline for de-notifying the reserve forest area. As per the Forest Conservation Act, 1980, the following conditions must be met to convert forest land:

- **Compensatory land:** An equivalent area of land must be provided by GMB to the Forest Department for compensatory afforestation.
- **Net Present Value (NPV):** Compensation must be paid by GMB for the land, as per the NPV determined by the authorities.
- **Afforestation Charges:** A payment, as specified by the Forest Department based on the area, must be made by GMB for compensatory afforestation.
- The complete de-notification process is expected to take approximately 6 to 9 months.

2.5 Road network and connectivity

Alang is connected by National Highway - 51 (NH 51) through the nearest town of Trapaj, connecting Dwarka to Bhavnagar via Una. The road connecting Alang ship recycling yard to Trapaj is around 9 km long and is a State Highway – 37 (SH 37). NH- 51 has four lane bituminous surface with 1.5 m hard shoulders on either side suitable for heavy vehicle movement. This 4-lane road has been proposed to upgrade to 6 lanes in the Development Plan proposed by Alang Area Development Authority (AADA).

The existing road connecting all the plots, spanning approximately 9.5 kilometres is connected through two bridges. Recently, one of these bridges (Manari Bridge) has

experienced structural failure, having minorly sunk into the ground. As a result, it has been closed to traffic.

Figure 2-7: Road connectivity to Alang shipyard

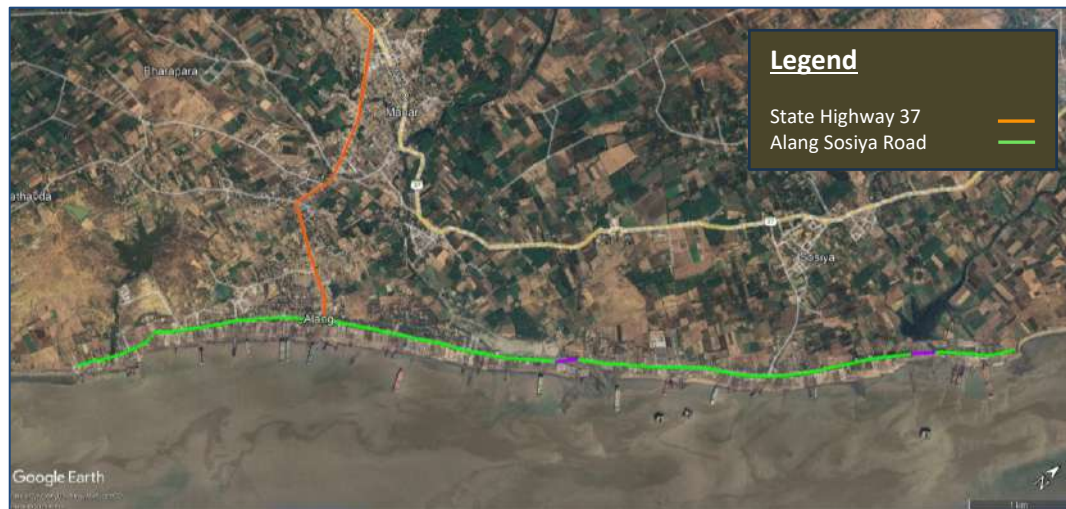
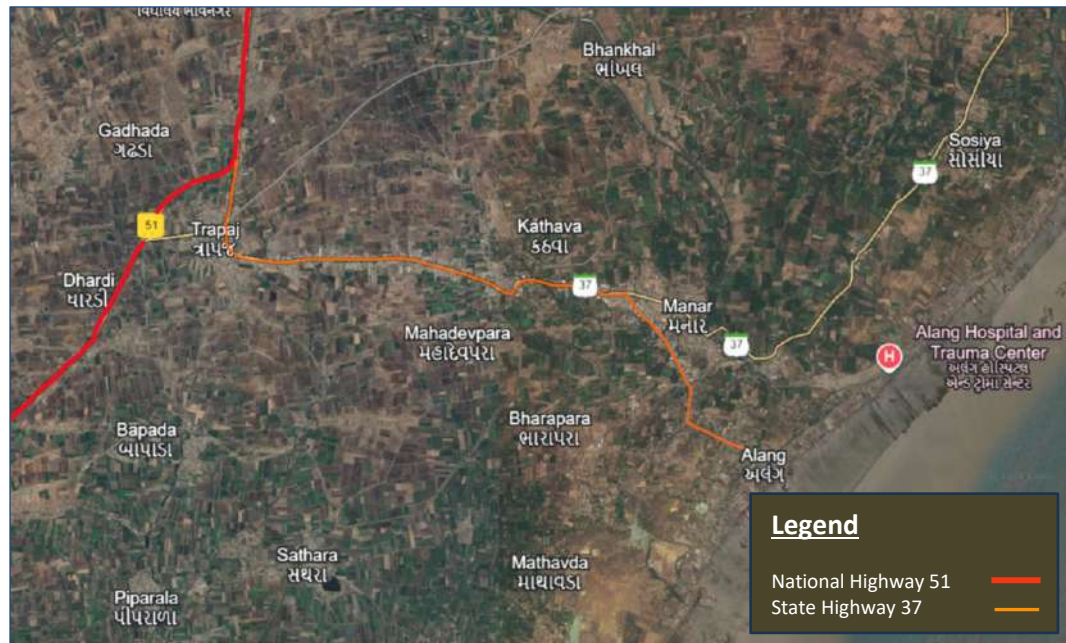
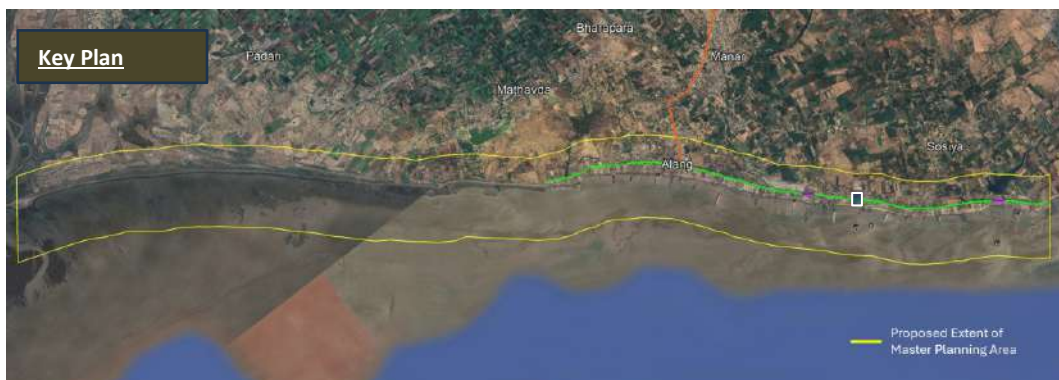


Figure 2-8: 24 m wide road connecting recycling plots





2.6

2.6.1

Infrastructure

Physical infrastructure

Physical infrastructure in Alang-Sosiya Ship Recycling Yard is primarily cantered around ship recycling plots and its supporting needs.

2.6.1.1

Water supply

Gujarat Water Supply & Sewerage Board (GWS&SB) supplies 1 MLD of water from Trapaj HGLR to underground water tanks located in Alang operated by GMB. The total capacity of water tanks located in Alang is 3 M liters. GMB will pay monthly tariff to GWSSB as per the quantity supplied.

Distribution system

GMB is responsible for all the pipe network laid from Trapaj HGLR to Alang and then the distribution to individual plots.

Figure 2-9: Water supply source**2.6.1.2 Stormwater and sewerage**

There is no sewerage network in Alang, and a stormwater drainage line runs along the main road to prevent stormwater from entering the ship recycling plots.

2.6.1.3 Electricity

Electricity to Alang is supplied through substation located in Manar of capacity 66 kv operated by Paschim Gujarat Vij Company Limited (PGVCL). This substation is connected to many transformers of capacity ranging from 10 KVA to 100 KVA across Alang of overhead cable network.

2.6.1.4 Solid waste management

All the solid waste from the plots and other GMB facilities are being sent to the landfill site located in TSDF site. Treatment facility for hazardous waste is currently operated and maintained by Gujarat Environment Protection Infrastructure Ltd (GEPIIL) on behalf of GMB for facilitating the collection, transport, treatment and disposal of waste that is generated from the ship recycling yard.

Treatment, Storage and Disposal Facility (TSDF)

A centralised Treatment, Storage and Disposal facility (TSDF) for ship recyclers in Alang Ship recycling yard is currently operated and maintained by GIPEL on behalf of GMB.

Figure 2-10: Treatment, Storage and Disposal Facility at Alang**Table 2-5: TSDF details**

Sr No	Item	Capacity	
1	Municipal solid waste cell	30,000 m ³	
2	Landfill cell for Hazardous waste	70,000 m ³	
3	Landfill cell for Municipal solid waste	30,000 m ³	
4	Common hazardous waste incinerator	5 Mt/day	
5	Fire hydrant system	Underground reservoir	200 m ³
		Overground reservoir	5 m ³ × 2
6	Effluent treatment plant	30 KLPD	

Source: GMB

2.6.2**Social infrastructure**

The ship recycling yard contains supporting social infrastructure such as administrative office, notified area office, safety training institute, Alang hospital and a fire station building. Dormitory type housing facilities is developed by GMB for the workers of ship recycling

yard. A dedicated safety and training institute is also available to provide free training to the workers.

Figure 2-11: Existing social infrastructure around Alang area



2.6.2.1 Worker training institute

GMB provides 2-week training on ship recycling and safety aspects to all the workers at the dedicated safety training & labour welfare institute. The training is provided with an objective to make the workers employable for safe and efficient ship recycling practices at the plots. The Institute has also developed a curriculum on various aspects of ship recycling practices. At the end of the course, the examinations are conducted to ensure that the workers have adequately grasped/assimilated the key aspects of ship recycling practices.

A visit to safety and training institute was conducted along with GMB Safety Officer Mr Nikhil Vyas. The safety and training institute conducts a two weeks/12 days training capsule for all the workers free of any charge. It has two training halls each equipped with audio visual aids, large screen TVs and seating capacity of approximate 60 trainees each. The training is conducted with the help of audio-visual helps, presentations and videos. In addition, props are used to demonstrate working of various safety equipment, personnel gear and hand-held firefighting equipment.

Figure 2-12: Worker safety & training institute

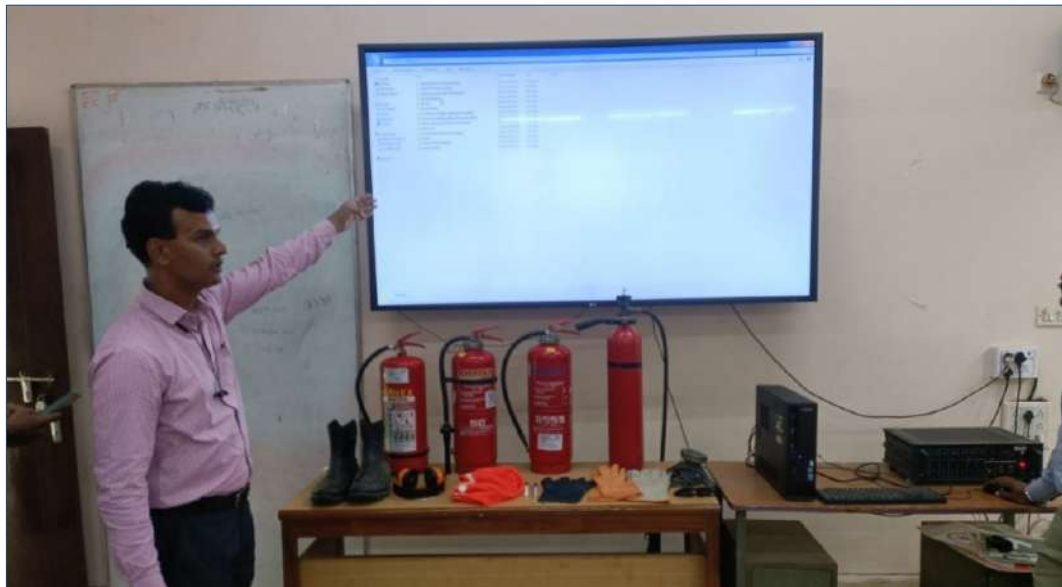


- It was noted that this training is mandatory for all the workers before they are employed. and it's a dormant period for them as they have to make their own arrangements for stay and logistics arrangement which is an issue for workers coming from economically weaker background.

Figure 2-13: Classroom at training institute



Figure 2-14: Safety equipment & personnel gear for demonstration



Initial stakeholder discussion feedback – Worker training challenges

It was noted during the discussions that the mandatory training for all workers must be completed before they can be officially employed. However, this training period is considered a dormant phase for the workers, during which they are not yet earning. They are required to make their own arrangements for accommodation and logistics, which poses a significant challenge, especially for those coming from economically disadvantaged backgrounds.

2.6.2.2 Medical infrastructure

GMB provides financial and administrative support to the Indian Red Cross Society managed hospital at Alang (35-bed capacity), which offers service for free. The hospital has many specialists including Cardiologist, Plastic surgeon, Orthopaedic surgeon, Physician, Dermatologist, Radiologist, etc. along with supplementary infrastructure comprising first aid care centre, special burn ward, etc. The specialist doctors are available at least once a week. The hospital is managed by the medical officer with two other assistant doctors who are available on daily basis.

Indian Red Cross Society also manages another hospital at Alang where it offers only primary medical care to the patients.

Figure 2-15: Multi specialty hospital at Alang

**Key observations**

Though this hospital caters to the whole of Alang industrial belt with workers strength up to 30,000 workers depending upon the ship recycling traffic in addition to the population from the villages from adjacent locations, the specialist doctors are not permanently positioned at the hospital and in case of emergency, there is a risk of significant delay in getting proper medical care.

Though, the hospital is equipped with MRI, CT scan and X-Ray machines etc, in the absence of permanent positioning of technicians and radiologist, the utilization of these facilities would be limited. The facility will further be able to facilitate yards in getting the EU compliance.

The newly built residential complex for doctors can house only four doctors and is grossly inadequate for a multi-speciality hospital which needs to house specialist doctors as well as support staff such as nurses, technicians and other paramedics etc.

2.6.2.3 Labour housing colony

The labour housing colony built jointly by GMB and Ship Recycling Industrial Association (SRIA) has a capacity to accommodate 1008 workers. This facility is of the dormitory type comprising 7 blocks (G+2), canteen building, office building, shops, road, water supply & sanitary facilities with sewerage treatment plant (STP), electrification in the said facilities, etc. The facility has been provided on GMB land to the workers of ship recycling yard as a welfare measure at no charges either to workers or to the employers. However, the occupancy is limited to 20-30% of the capacity.

Figure 2-16: Accommodation complex for workers**Key observations**

- It was found that since the facility is located at one corner of the 10 km long stretch of Alang belt, the workers prefer to stay in makeshift arrangements closer to their respective plots due to ease (proximity) in visiting their shanties for lunch and refreshments.
- A couple of major plot managements have accommodated their workers in few of the blocks with buses provided for their conveyance. The accommodation blocks are maintained by the plot owners.

2.7**Spatial growth**

Over the period from 2010 to 2024, significant changes in land cover were observed within the study area, reflecting increasing urban development and densification.

By 2015, urban expansion was observed as the density of the ship-recycling plots gradually increased. The plots were generally concentrated around the Alang-Soshiya region, a specific stretch of coastline.

Figure 2-17: Spatial growth in 2015



In 2020, there was expansion of ship-recycling plots, informal settlements, and infrastructure to accommodate the growing workforce is observed. Limited but steady growth in residential and commercial areas was also observed.

Figure 2-18: Spatial growth in 2020



Figure 2-19: Spatial growth in 2024

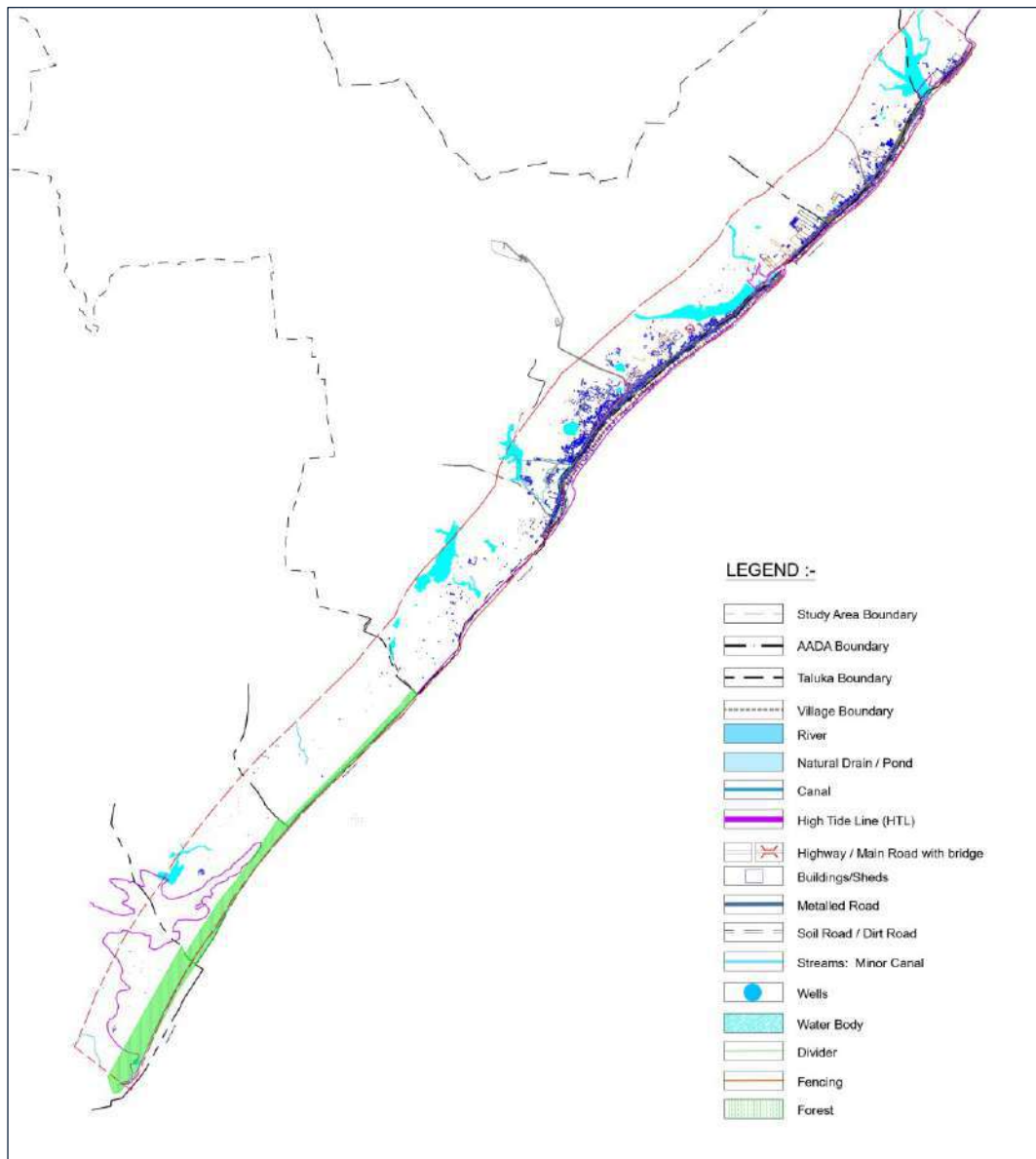
By 2024, the development trend was observed as below:

- **Along 24 m road**, infrastructure improvements facilitated the growth of logistics, commercial spaces, and residential areas. This road has become an essential transportation corridor, supporting the ship-recycling industry while fostering urban development around it.
- **Manar and Sosiya areas**, being industrial hubs, witnessed dense industrial growth with a focus on ship-recycling plots and supporting industries. The growth in residential development catered to the increasing number of workers, while commercial activity followed suit. Environmental considerations led to more structured land use to manage pollution and regulate waste from industrial operations.
- **Bharapara and Mathavada** areas remained predominantly agricultural, with limited industrialization or commercial growth. Residential development has been minimal, primarily limited to small rural settlements. However, there is potential for future growth as industrial activities expand further inland, creating a spillover effect.

Figure 2-20: Commercial and residential growth along the road

2.7.1 Existing situation

The existing situation map of the Alang area as above Figure 2-21 provides a comprehensive spatial analysis of the region, highlighting key infrastructural, environmental, and zoning aspects.

Figure 2-21: Existing situation map

Below is a breakdown of the key elements represented in the map:

- Industrial and economic zones:** The ship recycling yard, dominates the region's economic landscape. The map indicates the extent of this industrial zone, highlighting its proximity to the Gulf of Khambhat. The industrial activities necessitate well-planned infrastructure, including better roadways, worker housing, and waste management facilities to support sustainable growth.
- Environmental and natural features:** Several lakes, rivers, and drainage channels are visible, emphasizing the need for proper water management and flood prevention strategies. Also, a designated green buffer zone is marked, indicating the presence of ecologically sensitive areas that must be protected from industrial expansion.
- Residential zones:** Clusters of settlements and residential areas are evident, indicating workforce distribution. The proximity of these settlements to industrial areas

necessitates careful zoning to mitigate environmental and health hazards while ensuring accessibility to basic amenities like water, sanitation, and healthcare.

- **Transportation and road network:** Efficient evacuation through the main road to the highway ensures regional connectivity, supporting industrial activities and trade. This highway serves as a critical link between different economic zones and urban centres. A network of smaller roads connects settlements, industries, and essential services, improving accessibility within the region. Although, certain road links are missing or underdeveloped, indicating potential areas for infrastructure upgrades to improve mobility and reduce congestion.
- **Development challenges and opportunities:**
 - The need for additional road links and improved connectivity to ease movement between industrial and residential zones.
 - The proximity of industrial activities to water bodies and reserved forest areas requires stringent regulations to minimize pollution.
 - The presence of vast open spaces and connectivity to regional markets suggests opportunities for planned expansion, including new commercial hubs, logistics zones, and workforce housing projects.

The existing situation provides a vital foundation for urban and regional planning in the Alang area. It highlights key challenges, including the need for **improved transport infrastructure, sustainable industrial expansion, and environmental conservation**. A strategic approach integrating smart zoning, eco-friendly industrial practices, and enhanced connectivity will ensure balanced and sustainable growth in the region.

2.8

Evaluation of Development Plan prepared by AADA

From the compilation and analysis of all data, we have identified thrust areas relevant for making growth strategies and the negative factors, which may impede growth. This exercise enabled us to create possible strategies focussing on identified thrust areas and addressing factors impeding growth. The data gaps were found in certain aspects and strategies were worked out for fulfilling the needs or for finding out of optional ones.

Evaluation of the Development Plan (DP) prepared by the AADA was carried out and key proposals were identified and incorporated in the Master Plan of Alang Ship Recycling yard.

As per the sanctioned Alang Area Development Plan, most of the proposed Master Plan extent falls under Industrial Zone-A. Three villages within the expansion of the yard have not been included in the proposed DP namely Tarsara, Padri and Chopda.

- This zone predominantly falls under Coastal Regulation Zone (CRZ).
- This zone will be regulated based on the CRZ regulations as in the Gazette of India, Extraordinary, Part- II, Section 3, Sub-section (ii) of dated the 6th January, 2011 or the CZMP.
- This zone is demarcated along the coast, along the concentration of the ship recycling plots and the adjoining scrap cutting plots and other such small cutting and sorting areas.

- The zone is defined / demarcated considering the existing activities which are ancillary activity of the ship recycling yard such as scrap cutting yards, scrap sorting yards, oil and LPG storage.

For the implementation of the proposed development plan AADA has proposed 3 town planning schemes in the region. The status of the town planning schemes is not available. The regulations and permissible use classification as per the DP are presented in the tables below:

Table 2-6: Regulation as per Development Plan

Use Zone	Code	FSI- Permissible	FSI- Chargeable	FSI- Maximum Permissible	Permissible uses
Industrial- A	IA	1	Nil	1	Industrial 1, Storage 2 Utilities and services 1,2,3,4

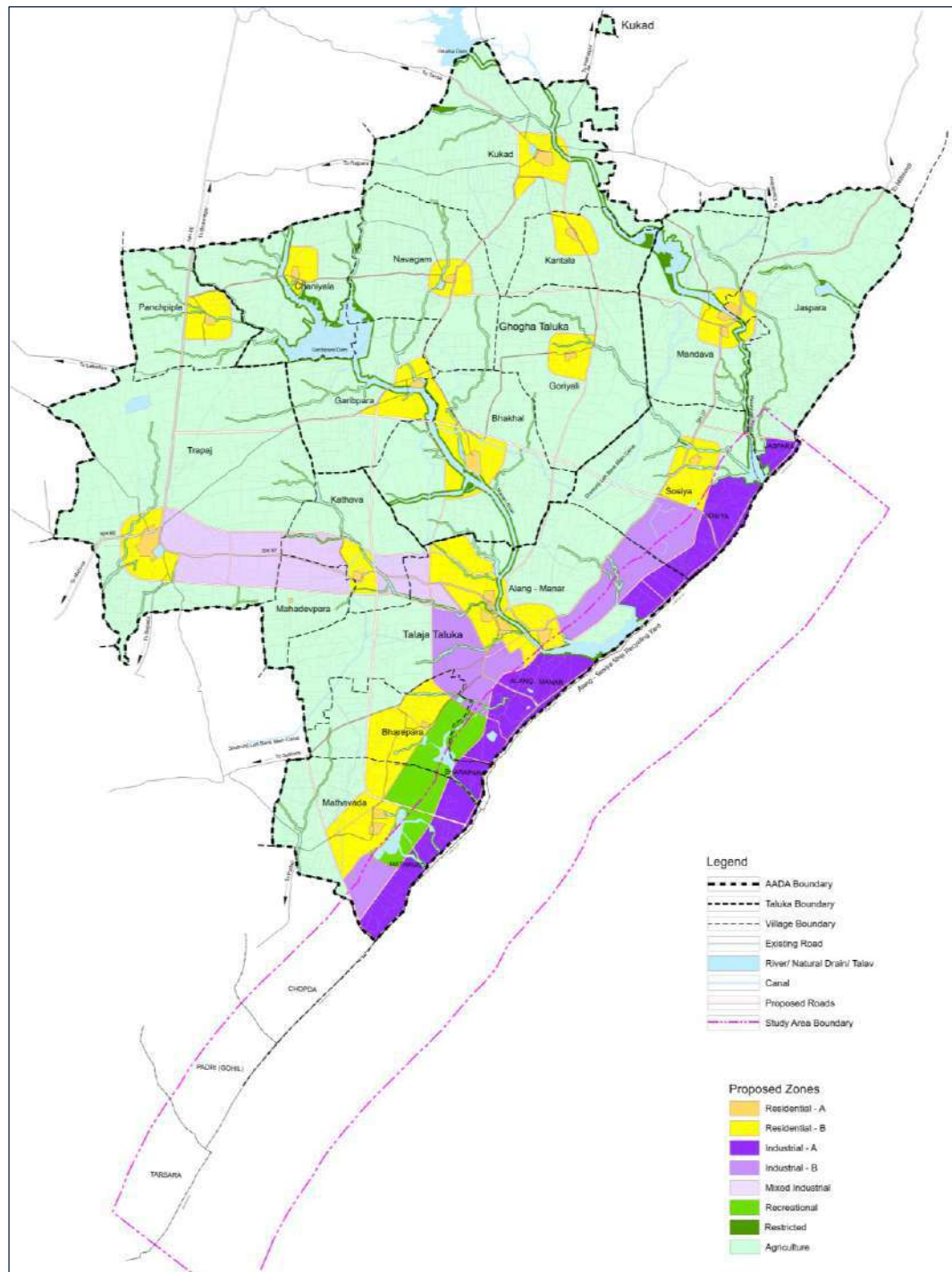
Table 2-7: Permissible uses classification

Industrial 1	Storage 2	Utilities and services 1.2.3.4
Ship Recycling unit	Storage	Electric Main, Sub Station, Police/ Chowki, Public Toilet. Telephone Exchange Tower, Water Pumping Station, Overhead Tank, Sump Sewerage Pumping Station, Fire station, Post Office
Scrap Processing	Depot for LPG	Water Treatment Plan
Cutting Unit	Oil Storage	Sewerage treatment plant, Sewerage Farm
Scrap Sorting yard	Processing	Effluent Treatment Plant

The soft copy of the Development Plan (DP) shared by AADA was observed to have inconsistencies in the coordinates, resulting in a mismatch between the proposed road network in the DP and the actual coordinates of the existing road network as captured through site survey.

To address this issue, it is recommended that the DP CAD files be re-evaluated and corrected with respect to an appropriate coordinate system, or alternatively verified and rectified through a detailed site-based re-survey prior to implementation.

Figure 2-22: AADA proposed development plan for the region



3 Ship Recycling Plots

3.1 Existing ship recycling plots

The Alang ship recycling yard stretching approximately 10 kilometres along the coast comprising around 153 plots, with 124 active plots (last 09 years data basis, till 2024).

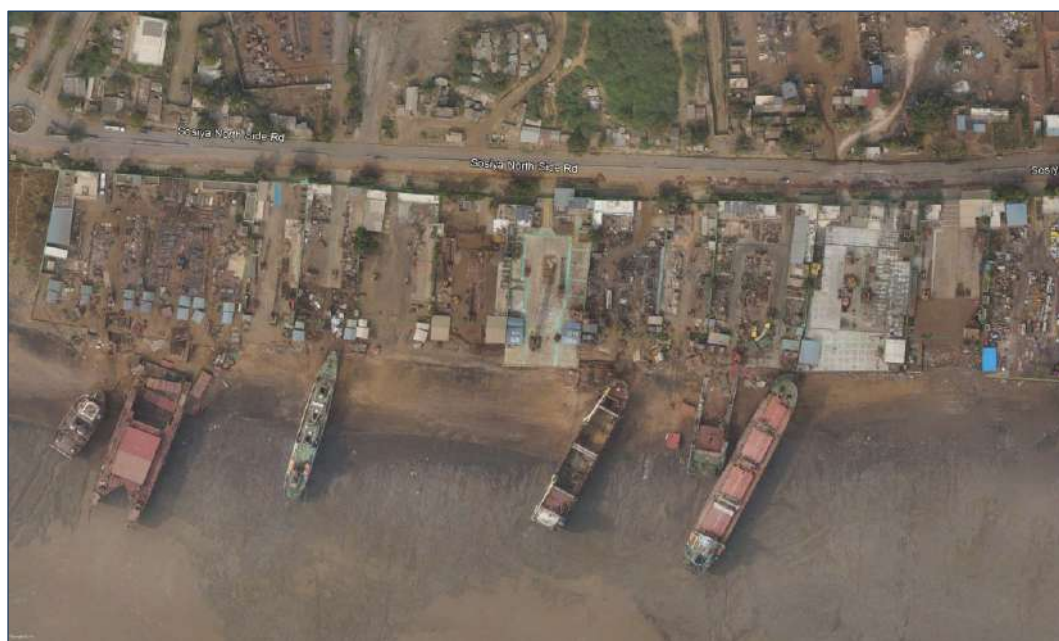
Many ship recycling plots at Alang have undergone changes over time due to consolidation and merging of plots. As of 2024, the yard comprised 153 plots, of which 124 were operational. All analyses, assessments, and projections in this chapter that are based on historical operational data refer to data collected up to 2024, covering a period of approximately nine years, and therefore adopt the plot configuration prevailing during that period.

Table 3-1: Existing ship recycling plots

Plot category	No. of Plots
Small size (1,000 - 5,000 m ²)	66
Medium size (5,000 - 10,000 m ²)	47
Large size (10,000 - 12,000 m ²)	11

At its peak production in the past, it was learnt that the yard employed nearly upto 30,000-40,000 workers, though the current workforce has declined to around 2,500-3,500, largely consisting of migrant labourers from states like Uttar Pradesh, Bihar, and Odisha.

Figure 3-1: Existing ship recycling plots



The ship recycling process at Alang involves beaching method where vessels are brought ashore for dismantling. In FY24, the yard dismantled around 125 ships, marking the lowest activity in 16 years. While safety concerns and environmental risks such as exposure to heavy metals and oil residues have historically plagued the industry, recent years have seen improvements in personal protective equipment (PPE), health screenings, and

regulatory enforcement. The facility operates under Indian laws and is progressing toward compliance with the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships. Despite its economic importance, particularly as a major contributor to India's scrap steel supply, declining activity poses challenges for the local economy and highlights the ongoing need for modernization and sustainability in the sector.

Currently, around 30 plots have applied for EU Ship Recycling Regulation (EU SRR) certification, out of which 3 plots have successfully undergone audits. It is anticipated that additional plots from the existing inventory will pursue EU approval and transition towards environmentally sound recycling practice.

3.2

3.2.1

Proposed ship recycling method

Proposed ship recycling method

The Alang-Sosiya Ship Recycling Yard is preparing to handle increased ship volumes in line with global trends, making it essential to assess dismantling methods such as drydock, slipway, and beaching, to determine the most compliant and suitable approach that leverages existing strengths.

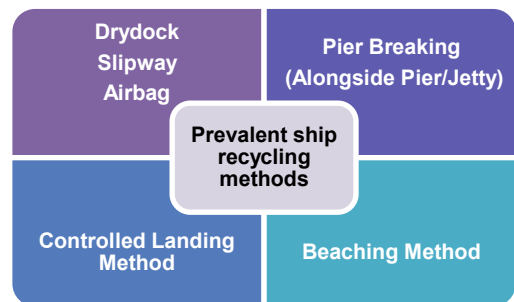


Figure 3-2: Methods of ship recycling



Source: Adapted from OECD (2019), *Ship recycling: an overview*, OECD/Paris

A detailed analysis of each method is presented as under:

3.2.1.1 Drydock: Applicability in Alang

A drydock is an enclosed structure used for ship dismantling, typically located in areas with adequate natural draught to allow vessel entry. Ships are positioned on keel blocks,

stabilized, and the water is pumped out to expose the hull for dismantling in a contained, controlled environment.

Key advantages for Alang:

- Accommodates large vessels (e.g., ULCCs, large container ships).
- Provides full containment, minimizing environmental impact.
- Enables compliance with **HKC** and **EU SRR** through impermeable flooring and drainage treatment systems.
- Controlled working conditions, unaffected by tides or weather.
- Enhances worker safety due to better access and ship stability.
- Likely to attract **EU-flagged ships** due to regulatory alignment.

Challenges of implementing drydock at Alang

While drydocks offer clear environmental and compliance advantages, their implementation at Alang faces significant geographical, technical, and financial barriers. Considering Alang's existing infrastructure, natural coastal profile, and economic model, the feasibility of a drydock is extremely limited. The beaching method, with ongoing upgrades for improved safety and compliance, remains the most viable and sustainable option for ship recycling at Alang in the near to medium term.

- **Geographical & environmental constraints**

- **High tidal variation (~10 m):** Requires complex design to manage fluctuating water levels.
- **Strong coastal currents:** Risk of long-term erosion and operational complexity.
- **Shallow depth and sloping beach:** Requires extensive dredging for approach channels and basin.
- **Sediment deposition:** Needs regular maintenance dredging, increasing costs and impacting marine ecology.
- **Unstable soil conditions:** May need advanced foundation solutions (e.g., deep piles), escalating capital costs.
- **Seismic vulnerability:** Design must account for potential earthquakes.
- **Cyclonic activity:** High risk of storm damage from Arabian Sea cyclones.

- **Engineering & construction challenges**

- Requires advanced design modelling and expensive feasibility studies.
- Complex logistics for material and equipment transportation to site.

- **Cost & infrastructure burden**

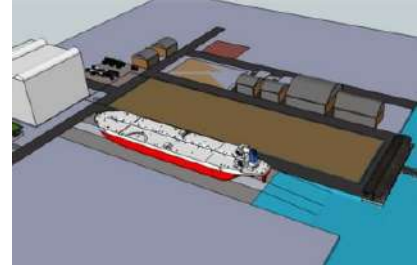
- **High capital costs:** Due to excavation, concrete structures, heavy-duty pumps, caissons, cranes, and compliance systems.
- **Operational expenses:** Higher than beaching/landing due to continuous dredging and maintenance.

- **Comparative disadvantages**

- **Lower throughput:** Ships handled sequentially, reducing annual dismantling capacity.
- **Higher costs vs. beaching:** Alang's dominance is driven by low-cost beaching methods; adopting drydock could reduce competitiveness and deter investment.

3.2.1.2 Slipway: Applicability in Alang

A slipway is a sloped, engineered structure extending from land into the sea, designed to haul vessels out of water using a cradle and mechanical winching systems (ropes, chains, pulleys, and winches). It is often viewed as an intermediate solution between drydock and beaching/landing methods, offering a balance between capital investment and environmental compliance.



Key advantages for Alang:

- **Lower capital investment:**
 - Slipways involve less initial investment and construction complexity than drydocks. While more expensive than traditional beaching infrastructure, they are comparatively simpler to build and maintain.
- **Moderate environmental control:**
 - Properly designed slipways can include impermeable surfaces, drainage systems, and containment features that enhance compliance with environmental regulations such as the HKC and EU SRR.

Challenges of implementing slipway at Alang

Slipways may offer a viable intermediate option for select plots at Alang that focus on small to medium vessels. However, their applicability for handling larger ships is constrained by technical limitations and environmental considerations, making them a niche solution rather than a broad replacement for the existing beaching model.

- **Risk of environmental runoff:**
 - Without proper containment, dismantling operations on slipways may lead to pollutant runoff, contaminating surrounding land and water.
- **Regulatory compliance costs:**
 - Achieving full compliance with EU and HKC standards would require additional investments in environmental and safety infrastructure.
- **Tidal influence:**
 - Operations may still be affected by tidal variations, complicating ship handling and dismantling schedules.
- **Vessel size limitations:**
 - Slipways are generally unsuitable for large vessels (above ~250 m in length) due to the risks associated with hauling operations. Their application is therefore limited to small and medium-sized ships.

3.2.1.3 **Controlled landing method: Alang's practical evolution**

The controlled landing method represents an improved version of the traditional beaching approach. Ships are manoeuvred onto a prepared, semi-engineered platform using tugs, winches, and ropes during high tide and are grounded in a planned, gradual manner as the tide recedes. The method incorporates reinforced intertidal and supratidal zones with impermeable surfaces, containment systems, and designated primary cutting areas, helping reduce environmental impact and improve worker safety.

This method is modelled on practices followed in **Aliaga, Turkey**, where modified landing yards have achieved EU SRR approvals. Several plots in Alang are now attempting to adopt similar features to meet international standards.

Key advantages for Alang:

- **Low capital investment:**
 - Requires minimal infrastructure upgrades (e.g., engineered slopes, impermeable flooring, drainage systems) compared to drydock or slipway systems.
- **Operational compatibility:**
 - Aligns well with the existing plot layouts and work practices at Alang. Workers are already trained and familiar with core operational steps, reducing the learning curve.
- **High throughput potential:**
 - Allows simultaneous handling of multiple vessels, including ultra-large ships, depending on plot frontage.
- **Customizable compliance:**
 - Compliance with EU SRR is feasible with suitable modifications, such as impermeable surfaces beyond the high-tide line, drainage and containment systems, and reinforced working platforms.

Challenges and mitigation measures:

The controlled landing method offers a cost-effective, scalable, and regulatory-aligned pathway for Alang's plots, particularly those aiming to transition toward EU-compliant operations. By building upon Alang's inherent strengths, this method presents the most practical and widely adoptable solution for enhancing environmental performance and worker safety.

- **Controlled movement and ship stability:**
 - Precise control during ship grounding, as well as adequate ship support and load distribution mechanisms, are essential to ensure stability and safety.
- **Environmental controls:**
 - Needs effective systems for pollutant collection and management in dry zones beyond the waterline.
- **Enhanced safety requirements:** Operational safety can be improved by integrating:
 - Friction-reducing systems over engineered slopes

- Use of slag trays, manlifts, staging, exhaust blowers, and controlled cutting protocols
- Maintenance of ship trim and ballast control during dismantling

3.2.1.4 **Pier breaking (Alongside Pier/Jetty)**

In Pier breaking, dismantling of a ship is undertaken while it is moored next to a solid, fixed pier or jetty. Instead of grounding the vessel on a beach, the ship remains afloat or partially afloat alongside the pier. Cranes and heavy machinery are used to dismantle the ship systematically and lift the sections directly from the ship to be loaded in trucks or transported to storage areas. Workers operate from the stability of the pier or from platforms on the ship itself. This method is considered more organized and offering contained dismantling process, as equipment, machinery, and waste collection systems are easily accessible from the pier. Pier breaking is typically used in locations where the natural shoreline does not allow for beaching or where there is already established port infrastructure.

Advantages:

- **Enhanced environmental control:**

- Reduces the risk of spills and allows easier integration of containment and waste collection systems.

- **Improved safety:**

- Workers benefit from a stable working platform, reducing risks associated with tidal movements or uneven terrain.

- **Efficient material handling:**

- Direct transfer of dismantled components from ship to pier allows for streamlined logistics and reduced material handling time.

Limitations:

While pier breaking offers controlled dismantling and safer working conditions, its applicability in Alang is limited by site-specific geographical constraints and high infrastructure requirements. It is not considered a feasible option under the current operating and economic model of the Alang-Sosiya ship recycling yard.

- **High infrastructure cost:**

- Construction of reinforced piers, jetties, and lifting equipment would require substantial capital investment.

- **Limited scalability:**

- More suited to small to medium-sized vessels, and less efficient for processing multiple ships simultaneously.

- **Geographical incompatibility:**

- Alang's natural sloping beach and open coastline are not conducive to pier-based operations. Establishing a pier dismantling system would conflict with the existing operational model and layout of the yard.

3.2.1.5 Airbag method

The airbag method involves using large, heavy-duty rubber airbags positioned beneath the hull of a vessel while it is afloat near the shoreline. Once properly aligned and inflated, the airbags slightly lift the vessel, reducing its draught and allowing it to be gently pulled ashore using winches, pulleys, and ropes. The ship moves gradually over a prepared surface through the rolling motion of the airbags, which helps distribute its weight evenly and minimizes structural stress.



This method is particularly useful in areas without natural beach slopes or where beaching is impractical. Once landed, dismantling proceeds similarly to the beaching or controlled landing methods.

Key advantages for Alang:

- **No permanent infrastructure required:**
 - The method eliminates the need for heavy civil works, making it a low-capital investment solution.
- **Reusability and cost efficiency:**
 - Airbags are reusable, reducing recurring operational costs.
- **Flexible vessel handling:**
 - Suitable for various ship sizes and hull types, and ideal for plots with limited depth or slope.
- **Smooth landing process:**
 - The rolling action ensures gradual and controlled movement, reducing hull stress and risk of structural damage.
- **Portable and adaptable:**
 - Airbags are easy to transport and can be adapted to different plot configurations and yard conditions.
- **Improved landing control:**
 - Offers better control over the vessel's landing position than traditional beaching, minimizing seabed disturbance.

Challenges and considerations:

The airbag method presents a low-cost, flexible alternative for bringing ships ashore in Alang, particularly for small to mid-sized vessels and plots with limited infrastructure or geographical constraints. However, its effectiveness depends on careful operational planning, ground preparation, and skilled handling. While not suitable for very large vessels or full containment of pollutants, it can be considered as a supplementary method in specific yard conditions or pilot applications.

- **Size limitations:**
 - Extremely large vessels may exceed airbag capacity, limiting applicability.
- **Operational risk:**
 - Incorrect placement or uneven inflation may cause instability or hull damage during movement.
- **Maintenance requirements:**
 - Airbags are prone to wear and tear and require regular inspection and maintenance.
- **Surface preparation needs:**
 - Landing area must be level, firm, and free of sharp objects to ensure airbag stability and longevity.
- **Weather dependency:**
 - High winds, tides, or rough waters may affect precision and safety during landing.
- **Environmental limitations:**
 - While more controlled than uncontrolled beaching, the airbag method does not provide full containment of pollutants, unlike drydocks.

3.2.1.6 Beaching method

The beaching method is the technique generally used in ship recycling plots in Alang, Bangladesh and Pakistan. In this method, the ship is brought under its own power or assisted by tugs during high tide onto a gently sloping beach closer to the ship recycling plots where it is beached and further assisted & guided by winches, ropes and pulleys. Once the vessel is beached and secured, the dismantling process begins. The ship is accessed using ramps, staging or ladders and the structure is cut down using oxy-acetylene or LPG torches from bow to stern. Cut steel sections are lifted using cranes and are moved to the secondary and tertiary cutting areas for further processing. The natural slope of the beach and tidal movement is utilized to move the ship as the cutting progresses. This method is labour intensive and is driven by advantage of natural topography, tides and slope. It has been the preferred method for Alang yard since Inception.

Advantages:

- **Low infrastructure cost:**
 - Requires minimal civil development, utilizing the natural sloping beach.
- **Tidal assistance:**
 - Takes advantage of high tide to bring vessels closer to shore.
- **Access to large vessels:**
 - Facilitates handling of large ships without deep-draught port infrastructure.
- **Employment intensive:**
 - Provides significant employment opportunities through manual labour.

Disadvantages:

- **Environmental concerns:**
 - Risk of oil spills, heavy metal leaching, and asbestos exposure during dismantling.
- **Lack of containment:**
 - Poor control over hazardous waste, especially in intertidal zones.
- **Worker safety risks:**
 - Exposes workers to falls, injuries, and toxic substances due to unstructured work environments.
- **Tide dependency:**
 - Operations are influenced by tidal cycles, affecting continuity.

Challenges specific to Alang:

The beaching method remains the most widely used and economically viable approach for ship dismantling in Alang, leveraging natural site conditions and enabling high-volume processing. However, it presents significant environmental and safety challenges and does not comply with international regulatory standards such as the EU SRR. Addressing these issues through controlled landing modifications, containment measures, and phased infrastructure improvements will be critical to ensure long-term sustainability and global acceptance.

- **Inadequate waste management:**
 - Limited infrastructure for containment, collection, and treatment of hazardous materials.
- **Worker safety issues:**
 - Insufficient personal protective equipment (PPE), training, and safety protocols.
- **Intertidal zone degradation:**
 - Repeated exposure to dismantling activities has led to ecological stress in the intertidal region.
- **Non-compliance with international norms:**
 - The existing method does not meet EU Ship Recycling Regulation (EU SRR) standards, due to the lack of impermeable flooring and containment systems in the primary cutting area.

3.2.1.7 Conclusion

Drydock has higher sustainability, compliance and are capable of handling very large ships. However, drydocks requires significant upfront investment and operational costs. Drydocks are vulnerable to damage from strong winds, storm surges and coastal flooding etc. For such high value projects, there are huge technical challenges related to design, engineering, construction and maintenance in Alang specific zone as discussed earlier.

Slipway offers a balance between compliance and cost. With proper upgrades, it can handle moderate size ships while adhering to environmental standards. But it also has

moderately high upfront investment requirement. Further handling large vessels on a slipway can be challenging and risky.

Controlled landing facility is cost-effective and can handle multiple large ships with higher output. However, it requires elaborate considerations for meeting EU regulations and workers safety standards. The tidal landing method is considered suitable for Alang due to its natural topography, high tidal range and shallow beach gradient. The controlled landing method can utilize the extensive Alang's shoreline to accommodate multiple ships simultaneously. This method also aligns with the region's established dismantling practices thereby minimizing operational costs and leveraging local expertise.

Table 3-2: Comparison of controlled landing facility, slipway and drydock

	Controlled Landing Facility	Slipway	Drydock
Cap Ex	Low	Moderately high	Huge
Development Period	6–12 months	18 Months–30 months	2–3 years or more
Capacity for Large Ships	Very High	Moderate (with proper design)	Very High
Environmental Risk	Moderate (can be reduced with upgrades)	Low to Moderate (with containment)	Very Low
Compliance (HKC/EU)	Achievable with upgrades	Achievable with upgrades	Fully compliant
Operational Complexity	Low	Moderate	High
Worker Familiarity	Very High	Moderate	Low (requires additional training)
Cyclone Resilience	High	Moderate	Low
Throughput	High	Low to Moderate due to limit on ship size	Lower than Landing method (due to sequential handling)
Maintenance Costs	Low	Moderate	High

Recommendations

Based on the above comparison, controlled landing facility with adequate upgrades for EU SRR compliance is recommended for Alang expansion as this is the cost-effective method with high throughput.

3.2.2 Controlled landing approach for Alang

Considering that some of the recycling plots in Turkey have received approval for using landing method by EU, here some insights obtained through public domain information are presented below:

3.2.2.1 Excerpts from NGO shipbreaking platform¹

Difference from traditional beaching: Through the study of public domain information published by NGO Shipbreaking Platform² on EU list of approved facilities in Turkey, it was revealed that the method referred to as "controlled landing" is slightly more structured than the conventional beaching used in Alang. From the referred "NGO Shipbreaking Platform" following text is reproduced regarding landing method *"The bow of the vessel is grounded on the shore while the stern is still afloat. The blocks are then lifted by cranes onto a drained and impermeable working area. The plots do not resort to the gravity method, that is, dropping blocks into the water or onto the beach in this method"*. An article published on digital platform "Shipping watch³" has brought out contradictions related to thorough checks for approval of Turkish facilities quoting "NGO Shipbreaking Platform".

The NGO Shipbreaking platform has brought out challenges being faced by Turkish facilities in its report⁴. In its press release dated 20 December 2023, it refers to some requirements brought out in this report like inclusion of:

- Effective drainage channels as well as use of oil-water separators for wastewater treatment.
- Need for third-party verification of hazardous materials during dismantling.
- Proper hazardous waste removal
- Secure pulling and lifting equipment
- Introduction of proper gas-free operations
- Cold-cutting techniques

3.2.2.2 Inferences about Turkish facilities in Aliaga

It is pertinent to mention that the tidal difference in Aliaga⁵ Turkey is insignificant compared with the tidal difference in Alang. As inferred from the NGO Shipbreaking Platform report, the Aliaga facilities try to meet the EU requirement by *"Lifting the blocks by cranes onto a drained and impermeable working area. The facilities do not resort to the gravity method, that is, dropping blocks into the water or onto the beach in this method⁶"*. It is also inferred from the above, that in Turkish facilities, the primary cutting zone in the landing area does not appear to be impermeable. This is further corroborated from google earth images of the Aliaga facilities.

3.2.2.3 Proposed "Controlled Landing Approach" at Alang

Taking a cue from approval of shipyards in Turkey despite contradictions as brought out by some digital platforms referred above, the adoption of landing method in Alang is possible with improvisation over the existing method and model it on Turkish yard's landing method.

¹ <https://shipbreakingplatform.org/ngo-sbp-publishes-report-on-shiprecycling-in-turkey/>

² <https://shipbreakingplatform.org/our-work/the-problem/turkey/>

³ <https://shippingwatch.com/regulation/article16709762.ece>

⁴ <https://shipbreakingplatform.org/ngo-sbp-publishes-report-on-shiprecycling-in-turkey/>

⁵ <https://www.tide-forecast.com/locations/Aliaga-1/tides/latest>

⁶ <https://shipbreakingplatform.org/our-work/the-problem/turkey/>

In Alang, carefully designed **impermeable reinforced low friction padded slope like interventions duly incorporating drainage channels 3-7 m beyond the start of impermeable zone (or as appropriate) on land side along with** sediment filters, traps and adequate capacity drain tanks can be introduced in the primary cutting zone that could extend approximately 25-30 m towards landside above High Tide Line into the plot boundary. The ships can be brought onto this gently sloping platform on the shoreline along with high tide with careful planning and calculations and if required, with the additional help of suitable arrangements such as guiding rails, cradles for bow region or airbags placed on approximately 25 m impermeable slope and around 30-40 m semi-engineered compacted intertidal seabed. The ships are then made to stabilize on the slope when tide recedes. The airbags can be deployed with pressure adjustment for greater control, necessary safety measures and infrastructure to handle hazardous materials.

- **Impermeable slopes:** The primary cutting area extends around 25 m depending upon the plot size and cutting strategy on dry land beyond high tide line inside the plot with gentle slope aligning with natural beach gradient in the intertidal zone coupled with drainage channel at least 3-5 m well beyond the high-water line to avoid ingress of sea water with associated filters, traps and collection tank and oily water separator. The 30-40 m intertidal area adjoining High tide line may be semi-engineered or compacted for even load distribution if airbags are used for supporting the forward bottom of the ship. Concrete with suitable reinforcing material can be used in the primary cutting zone and the slope be designed to arrest the direct seepage of contaminants into the soil.
- **Improved drainage systems in landing zone:** The plots may include drainage systems that capture any runoff or spills from the ship dismantling process. These systems can be designed to prevent contaminated water from entering the sea directly and collecting it for treatment using drain collection system and oily water separators.
- **Collection of runoff:** The drainage system can be designed to collect any runoff or spilled oil, fuel or contaminated water during the dismantling process in the landing area.
- **Channels and drains:** The sloped impermeable surfaces in the landing zone can be equipped with channels, trenches or drains that guide any liquids toward a collection system to prevent pollutants from seeping into the ground or mixing with seawater.
- **Critical cutting and segregation operations:** Critical dismantling operations involving hazardous materials are to be undertaken on impermeable platforms or concrete pads. These platforms should be equipped with proper drainage and collection systems to capture and treat any hazardous substances, such as oil residues, bilge water or other pollutants that may be released during the cutting process.
- Facilities should be equipped with systems to handle and treat waste, such as oil-water separators.
- The plots need to follow strict hazardous waste handling protocols in compliance with HKC and EU SRR.
- Plots must meet EU standards for worker safety standards such as providing appropriate PPE protective equipment, ensuring proper training and having safety protocols in place.

- The recycling process should be monitored and supervised to ensure that dismantling is carried out safely and according to environmental guidelines.
- It is brought out that notwithstanding incorporation of provisions listed in this report, the inclusion in EU approved list of recycling facilities totally depends upon satisfying EU auditors regarding meeting all EU SRR requirements which may be subject to change based on evolving requirements.

3.2.2.4 Suitability of controlled landing method

Considering the requirement to dismantle Ships 350–450 m in length and 50–65 m in beam, the controlled landing facility with careful engineering, adequate upgrades and safety provisions may emerge as the practical and cost-effective solution. While alternatives such as drydocks and slipways have their advantages, the unique characteristics of Alang's topography, weather patterns and economic considerations strongly favour a facility that builds upon inherent strengths of Alang. The subsequent paras articulate the rationale for considering modified landing facilities in newer plots that are to be developed south of Alang towards Mathwada along with addressing viability considerations.

- The initial capital expenditure required for modified landing facilities is expected to be lower compared with drydocks or slipways and this makes them more economically viable as they achieve higher throughput by processing multiple ships simultaneously
- Controlled landing facilities can be developed and made operational in significantly lesser time compared with the lengthy construction periods required for drydocks or slipways. This would result in early revenue generation which would be crucial for managing cash flows in this capital-intensive industry.
- The region's exposure to tides, cyclones and seasonal weather variability makes landing facility more technically viable compared with drydock and slipway method.
- Alang's tidal range naturally supports beaching operations which could be extended to modified landing operations of ships during high tide and dismantling during low tide

3.2.2.5 Modified controlled landing method for Alang based ship recycling plots

It was learnt that some of the Alang recycling plots that have upgraded their facilities and opted for EU audits with encouraging initial feedback regarding compliances. Apparently, these plots were able to display their use of modified landing method and were able to cut ship's double bottoms on impermeable floor with a proper drain system. In some cases, it is learnt that the plots can pull the ship beyond this drain line so that primary cutting of bow, aft, double bottom and side shell part of the vessel can be carried out on the impermeable concrete floor with efficient drainage.

Further, similar to Turkish yards, the hull of the ship can be impermeable surface by maintaining integrity of the lower hull/double bottom. The slag trays can be deployed for collection of slags, and the cut blocks can be lifted and taken to impermeable secondary cutting zone for processing.

Despite the advantages of drydocks and slipways related to EU SRR compliance requirement, the modified landing facility is the most practical solution for Alang as brought out in the previous sections.

By improvising the intertidal zone and providing impermeable slope beyond intertidal zone for ship recycling through innovative design and additional compliance measures through introduction of impermeable slope with containment measures, the adoption of modified landing method for ship dismantling appears to be a viable option for Alang's newly proposed ship recycling facilities to ensure seamless integration with forthcoming market targets. If implemented, the individual plots may carefully engineer the design aspects as per their operational needs, cutting strategies, machine capabilities and crane capacities etc.

Further, it is also recommended that GMB may implement a pilot model recycling facility as a test case for study/research of the evolving ship recycling process complying with HKC & EU SRR and demonstration before phase-1 of the master plan execution in one of the existing un-utilized plots (preferably 60 m or above waterfront width). This facility should be fully optimized as per earlier recommendations and compliant with HKC and EU SRR requirements. This could be implemented in collaboration with stakeholders such as Central Govt, research/academic organisations/ship-owner's association, potential investors, EU and class societies etc. Such a model facility could be used for training, demonstration, and for further studies/research related to improvisation of various aspects of safe and efficient ship landing and recycling in continuously evolving scenario and changing dynamics of international regulations. Such a facility after establishing all aspects of the safe and compliant controlled landing method would also serve as a template for newer larger plots to be developed in future phases.

3.2.2.6 Operational caveats and risk considerations for beaching heavy vessels at Alang-type intertidal zones

The beaching and landward movement of large vessels across extensive intertidal flats involves multiple interacting uncertainties. These uncertainties arise from hydrodynamic, geotechnical, environmental, and structural factors that can influence the magnitude and distribution of forces acting on the vessel. The following caveats describe key domains of risk inherent in such operations.

A. Tidal variability and hydrostatic sensitivity

Beaching in shallow-gradient environments is highly sensitive to the precise tidal level at the moment of grounding. Small variations in peak tide height, phase lag, or timing of approach can alter the vessel's under-keel clearance and the extent of initial ground contact. These changes directly affect the onset of lost buoyancy, the magnitude of ground reaction, and the subsequent forces required to initiate movement. Residual tidal currents at or near high water may also induce sideways drift or misalignment.

B. Trim distribution and hydrostatic balance

Large vessels approaching the beach typically maintain a modest stern trim. As depth decreases, bow contact may occur while the stern remains buoyant, producing asymmetric grounding conditions. Variations in ballast distribution, onboard liquid transfer, or hydrodynamic squat may shift the point or extent of first contact. These effects can influence both localised bearing pressures and the global distribution of grounded weight.

C. Seabed strength, consolidation, and suction behaviour

The silty and clayey sediments characteristic of Alang's intertidal zone exhibit non-uniform shear strength, variable consolidation, and spatially irregular stiffness. Local layers of soft

or semi-fluid mud can reduce shear resistance, while consolidated pockets may produce concentrated reaction forces. Prolonged dwell time can increase soil adhesion and suction, raising breakaway loads well above running loads. Temporal changes in pore-water pressure, drainage, and soil settlement between tidal cycles can further alter ground-reaction characteristics.

D. Hull orientation and contact geometry

Small deviations from perpendicular alignment relative to the beach gradient may lead to uneven bearing pressures across the hull. Localised seabed irregularities, such as ridges, under ridged patches, or debris, can create point or multi-point contact zones. These conditions may produce elevated reaction forces, differential grounding between port and starboard sides, and non-uniform load paths along the hull structure.

E. Traction forces and line load behaviour

The forces required to initiate and maintain vessel movement over the seabed are not constant. Breakaway loads may substantially exceed running loads due to static friction and suction effects. The non-linear development of ground reaction as additional hull length settles can cause rapid changes in traction demands. Winch lines may experience transient load peaks, oscillations, or sudden slack-snap behaviour when traction is uneven or external disturbances occur.

F. Environmental disturbances.

Wave action, swell, or long-period oscillations superimposed on the tidal cycle may produce intermittent vertical motions at the bow or mid-body. These motions can influence the instantaneous ground reaction and frictional resistance. Cross-shore winds can induce yaw during grounding, contributing to misalignment or asymmetric contact patterns. Seasonal siltation or localised erosion may alter seabed profiles between operations.

G. Structural load concentration risks

Large vessels traversing shallow gradients may experience concentrated soil reaction at the forefoot or areas of the flat bottom. Multi-point grounding, uneven contact distribution, or differential settlement can impose torsional or bending loads on the hull girder. Long parallel mid-body sections are particularly sensitive to small changes in seabed topography over extended contact lengths.

H. Uncertainties in soil–water interaction

Where fluid mud layers are present, the soil may behave as a viscoplastic medium with variable yield stress and viscosity. Under-keel clearance that is small relative to mud-layer thickness may lead to internal wave generation or pressure build-up at the mud & water interface, creating additional but unpredictable resistance. These conditions introduce complexity beyond classical Coulomb friction and require caution in interpreting calculated traction forces.

Note: General responsibility of operator and plot owner

The processes of grounding, pulling, and manoeuvring heavy vessels across intertidal zones entail inherent uncertainties related to tide, seabed behaviour, soil consolidation, suction, environmental conditions, and structural load distribution. It remains the

responsibility of the vessel operator and the plot owner to ensure that the overall operation is planned, monitored, and executed in a manner that adequately addresses these uncertainties, considering the prevailing site conditions, geotechnical characteristics, and any operational constraints applicable to the specific plot.

3.2.2.7 **Environmental measures in modified landing method**

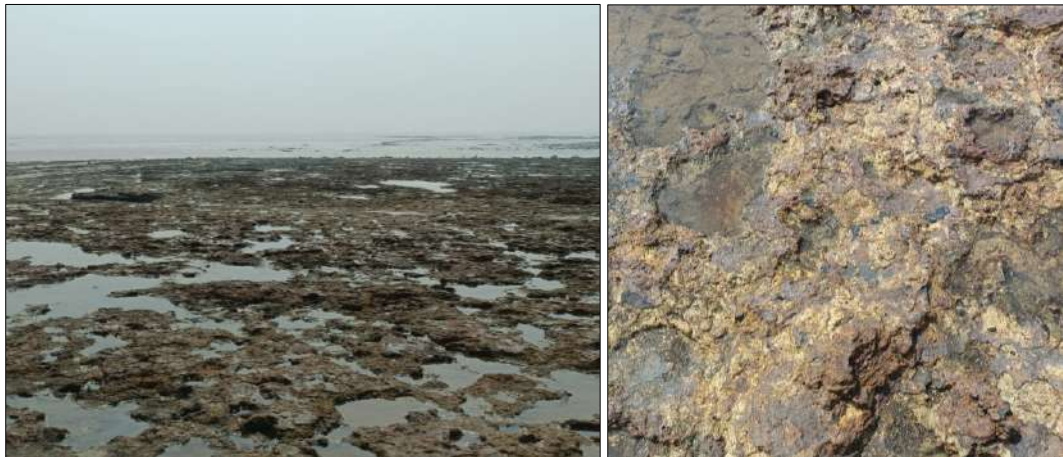
The primary dismantling area would be within the land well beyond the high tide line that makes it environmentally compliant by implementing impermeable surfaces using:

- Steel linings or reinforced concrete.
- Drainage systems to collect runoff and direct it to treatment plants.
- On-site waste treatment units such as oily water and bilge water separators for reducing pollution before disposal.
- Adhering to impermeability requirements.
- Implementing worker safety protocols, such as protective gear and well-defined dismantling procedures.

3.2.3 **Intertidal soil characteristics**

The soil in the proposed section of area, particularly in the intertidal zone, is characterized by a rocky terrain that can poses challenges for ship recycling activities. The site's intertidal area is predominantly composed of clay and some laterite presence, which, while presenting a firm base, requires some degree of dredging and levelling to create a suitable, flat surface for smooth ship landing and recycling operations.

Figure 3-3: Hard shore in the proposed expansion



3.2.4 **Primary cutting zone**

All the zones except green areas are required to have impermeable flooring in accordance with HKC and EU SRR. Cover all cutting zones (primary, secondary and tertiary) and scrap stacking areas with impermeable flooring to prevent soil and groundwater contamination. Impermeable surfaces should be reinforced with a leachate collection system. Extend impermeable surfaces to include all storage zones (e.g. oily block, non-ferrous, hazardous waste) and machinery areas.

Since the ship hull must land/be brought on primary cutting zone of the plot, special attention towards this zone is required in terms of design engineering, structural stability and protective measures regarding pollutant outwash.

3.2.4.1 Structural design considerations

Design considerations in respect of impermeable slope within primary cutting zone are suggestive and more elaborate design considerations and process by specific plot owners must be exercised as per site conditions and operational requirements:

Base structure:

- The base could be constructed using reinforced concrete slabs with a suitable design thickness of approx. 400–600 mm or more as per specific design requirement to withstand high concentrated loads.
- Reinforcement with high-strength steel mesh to handle dynamic and static stresses.
- Designing of the pad should ensure to distribute loads over a broader area using steel or composite load distribution plates under the keel points.
- Below the concrete slab, a multi-layered impermeable barrier system may be installed for further impermeability such as:
 - High-Density Polyethylene (HDPE) geomembrane as primary layer.
 - Geosynthetic clay liner (GCL) to provide an additional barrier.
 - A geotextile fabric above the GCL may also be incorporated to prevent mechanical damage from concrete during installation.

Figure 3-4: Impermeable primary cutting zone



(Note: The internal dimensions may be optimized by the individual plots as per their operational and implementation strategy)

Further reinforcement with steel plating surface (optional):

- Further reinforcement by Installing marine grade **steel plates** with thickness ranging from 20–25 mm or as per design requirement may be considered on top of the concrete slabs in the areas subject to the highest loads such as the keel path.
- The plate can be bolted or secured appropriately to the concrete slab to prevent movement.
- Use of composite or rubber liners between the steel plates and concrete may reduce stress concentration.

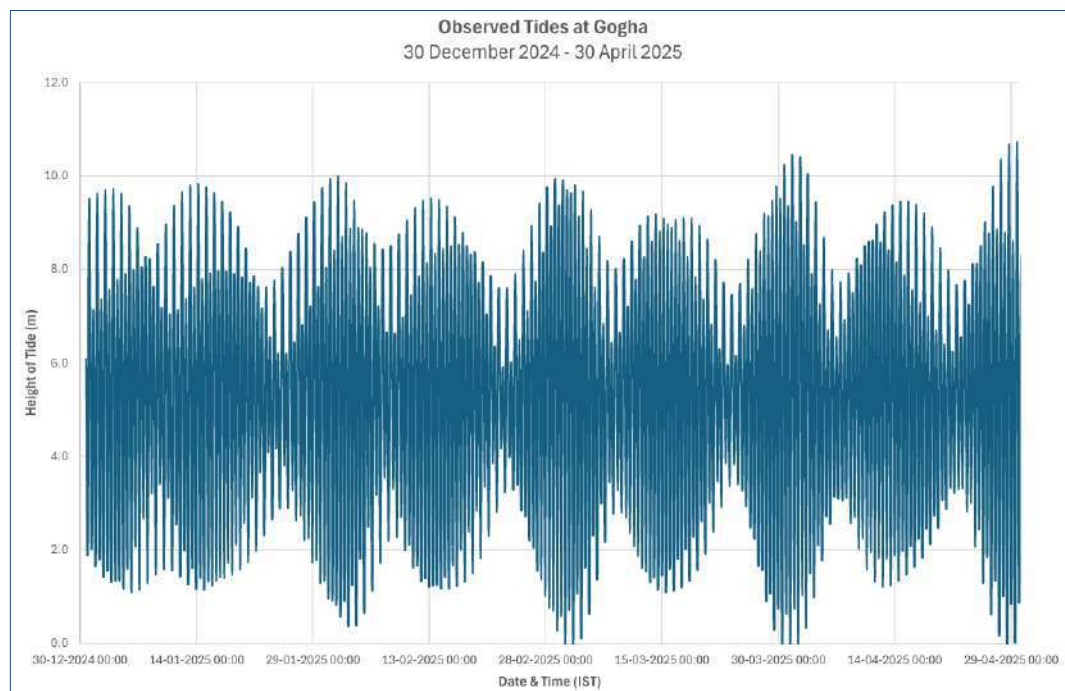
3.2.4.2 Level

Demarcation of High Tide Level provided by National Centre for Sustainable Coastal Management (NCSCM) portal as per CRZ 2011 for Alang and plotted in the best way possible to tag the High Tide accurately. However, it is observed to have an error (offset) in scaling for each point from the actual position. It is advised to demark CRZ mapping for the entire 20 km stretch by National Centre for Sustainable Coastal Management as per CRZ 2019 for the modified HTL.

In order to assess the best elevation to position the primary cutting zone, the tidal measurement data as well as shoreline obtained from the admiralty chart have been referred and concluded that positioning the primary cutting zone at 9.5 m above the CD be an optimum level considering the existing ship recycling plot positions and High-Water Line.

Though the highest astronomical tide in the tidal chart is beyond 10 m from CD, the placement of primary cutting zone at 9.5 m is adjusted to in order to be able to pull ship on to primary cutting zone easily and only very few times in an astronomical cycle the water will reach on to primary cutting zone for a minimum amount of time and at this times the drainage chambers can be shut down to avoid water and soil jamming the drainage line.

Figure 3-5: Tidal chart

**3.2.4.3 Slope****Land-based impermeable slope**

Approximately 25 m from HTL or as appropriate, engineered as per plot's operational design requirement, gentle gradient merging with beach gradient while ensuring that sea water does not rise beyond HTL during high tide Spring.

- This would be the cutting area for bow, aft, double bottom and side shell sections.

- It must be equipped with efficient drainage and waste collection system. The drain system is recommended to be provided with sediment traps and filters before the runoff enters drain tanks. Water Centrifuge separation system to be incorporated.
- This area needs to be provided with high-impact resistance materials to handle large block removals.

Intertidal semi-engineered/compacted slope (30-40 m extension into sea after primary cutting zone)

- Provided with **reinforced support** (geotextile or compacted sand) to prevent excessive sinking.
- Use of load bearing rubble with clay and laterite soil to form a gradual slope in case of filling required
- This allows for safe ship movement before dismantling begins.
- Helps stabilize the ship when it is partially afloat at high tide.
- Would help in deploying airbags for supporting the vessel while pulling the ship with winches if required.

3.2.4.4 **Surface enhancement for friction reduction & movement control**

Some of the measures that could be considered (but not limited to) are discussed below

- **Reinforced concrete with UHMW-PE Coating /pads which is a durable low-friction surface** may be deployed for primary cutting area and impermeable slope in the surface contact area.
- **Marine airbags (Intertidal & beach areas):** Heavy duty marine airbags may be placed under the forward and forward-mid-ship sections. They will assist in reducing friction, impact as well as supporting the ship section when the aft section is afloat during high tide. It could also be used for **initial movement** to assist winching.
- **Heavy duty steel rollers (optional for land-based slope):** These may be provided to ensure **smooth ship movement** beyond the drain line.
- **Lubrication system:** In addition, water jets or greased steel plates may be considered to reduce hull resistance.

3.2.4.5 **Winching & controlled pulling system**

- **Heavy-duty winches (Positioned inland):** Adequate numbers of heavy-duty winches with multi-stage pulley system for mechanical advantage and wire ropes/chains may be used to move the vessel gradually beyond the drain line during high tide.
- Multi-Point winching may be employed to ensure even pulling force distribution to prevent misalignment.
- **Tidal synchronization:** The ship should be moved during high tide to reduce frictional resistance and floating support.

3.2.4.6 **Other measures**

- A robust operational strategy duly considering all factors related to vessel movement, reception, securing recycling and subsequent disposal. A ship recycling plan and Ship

Recycling Facility Plan adhering to the compliance requirements of HKC and EU SRR must be in place.

- Integrated drainage system for wastewater collection & filtration before disposal.
- Waste block transfer pathway be designated area for safe movement of cut sections.
- Pneumatic fenders may be deployed to prevent stern impact from wave motion.
- Slag collection trays of at least 2 m width- may be deployed to collect slag around the primary cutting area.

3.2.4.7 Conditional provision of finger jetty:

As per the suggestions by CRDF, to consider conditional provision for inclusion of finger jetty in the plot layout at the discretion of plot owners. However, such discretionary provision would be subject to meeting following conditions and caveats:

- Provision of finger jetties shall be optional at the sole discretion and responsibility of the individual plot owner and shall be subject to specific design approval, environmental clearance, and operational approval by the Gujarat Maritime Board (GMB) and relevant regulatory authorities.
- Jetties must not interfere with ship beaching, tidal flow, or sediment transport patterns within or adjoining plots.
- Approval will be conditional, revocable, and site-specific.

Environmental caveats for finger jetties

1. EIA/CRZ clearance for any jetty proposal would be mandatory
 - i Each proposal shall undergo environmental scrutiny under Coastal Regulation Zone (CRZ) norms and, where required, a rapid EIA.
 - ii The design must demonstrate no adverse impact on intertidal ecology, sedimentation, or neighbouring yard stability.
2. There should be no encroachment into active intertidal work zone
 - i The jetty head shall not obstruct beaching approaches or block natural tidal flushing.
 - ii A minimum buffer must remain between the jetty and the active dismantling/beaching area.
3. Materials and runoff control
 - i Jetty decks shall be impervious; all runoffs must be routed to oil water separators or settlement pits before discharge.
 - ii No cutting, storage, or scrapping operations allowed on or under the jetty.
4. Sediment monitoring: Operators must conduct periodic bathymetric surveys and report any accretion or scour >0.3 m. Corrective dredging or structural modification may be required in such a case.

Capacity and approval process:

1. Each yard shall submit:
 - i Concept design drawings, structural calculations, and hydrodynamic/ sediment impact note.
 - ii Operational justification (why a jetty is necessary for the plot).
 - iii EIA summary and mitigation plan.
2. Review must be undertaken by GMB and regulatory authorities including MoEFCC (if required) prior to construction.
3. Annual compliance audit must be undertaken by third-party verifier.

Revocation and liability

- If a jetty is found to cause erosion, deposition, or operational hazard to adjoining plots, or environmental non-compliance, GMB may require modification or removal at the owner's cost.
- The yard operator shall maintain insurance and indemnity covering third-party damage due to jetty-induced effects.

Implementation

- Jetties must coexist with Alang's tidal beaching/modified landing method, where large hulls ground directly on the shore; no jetty shall compromise this fundamental process.
- Jetty use shall not create artificial "shadow zones" that trap pollutants or disrupt natural flushing of the intertidal zone.
- Movement of lifted blocks on the jetty (if allowed) must remain within HKC-compliant handling practices, using impermeable flooring and controlled lifting only.

Waterfront capacity responsibility

The provision of a finger jetty shall not entitle any plot owner to additional waterfront allocation or compensation for loss of usable frontage. Any reduction in effective beaching width, operational manoeuvring space, or throughput capacity arising from the presence or alignment of a jetty shall be solely the responsibility of the respective plot owner. GMB or regulatory authorities shall not be liable to adjust plot dimensions or operational entitlements on account of jetty-induced constraints.

3.2.4.8 Environmental measures**Drainage and containment:**

- A subsurface drainage system should be incorporated and should include embedded drainage lines or perforated pipes with the following features:
 - Pre-filtration grates to trap large debris and sand before it enters the drainage lines.

- Sediment traps or settling chambers to capture finer particles and prevent clogging of the main drainage system.
- Sloping design to ensure efficient flow of water and prevent stagnation.
- Sand exclusion traps or perforated screens at drainage inlets.

Drain shutting traps and valves

Though the drain channel is recommended to be placed 3-5 m above the HTL, to prevent sand and tidal water ingress during high tide during inclement weather, cyclones or monsoon, following additional features can be considered:

- Automatic tide responsive flap valves or float operated shut-off valves that close during high tide.
- Non-return valves (such as check valves) to prevent backflow into the drainage system.
- Timed drainage operations with sensors to restrict drainage opening only during low tide.

Pollution collection and management

The pollution collection system should be integrated with the drainage lines comprising of a sealed drain tank designed to collect and store pollutants including oil, hydrocarbons and heavy metals. An oily-water separator should be incorporated to separate and manage hydrocarbon contamination.

Surrounding bund:

The sloping impermeable platform can be surrounded with a bund lined with concrete or HDPE for containment.

Access and stability enhancements

- **Piled foundation:** In zones with weak subsoil or high tidal action, driven or bored piles can be used to anchor the concrete slabs.
- The reinforced slope can have gradual 1- or 2-degree gradient aligning with the beach gradient at the seaward edge to facilitate access to the ships.

Monitoring and maintenance

- Embedded sensors (e.g. piezometers or strain gauges) can be installed to monitor stress and movement and suitable devices for monitoring groundwater contamination.
- Regular inspections and maintenance are must for impermeable layers and drainage system including sediment traps, filters and drainage lines for continued compliance with EU SRR.
- Periodic desilting of the sump and settling chambers and routine maintenance of valves and tide-responsive mechanisms (if incorporated) should be undertaken to prevent malfunction.

Table 3-3: Challenges & mitigation suggestions for possible complexities

Challenge/weakness	Mitigation action
Tidal dependence	Implement automated tide monitoring with real-time alerts and windows for optimized winching.
Winching misalignment	Add laser-based alignment systems ⁷ or GPS-assisted positioning/tracking to monitor and correct pull vectors. Conduct regular calibration of winches.
Soil and geotechnical risks	The individual plot owners must perform detailed geotechnical surveys and finite element modelling (FEM) of load distribution. Use deep pile foundations where necessary.
Drainage system overload	Schedule quarterly maintenance with emergency overflow tanks. Add sensor-based sediment level alarms. Design redundancy into the drainage layout.
Equipment durability	Use marine-grade materials and establish predictive maintenance programs for airbags, rollers and winches. Keep critical spares on-site.
Weather events	Develop emergency shutdown procedures and temporary sealing systems (inflatable barriers, sandbags) to block drainage ingress.
Pollution spills	Install spill containment booms and mobile vacuum recovery systems. Use of oil booms around the vessel, till completion of oil removal from the vessel. Train staff in rapid-response protocols.

3.2.5 Compliance with guidelines

Ensuring compliance with international and national regulations is essential for establishing a safe, environmentally sound, and globally recognized ship recycling industry at Alang. The key regulatory frameworks that govern ship recycling operations are summarized below, with detailed requirements provided in Annexure A of this report.

3.2.5.1 Hong Kong International Convention (HKC), 2009

The HKC, adopted by the International Maritime Organization (IMO), sets forth comprehensive standards for safe and environmentally sound recycling of ships. It mandates that ship recycling facilities operate under a formally approved Ship Recycling Facility Plan (SRFP), which must include procedural systems for:

- Hazardous material management
- Worker safety protocols
- Emergency preparedness
- Waste management
- Environmental monitoring and control

Infrastructural requirements under HKC include the provision of impermeable flooring in cutting areas, drainage and effluent treatment systems, secure hazardous waste storage, firefighting and first-aid infrastructure, and environmental monitoring tools.

⁷ <https://www.trelleborg.com/en/marine-and-infrastructure/products-solutions/docking-and-mooring-systems/docking-aid-systems>

3.2.5.2 EU Ship Recycling Regulation (EU SRR)

The EU SRR (Regulation No. 1257/2013) applies to EU-flagged vessels and mandates that recycling be carried out in facilities listed on the European List of Approved Ship Recycling Facilities. The regulation imposes stricter compliance than HKC and includes detailed requirements for:

- Review and management of the ship's Inventory of Hazardous Materials (IHM)
- Full lifecycle waste management and documentation
- Advanced environmental and air emission controls
- Continuous health monitoring and worker training
- Enhanced infrastructure for secure berthing, safe dismantling, and pollution prevention
- Facilities must also implement internal audits, maintain detailed records, and demonstrate continuous improvement in operational performance and safety.

3.2.5.3 Indian Ship Recycling Act, 2019

Enacted to align India's ship recycling industry with HKC standards, the Indian Ship Recycling Act, 2019 provides a national legal framework for environmentally sound and safe ship recycling. It mandates compliance with:

- Approved SRFPs
- Worker health and safety standards
- Environmentally compliant infrastructure
- Hazardous waste management and emergency preparedness

While the requirements closely mirror those of the HKC, the Act provides legal enforceability within India and aims to elevate Indian ship recycling plots—particularly those at Alang to globally accepted standards.

4

4.1

Proposed Ship Recycling Plots

Approach to optimizing plot size and utilization for projected capacity targets

In the development of the master plan for achieving phase wise capacity targets, there is a requirement to look at the historical perspective through statistical analysis and combine it with other optimization techniques to achieve a robust transition strategy. It is also important to cater for uninterrupted current operations without disruptions while implementing the long-term vision of an optimized layout with projected capacity arising from the increasing demand for ship recycling operations. The approach is required to ensure that targets such as achieving 11.3 M LDT under accelerated scenario by 2040 and above if required, are met without losing existing business while meeting the stringent compliance requirement of HKC and EU SRR in addition to other national/local/international requirements are met.

4.1.1

Objective

The primary goal of the proposed approach is to transform the current industrial set up at Alang-Sosiya Ship Recycling Yard into a high-performing system of optimized plots that would maximize its productivity in terms of area utilization and worker level productivity to align with phase wise capacity targets. The approach caters for a balance between immediate operational needs and the progressive redesign of plots to meet future demand.

Key objectives include:

- Meeting phase wise ship recycling capacity targets with approx. 15% surplus to absorb unforeseen challenges.
- Minimum disruption to ongoing operations during the transition.
- To ensure efficient land use by avoiding over-expansion/underutilization.

4.1.2

Framework of the approach

The approach follows a structured and phase wise methodology described in the following paras:

- Statistical analysis of past nine years data provided by GMB and drawing useful inferences (though the data pertains to declined business period, however efforts are made to extract as much co-relation as possible).
- Detailed industrial analysis of some of the key metrics of few existing high performing sample plots as case studies. In this methodology, current productivity levels are mapped against physical dimensions and infrastructure facilities to establish correlation and establish a baseline for further improvement/optimization.
- Hypothetical modelling:
 - **Scenario building:** This involves analysis of various scenario and to simulate outcomes by hypothetically examining effect of improved dimensions or enhanced facilities.
 - **What-If analysis:** To assess "what if" scenarios, such as changes in ship recycling practices, infrastructure improvements or waterfront modifications etc.

- **Identification of optimal plot dimensions:** The optimal plot dimensions are identified through evaluating waterfront widths, plot lengths, resources and infrastructure requirements etc to achieve optimum production level in a practically achievable manner. The evaluation considers the principle of diminishing returns, accommodation of multiples and larger ships, worker's density, bottle necks etc. The optimized dimensions are to ensure that waterfront resources are utilized effectively while minimizing unnecessary expansions. Due care is taken to meet the requirements of EU SRR, HKC, Basel Convention Guidelines, National laws, ILO and ISO 30000, etc.
- **Phased transition to ideal configurations:** A gradual, phased plan is devised to reconfigure existing plots into the ideal sizes and allocation of new optimized plots as per requirement to enhance capacity requirements in phases. As per accelerated market scenario, the transition is aimed to align with year-wise targets viz 1.5 M LDT by 2025, 5.6 M LDT by 2030 and so on, culminating to 11.3 M LDT by 2040. And increase beyond aligning to future market.
- **Dynamic adjustments and market alignment:** Flexibility to adapt to the market conditions, while ensuring that capacity targets remain realistic and achievable is addressed in phasing programme. It is important that real-time data on market demand, worker productivity and operational constraints are analysed at plot level and yard level during each phase to recalibrate and refine the transition strategy.

4.1.3 Key highlights of the approach

4.1.3.1 *Diminishing returns consideration for plot size optimization*

- Plot widths and length are optimized only to the extent that they yield tangible productivity gains. Beyond this point, unnecessary extension is avoided to ensure efficient land use.

4.1.3.2 *Graded consolidation of plots*

- Efficient and high performing plots are recommended for retention with optimized layouts to accommodate requirements of international guidelines
- Constrained and inefficient plots can be merged/reconfigured phase wise in a graded manner to form larger and more efficient configurations.

4.1.3.3 *Scenario-based capacity planning*

- The strategy accounts for various scenario such as Business as Usual (BAU), Moderate and Accelerated scenario. Operational disruptions and reduced productivity (e.g. 85% capacity) etc are accounted for in the plot sizes combinations to still meet targets.

4.1.3.4 *Worker and unit area productivity*

- The approach carefully balances worker and unit area productivity to ensure that workforce and resources are utilized optimally.

4.1.4 Expected outcomes

- Enhanced productivity and capacity
- Operational continuity
- Efficient waterfront and land Use
- Long-term environmental, operational and economic sustainability even during fluctuating market conditions.

4.2

Statistical analysis of existing plots

GMB has shared plot wise production data since 2016. The data table placed at Annexure J has 153 plots⁸ out of which 124 plots that have produced in any of the nine years are considered here for statistical analysis. There are 29 plots (22 non-allotted and 07 with nil production) that have produced nothing in last nine years and are excluded from statistical analysis for drawing various inferences. The plots in the table at Annexure J are arranged in clusters as per their waterfront width in ascending order.

Table 4-1: Overview of plot analysis

A	Stated annual capacity of Alang Sosiya yard in LDT (GMB's estimate)	4,500,000
B	Overall plot area of all 153 Plots ⁹ m ² (from the GMB provided data at Annexure J)	783,133
C	Average achievable LDT/m ² (GMB estimated capacity/overall plot area=A/B)	5.75
D	Overall plot waterfront width (m) (from GMB provided data at Annexure J)	8933
E	Average achievable LDT/Waterfront width m (GMB estimated capacity/overall plot waterfront width=A/D)	503.75

4.2.1

Performance based ranking of the plots

The 124 plots that have performed in any of the last nine years have been considered for ranking.

Following procedure has been followed for ranking:

4.2.1.1 Step 1:

The dataset provided by GMB at Annexure J was rearranged containing information originally included and in addition new columns of key performance metrics have been added such as:

- **Max yearly LDT/ m²:** Maximum light displacement tons (LDT) achieved per unit area in a single year in last 09 years.
- **Average active LDT/m²:** Average LDT per square meter during the years of active production (i.e. when LDT > 0).
- **Goal:**
 - Normalize these two metrics.
 - Add the normalized values to compute a ranking score.
 - Rank the plots based on the combined score.

4.2.1.2 Step 2: Normalization

Normalization has been done using the following formula to ensure that both metrics are scaled to a comparable range (0 to 1):

$$\text{Normalized value} = (\text{Value} - \text{Min Value}) / (\text{Max Value} - \text{Min Value})$$

- **Max yearly LDT/unit area m²**

⁸ Plot numbers cited are based on the 2024 configuration used for data analysis

⁹ Plot numbers cited are based on the 2024 configuration used for data analysis

- Maximum value: 23.7
- Minimum value: 1.0
- Each value in this column is normalized using the formula above.

- **Average active LDT/m²**

- Maximum value: 9.9
- Minimum value: 0.5
- Similarly, values in this column are also normalized.

4.2.1.3 **Step 3: Add normalized metrics**

The two normalized values are added to calculate a ranking score that accounts for both max achieved and average productivity.

Ranking score=Normalized max yearly LDT/ m²+normalized average active LDT/m²

4.2.1.4 **Step 4: Assignment of ranks**

Using the combined score the ranks are assigned in descending order. Ties (if any) are assigned the same ranking to plots with identical score.

4.2.1.5 **Step 5: Rearrange the data**

Finally, the dataset is sorted based on the ranks, so plots with the best performance (highest scores) appear at the top.

The “Plot data table” as per the rank of the active 124 plots is placed at Annexure K.

4.2.2 **Statistical analysis**

It may be noted that the GMB data pertains to the last 09 years period which coincides with decline in the global and local ship recycling volumes. Out of 153 plots¹⁰, around 22 plots were non-functional due to various socio-legal issues and another 07 plots have shown nil production in all 09 years (In Nov 2024). These non-functional 22 plots and 07 plots with nil production in last 09 years have been excluded from any analytical considerations.

The maximum yearly production achieved by the respective plots in last 09 years is considered as benchmark for max yearly LDT production for further statistical analysis and interpretations **as this metric indicates the achievable potential of each plot** subject to proportional and favourable business opportunity.

The plots are categorized in four clusters based on waterfront width i.e. 30-50 m; 51-80 m; 81-100 m and 101-135 m. Following further statistical analysis is undertaken with regards to productivity measured per unit area, per unit length and per unit waterfront width. The detailed statistical analysis is provided at Annexure B.

The summary and finding of the statistical analysis are provided below:

4.2.2.1 **Conclusions drawn from overall statistical analysis:**

More than 50% plots in all categories have performed better than GMB’s estimate of maximum achievable productivity

¹⁰ Plot numbers cited are based on the 2024 configuration used for data analysis

- From overall analysis of all 124 plots, it is seen that both the mean and median of the max LDT/unit area/year are higher than the estimated average productivity of 5.74 LDT/m²/year based on maximum projected annual capacity of 4.5 M LDT/year for Alang Sosiya Yard. It indicates that the Alang plots have potential to achieve higher production capacity even though the last 09 years of data pertains to the decline period of ship recycling cycle.
- One important insight deduced is that high performing plots which are almost above 50 % in all categories of plots except 80-100 m waterfront width category have achieved better mean and median of max achievable LDT/m² in last 09 years. This is despite being in the declining stage of ship recycling cycle. These plots can be expected to achieve better productivity during peak of the ship recycling cycle with better facilities and layouts.
- Smaller plots have shown high productivity per unit area, while larger plots have displayed higher handling capacity and consistency.
- Small plots (30-80 m) show the most variability, suggesting room for improvement in workflows or resource allocation.
- Larger plots (100+ m) thrive on stability and specialization, which can be further leveraged for high-value, large-volume projects.
- Larger plots in 81-100 m and 100+ m category though have higher capacity in terms of total (cumulative LDT) but lower productivity compared with smaller well performing plots which tend to suggest diminishing productivity per unit area.

4.2.2.2 **Correlation and regression analysis**

The following parameters have been analysed using correlation and regression analysis

- **Correlation analysis:** Relationship between plot dimensions (e.g. area, waterfront width and length etc) and LDT recycled per unit length or width or area.
- **Regression analysis:** To derive models for LDT/unit length or area or width based on plot characteristics.

The detailed analysis is provided in Annexure C. The results, summary and recommendations from correlation and regression analysis is presented below: -

4.2.2.3 **Final take aways from the statistical analysis and regression & co-relation analysis**

- **Larger Plots.** It could be interpreted that larger plots seem underutilized probably due to low business volumes and are better suited for peak demands when higher volumes are handled and for handling specialized operations (e.g. dismantling ultra-large vessels). Larger plots (100+ m) with more consistent parameters and flexibility to accommodate changes can be considered ideal for Improving layout and aligning ship recycling strategies in accordance with HKC, Basel and EU guidelines. Better layouts and addition of technology may further help to increase their overall productivity as well
- **Medium and large plots** can benefit from optimization to improve their productivity. Investment in operational workflows, material handling and better technologies can help bridge the gap between perceived capacity and delivered output.

- **Smaller plots** (e.g. 30-50 m and 51-80 m) have some of the highest efficiency possibly due to compact layouts that allow faster and denser ship recycling as well as better worker and equipment utilization in confined spaces.
- It may be useful to examine plots with unusually high or low LDT/m² for insights into best practices or inefficiencies. The bottom 50 performers may be considered for mergers/modifications/relocation as per master plan. The plot size of 80 to 100 m is also the category which may be considered for consolidation.
- **Retain best performing narrower plots:** Retain operations around the best performing plots in 30-50 m and 51-80 m waterfront width range even during transition and consolidation, as these appear to be more efficient on a per-area basis. Making them compliant with HKC and EU SRR and increasing their length upto a certain point may be beneficial and will unblock their process lines for faster production. Beyond a certain increase, the diminishing returns are expected.

Note:

- It is pertinent to mention that the data for last nine years during a period of decline does not include trends of peak productivity years of 2010-2015 and therefore the peak achievable productivity could not be captured from this data. The peak achievable productivity under the same set of parameters is expected to be higher when the market peaks.*
- It was also learnt from GMB that the earlier data before 2016 does not pertain to the same set of plot sizes since there has been reconfiguration and consolidation in plots after 2016 so earlier data may not correlate with this set of data for the purpose of statistical analysis.*

4.2.2.4 Current capacity of Alang Sosiya ship recycling yard

Based on the statistical analysis, regression studies, baseline productivity assessments, and case study evaluations in the report, the rationale for taking 4.5 million LDT/year as the baseline capacity of the Alang-Sosiya Ship recycling yard is well thought off and multi-dimensional.

Here's the consolidated rationale:

- Alignment with empirical production data (GMB estimates)
 - The Gujarat Maritime Board (GMB) officially states the yard's baseline capacity as 4.5 M LDT/year. This was found to be the most conservative estimate of production capacity even on the basis of assessment of data of period of decline. The most conservative estimate has been selected as baseline to take care of uncertainties.
 - This figure corresponds to the maximum cumulative estimated output achievable by the configuration of 153 plots¹¹.
 - This estimate yields a yard-wide average productivity of approximately 5.74 LDT/m²/year and 503.75 LDT/meter of waterfront, as derived from the overall area and waterfront length data.

¹¹ Plot numbers cited are based on the 2024 configuration used for data analysis

- Validation from long-term statistical analysis
 - An extensive statistical review of 9 years (2016–2024) of production data shows that the mean max productivity per unit area was 6.786 LDT/m²/year and the median per unit area was 5.78 LDT/m²/year
 - Both mean and median are above the 5.74 LDT/m²/year baseline used to derive the 4.5 M LDT/year.
 - These values were observed during a business decline period, indicating that 4.5 M LDT is a conservative and achievable baseline even under suboptimal market conditions.

4.3 Baseline industrial analysis of existing high performing sample plots: case studies

In line with the basic principles of industrial engineering, one plot of each category i.e. small, medium and large was visited at Alang – Sosiya yard and analysed to infer insights into productivity and capacity related aspects of ship recycling activities. These plots have already progressed with HKC compliance and are also working to comply with EU SRR. After discussions with owners, stakeholders and observations at the site, relevant data was gathered to the extent possible for deep dive analysis. The case studies containing baseline industrial analysis of plots is presented at Annexure D. The findings of the case studies for small, medium and large plots are summarized below:

4.3.1 Summary of findings of case studies for small, medium and large plots

Table 4-2: Comparison matrix of various plot sizes

Aspect/ Parameter	Case study 1: Small (Plot no 30)	Case study 2: Medium (Plot No 11)	Case study 3: Large (Plot No V-1)
Dimensions (waterfront × length)	51 m × 130 m = 6,630 m ²	82 m × 111 m = 9102 m ²	120 m × 90 m + 21,000 m ² = 31,800 m ²
Potential extended dimensions	51 m × 220 m = 11,220 m ²	82 m × 200 m = 16,400 m ²	Additional processing area already included
Crane lifting capacity	18 tons/block	200 tons/block but max block limited to 100 tons by cutting constraints/complexities	280-300 tons/block (potential for 1,750 tons lifting)
Block processing rate	5-6 blocks/day (~100 LDT/day) 8-10 blocks/day with improvements	100 LDT/day regular 150 LDT/day maximum with same setup but improvements 350 LDT/day with length extension	~600 LDT/day (regular capacity); up to 1,200 LDT/day (max capacity)
Cutting and processing time per block	4-6 hours	~10 hours	9-12 hours
Daily block handling	5-6 blocks/day	1-2 blocks/day 3-4 blocks at peak capacity	2 block/day currently

Aspect/ Parameter	Case study 1: Small (Plot no 30)	Case study 2: Medium (Plot No 11)	Case study 3: Large (Plot No V-1)
	8-10 blocks/day at peak capacity		4 blocks/day at peak capacity
Workers required	150 workers (current strength) 220 workers (with extended area)	250 workers (current) 350 workers (extended area)	350 workers (regular) 600 workers (max capacity)
Worker productivity	0.66 LDT/worker/day $\approx$ 200 LDT/worker/year Target 1.09 LDT/worker/day	0.6 LDT/worker/day $\approx$ 180 LDT/worker/year Target 1.0 LDT/Worker/day	1.71 LDT/worker/day $\approx$ 513 LDT/worker/year (regular); Target: 1.76 LDT/worker/day $\approx$ 528 LDT/worker/year (max)
Unit area productivity (Current)	0.015 LDT/m ² /day $\approx$ 4.5 LDT/m ² /year	0.0164 LDT/m ² /day $\approx$ 4.94 LDT/m ² /year	0.019 LDT/m ² /day $\approx$ 5.7 LDT/m ² /year (regular)
Unit area productivity (Extended target)	0.0213 LDT/m ² /day $\approx$ 6.39 LDT/m ² /year with increased area (51 m x 220 m)	0.0213 LDT/m ² /day $\approx$ 6.4 LDT/m ² /year (82 m x 200 m)	0.0332 LDT/m ² /day $\approx$ 9.96 LDT/m ² /year at max targeted capacity)
Maximum achievable annual Capacity	30,000 LDT/year (current) ~70,000 LDT/year (max with extended area)	45,000 LDT/year (current) ~105,000 LDT/year (max with extended area)	180,000 LDT/year (regular) ~316,800 or more LDT/year (max target)
Actual maximum annual production in last 9 years despite market decline	44,570 LDT in 2017 (~149 LDT/day)	35,735 LDT in 2022 (~119 LDT/day)	125,974 LDT in 2016 (~419 LDT/day)
Block size limitation(current)	18 tons per block due to crane capacity	100 tons per block due to cutting complexities	300 tons per block due to cutting complexities. potential for 1,000–1,200 tons
Constraints	Limited crane capacity, inefficient layout	Limited scalability due to plot size	Workforce scaling, logistical complexity
Technology impact	Advanced cutting - 8-10 blocks/day; 30 ton per block, high-capacity cranes	Efficient layout, ability to handle faster cutting - Faster block handling	Optimized workflows, faster production - Higher capacity
Area impact	Additional Production can be achieved with additional area and improved crane capacity, layout and technology.	Additional Production can be achieved with additional area and improved crane capacity, layout and technology.	Sufficient area already available

4.3.2 Insights and Inferences

- **Productivity trends**

- Small plot no 30 has shown limited productivity (~4.5 LDT/m²/year) due to restricted dimensions, low crane capacity and layout inefficiencies. The plot

has potential to improve and the targeted potential with extension is ~6.39 LDT/m²/year.

- Medium plot No 11 has moderate productivity (~4.94 LDT/m²/year), with limited potential to increase to ~6.3 LDT/m²/year as target by extending the plot length to 200 m length or beyond.
- Large plot no V-1 has been able to achieve higher productivity (~5.7 LDT/m²/year regular; ~9.96 LDT/m²/year max target), thanks to larger dimensions, better layout and higher crane capacity.

- **Worker utilization**

- Large plot workers are significantly more productive, achieving up to 600 LDT/worker/year at regular capacity. This is almost 3 times the productivity of small plot workers due to advanced layouts, crane capacities and technology.
- Optimizing workers utilization through streamlined flow and introduction of advanced technologies such as RFID tracking, advanced cutting etc in small and medium plots has potential to increase their productivity further substantially.

- **Potential for expansion**

- Merging non-functional and poor performing plots into larger ones and extending land lengths up to 200-220 m is expected to improve capacity and productivity by unlocking bottlenecks and leveraging economies of scale. However, beyond a certain point, the extension of length follows diminishing returns as derived from statistical/regression analysis.
- Advanced technologies (e.g. plasma cutting, robotics) and higher-capacity cranes (30 tons for small plots; 100-200 tons for medium plots and 150-300 tons or more capacity for large plots) can bridge productivity gaps to large extent.

- **Challenges in scaling**

- Small plots face scalability issues due to their constrained waterfront and low crane capacities, even with extended lengths. Imperative that cutting rates and crane capacities along with effective layout required to be improved.
- Medium plots require significant upgrades in infrastructure and technology to match the productivity of large plots.

- **Reallocation of waterfront and area**

- For higher targets, the plot area should be distributed in the most viable and optimum manner.

4.3.3 What if analysis

4.3.3.1 What It Is

- **Current situation**

- The small plots have limited capacity due to restricted dimensions, low crane capacities and inefficient layouts.
- Medium plots: Their current worker productivity and unit area efficiency remain below optimal levels.

- Large plots dominate production with advanced layouts and technology. They handle heavy blocks (280–300 tons) and achieve up to ~ 600 LDT/day, with a potential for ~ 1,200 LDT/day at maximum target capacity.

- **Key strengths**

- The large plots benefit from additional land for dismantling and segregation, significantly reducing bottlenecks.
- Introduction of advanced technologies due to scale of economy on larger plots is more feasible allowing for faster cutting, higher block weights and better worker productivity.

- **Challenges**

- Small plots face scalability issues and inefficiencies in crane use and layout, leading to low output and high worker-to-output ratios.
- Medium plots are underutilizing their crane capacity (200 tons) and have limited space for block processing.
- Large plots, while highly productive, require significant labour scaling (up to 600 workers) and logistics management to achieve maximum capacity.

4.3.3.2 **What it could be**

- **Transformational potential**

- Small plots:
- Could also evolve into specialized zones for lighter dismantling or ancillary processes like segregating scrap.
- Could increase capacities and improve productivity by extending length to unblock bottlenecks and improve layouts. Introduction of advanced cutting methods, training of workers and resource management would help additionally.
- Merging smaller plots into large sized units (minimum 120 m waterfront) could drastically improve capacity and economies of scale.
- Medium plots:
- By extending plot lengths and introducing modern cutting technologies, production could increase substantially.
- Enhanced worker training and workflow management could achieve higher worker productivity.
- Large plots:
- With additional improvements such as automation (e.g. robotic cutting, automated cranes and optimized layout etc large plots could sustain ~1,000-1200 LDT/day regularly and peak at even higher productivity.

- **Plan for future**

- Small plots:
- Retain better performing plots by allocation of additional land. Must focus on compliances with HKC and EU SRR and improvement in layout and technology.
- Medium and large plots:

- Medium plots could be optimized for 300-350 LDT/day by extending land and upgrading infrastructure.
- Large plots could handle multi-ship operations at ~1,200 LDT/day regularly, with peaks possibly up to 1,500 LDT/day.
- Compliance with HKC is a must and EU SRR must be strived for.

- **Vision 2025 to 2040**

- Strategic reconfiguration and allocation of additional land.
- Efficient layouts meeting HKC and EU regulations.
- Efficient workflows and technology driven Operations.

4.3.3.3 Actionable roadmap

- **Infrastructure investments**

- Upgrade crane capacities
- Introduce automated cutting where possible to reduce processing times.
- Technologies that drive the productivity such as RFID tracking and digital workflow management should be incorporated.

- **Layout optimization**

- Extend plot lengths seaside or landside to accommodate processing of more blocks simultaneously.
- Use land behind the plots for dismantling and staging to avoid congestion.

- **Workforce management**

- Upskill workers to handle modern equipment.
- Implement optimized layouts and workflows to boost worker productivity to 1.0–2.0 LDT/worker/day.

- **Strategic mergers**

- Merge inefficient small and medium plots into larger, more efficient units.
- Phase out standalone small and medium plots that have shown poor outputs in the past and cannot scale.

Table 4-3: Key objectives

Metric	Current state	Future state by 2040
Annual capacity	~4.5M LDT/year	~11.3M LDT/year
Worker productivity	0.66–1.71 LDT/worker/day	1.0–2.0 LDT/worker/day
Unit area Productivity	4.5–9.6 LDT/m ² /year	6.0–11.0 LDT/m ² /year
Daily maximum output	~600 LDT/day (large plots)	~1200 - 1,500 LDT/day (plots of 240 M waterfront, optimized)

4.4

Identification of optimal plot dimensions

To determine the optimal plot dimension w.r.t plot length and waterfront width and identify the limit beyond which further extension yields no additional productivity gains, we will

analyse the case studies by considering constraints, productivity metrics and diminishing returns and arrive at optimum plot dimensions.

4.4.1 Methodology

The following methodology is applied here:

- Scaling technique to analyse how certain parameters would change with change in plot dimension. Production capacity in this case is considered proportional to the usable area for operations, if the worker density and infrastructure would scale appropriately.
- Proportional estimation for workers and infrastructure scaling.
- Constraint-based analysis to evaluate bottlenecks like cutting speed, crane capacity and block size limits.
- Diminishing returns assessment to identify the optimal point where productivity gains plateau.

Bottlenecks identified

- **Waterfront width** is a bottleneck as it limits the size and number of ships that can be accommodated side by side and also poses limit on parallel operations as well as workflow area.
- **Cutting capacity** due to limitation on cutting technologies, team co-ordination, capability to handle cutting complexities etc are bottlenecks which limit the size and numbers of the block that can be cut/processed.
- **Crane capacity** limits the size of the block that can be lifted and moved.
- **Length of the plot** restricts the processing capacity due to bottlenecks encountered in serial workflow. However, beyond a point, additional length will not yield any additional gain due to other limiting factors as mentioned earlier and logistics complexities.
- **Layout and team co-ordination:** The poor layout and inefficient team co-ordination can be a bottleneck.
- **Final disposal of recycled material:** The recycled material recovered needs to be disposed to avoid clogging the flow of operations and can become a bottleneck.

4.4.2 Optimisation of plots basis case studies

The detailed optimization exercise in respect of different sizes of plots based on earlier case studies is provided at Annexure E. The summary of optimization exercise and recommendations are provided below:

Table 4-4: Summary and recommendations based on optimization exercise

Parameter	Small Plot (No. 30)	Medium Plot (No. 11)	Large Plot (V-1)
Plot dimensions (Current)	51 m × 130 m = 6,630 m ²	82 m × 111 m = 9,102 m ²	120m × 90m + 21,000 m ² = 31,800 m ²

Parameter	Small Plot (No. 30)	Medium Plot (No. 11)	Large Plot (V-1)
Plot dimensions (Optimized)	51 m × 220 m = 11,220 m ²	82 m × 200 m = 16,400 m ²	Same total area, optimized layout
Crane capacity (Current)	18 tons/block	200 tons/block (limited to 100 tons)	280-300 tons/block
Crane capacity (Optimized)	30 tons/block	Maintain 200 tons but optimize usage	Optimize layout, maximize use of existing cranes
Cutting rate (Current)	5-6 blocks/day	1-2 blocks/day	2 blocks/day (regular), 4 (peak)
Cutting rate (Optimized)	8-10 blocks/day	3-4 blocks/day	4 blocks/day (optimized)
Daily production (Current)	~100 LDT/day	150 LDT/day	600 LDT/day (regular)
Daily production (Optimized)	~240 LDT/day	350 LDT/day	1,200 LDT/day (maximum)
Worker count (Current)	150	250	360 (regular), 600 (max)
Worker count (Optimized)	220	350	600
Worker productivity (Current)	0.66 LDT/worker/day (~200/year)	0.6 LDT/worker/day (~180/year)	1.71 LDT/worker/day (~513/year)
Worker productivity (Optimized)	1.09 LDT/worker/day (~327/year)	1.0 LDT/worker/day (~300/year)	1.76 LDT/worker/day (~528/year)
Unit area productivity (Current)	0.015 LDT/m ² /day (4.5/year)	0.0164 LDT/m ² /day (4.94/year)	0.019 LDT/m ² /day (5.7/year)
Unit area productivity (Optimized)	0.0213 LDT/m ² /day (6.39/year)	0.0213 LDT/m ² /day (6.4/year)	0.0332 LDT/m ² /day (9.96/year)
Annual capacity (Current)	30,000 LDT/year	45,000 LDT/year	180,000 LDT/year
Annual capacity (Optimized)	70,000 LDT/year	105,000 LDT/year	316,800 LDT/year
Actual max production (Historic)	44,570 LDT (2017)	35,735 LDT (2022)	125,974 LDT (2016)
Block size limit (Current)	18 tons	100 tons	300 tons
Optimization focus	Extend length, crane upgrade, technology	Length extension, layout, tech upgrade	Layout, parallel processing, automation

4.4.2.1 Recommendations for small plots (30-80 m width)

- **Current challenges**

- Limited waterfront width, restricting vessel size and processing rate.
- Low crane lifting capacity.
- Restricted layout and congestion.
- Worker productivity is relatively low.

- **Key recommendations**

- Extend plot length
- Increase length from existing length to 200-220 m (max practical before diminishing returns).
- Area increases supporting higher block flow.
- Upgrade crane capacity
- Replace or add cranes with higher lifting capacity to handle larger blocks efficiently.
- Cutting technology enhancement
- Introduce advanced cutting tools (plasma/laser cutting).
- Target 8–10 or more blocks/day from the current 5–6 blocks/day.
- Optimize layout
- Redesign for smooth block movement, end-to-end processing and reduced congestion.
- Boost worker productivity
- Increase worker level productivity through training and better coordination.
- Target annual capacity of at least up to 80,000 LDT/year per for a 50 m waterfront width plot and proportionately for other sizes.

4.4.2.2 Recommendations for medium plots (80-100 m width)

- **Current challenges**

- Limited length and moderate waterfront width.
- Underutilization of crane capacity (e.g. 200 tons but limited to 100-ton blocks).
- Moderate or low productivity.
- Worker productivity is low.

- **Key recommendations**

- Extend plot length
- Increase length up to 200-215 m (optimal before diminishing returns).
- Area increase will unlock potential and remove bottlenecks.
- Crane and processing upgrades
- Fully utilize crane capacity by improving primary cutting to handle 100–200-ton blocks.
- Consider twin processing lines for parallel dismantling.
- Increase cutting speeds
- Target at least 2 blocks of 100 tons per line per day, achieving up to 400 LDT/day.
- Layout optimization
- Streamline flow and minimize block transfer times with improved zoning.
- Boost worker productivity
- Increase through training and skill enhancement.
- Add trained workforce as required.

- Capacity goals
- Target annual capacity of up to 125,000 LDT/year for an 80-meter plot and proportionately for other widths.
- Beyond 200–220 m length, gains diminish; prioritize width extension if needed.

4.4.2.3 **Recommendations for large plots (100-120 m)**

- **Current strengths**

- Ample waterfront width (100-120 m) and large additional processing land in some cases.
- High crane capacity (280–300 tons, with potential beyond).
- Advanced processing capability, handling up to 1,200 LDT/day.

- **Key recommendations**

- Maximize additional land usage
- Ensure full use of the additionally available processing area
- Create multiple dismantling lines and optimize block flow
- Advanced technologies
- Integrate robotic cutting, automated cranes and digital workflow systems (RFID tracking)
- Improve cutting and dismantling efficiencies
- Boost worker productivity
- Target 1.76 LDT/worker/day at peak
- Maximize with around 600 workers
- Optimized layout
- Enhance material flow, reduce movement and avoid bottlenecks
- Capacity goals
- Sustain 219,000–316,000 LDT/year
- Prepare for strategic peaks exceeding 1,200 LDT/day
- Scalability
- For even larger plots (240–300 m waterfront), replicate efficient layouts, scaling up to 500,000–790,000 LDT/year

4.4.2.4 **Cross-cutting strategies (All Plot Sizes)**

Table 4-5: Mitigation suggestions for possible complexities

Strategy	Action
Crane upgrades	Match crane capacity to block size and cutting speeds.
Cutting tech	Plasma, laser cutting, automation.
Layout optimization	Minimize worker travel, avoid congestion.
Worker training	Upskill workers for higher productivity.
Digital tools	Implement workflow tracking and resource management.
Land merging	Consolidate small non-functional plots to unlock scalability.
Compliance	Ensure HKC and EU SRR standards for global competitiveness.

4.4.2.5 Vision 2025–2030

- Worker productivity: Elevate from 0.66–1.71 LDT/worker/day to 1.0–2.0 LDT/worker/day
- Unit area productivity: Raise from 4.5–9.6 LDT/m²/year to 6.0–11.0 LDT/m²/year
- Daily output: Move from ~600 LDT/day (large plots) to 1,500 LDT/day on optimized large plots

4.4.3 Conceptualization of very large plots.

Based on earlier analysis and optimization exercise undertaken placed at Annexure E, following very large plots of size 240 m x 215 m and 300 m x 215 m have been conceptualized.

Table 4-6: Key specifications of 240 m and 300 m waterfront plot

Parameter	240 m Waterfront Plot	300 m Waterfront Plot
Total area	51,600 m ²	64,500 m ²
Ship handling capacity	5–6 medium ships 3–4 large ships	6–7 medium ships 4–5 large ships
Conservative productivity	0.028 LDT/m ² /day	0.028 LDT/m ² /day
Conservative capacity (Annual)	439,246 LDT/year	549,057 LDT/year
Optimistic capacity (Annual)	633,600 LDT/year	792,000 LDT/year
Adjusted capacity (90%)	409,860 LDT/year (1,366 LDT/day)	494,100 LDT/year (1,647 LDT/day)
Estimated workers (Base)	~1,200	~1,480–1,500
Estimated workers (Optimized)	~1,100	~1,350
Productivity/worker/day (Base)	1.39–1.76 LDT	1.39–1.76 LDT
Productivity/worker/day (Improved)	1.51–1.92 LDT	1.53–1.94 LDT
Efficiency features	Better layout, crane coverage, fewer delays	Same advantages as 240 m plot, slightly larger scale

Key insights

- Doubling or increasing waterfront width increases *total capacity* proportionally, despite productivity per m² remaining flat.
- Larger plots allow smoother workflows, reduced delays, and better crane movement.
- 240m and 300m plots are very large compared with existing plots and can handle significantly more and larger ships side-by-side.
- **Worker productivity increases with size:** Gains in layout efficiency and resource utilization raise per-worker output, though at diminishing returns.
- Tech & layout optimization/Improvements can help reduce worker count by approx. 10–15% and increase productivity by around 10-12%.

4.4.4

Favouring larger plots over smaller plots

In view of the higher capacity and operational flexibility provided by larger plots with **120-meter waterfront x 215-meter length**, it is expected that **240-meter waterfront x 215-meter length** plots and 300 m waterfront width x 215 m length plots would provide better layouts, more flexibility and more room for compliances with the **Hong Kong Convention (HKC)**, **Basel Convention** and **EU Ship Recycling Regulation (EU SRR)**, here's a rationale for prioritizing larger plots over smaller plots:

- **Regulatory compliance and safety**
 - **HKC and EU SRR requirements:** These regulations emphasize on environmentally sound management of ship recycling operations such as containment of hazardous materials, waste management and worker safety etc. Larger plots provide adequate additional space necessary to create **dedicated zones** for dismantling, hazardous material storage and waste segregation in addition to spaces for worker's welfare and safety measures. This would help in ensuring compliance with these regulations.
 - **Operational safety:** Larger plots would allow for better workflow management which would help in reducing congestion and minimizing accidents to ensure safer working conditions.
- **Capacity for larger ships**
 - Large ships such as container ships, bulk carriers and tankers etc require significant space for dismantling. A larger waterfront would provide for easier landing and handling of large vessels.
 - Larger plots would also cater for sufficient space for dismantling sections, storing components and segregation of materials for recycling.
- **Future scalability and adaptability**
 - The maritime industry is trending toward larger ships and ship recycling plots need to scale operations in accordance with emerging requirements.
 - Larger plots would also provide flexibility to handle multiple ships simultaneously as well as to expand operations to meet future demands without compromising efficiency.
 - As regulatory standards continue to evolve, larger plots would have capacity to accommodate additional compliance requirements e.g. larger hazardous material storage areas or enhanced containment systems etc.
- **Machinery and systems**
 - Larger plot areas can house advanced machinery, large capacity cranes and other such systems that may help to enhance production and streamline operations.
- **Environmental and community impact**
 - Adequate space available on larger plots will allow to better manage the risk of spills and contamination etc which could affect local environments.

- Larger plots will also have adequate space for welfare, training, medical, messing and other such facilities which would positively impact the workers community.
- **Economies of scale**
 - With high-capacity potential, larger plots would generate higher cumulative LDT and have higher revenue potential.
 - Larger plots can cater for specialized or high LDT as in case of V-1 plot.
 - With economy of scales, it would be possible to invest in upgrading technologies and systems to boost productivity and safety.
- **Conclusion:**
 - In line with future predictions of **very large ship recycling** volumes to be dismantled and the substantial **business opportunity**, larger plots like the **240-m waterfront x 215-m length and 300 m waterfront x 215 m length** are likely to become strategically important.

4.4.4.1 Product mix

To meet the market demand as per various scenarios projected in market assessment and aligning with the target by GMB to reach the capacity 11.3 M LDT and above by 2040, the following product mix must be operational. Further to increase the capacity, additional plots can be developed as required in phase 3.

Table 4-7: No. of plots proposed

Proposed new plot sizes	No. of plots	
	Phase 1	Phase 2
240 m x 215 m	05	03
300 m x 215 m	04	03
Waterfront required (in m) (including buffers)	2705	1675

4.5 Detailed plot layouts *(Suggestive)*

4.5.1 Design requirements

This section deals with the layout and design requirements under HKC, EU SRR, Basel Convention Guidelines, ILO guidelines and ISO 30000:2009 requirements. The layout and facilities are suggestive and flexibility by plot owners in accordance with EU SRR and HKC requirements are to be exercised.

The plot is laid out into following zones in accordance with **Basel Convention 2003 Technical Guidelines**:

- **Zone A: Primary block breaking area** - This zone handles the initial disassembly and dismantling of ships in the intertidal area, requiring containment and safety measures to manage hazardous materials and waste.
 - Primary cutting zone (Intertidal Area)
 - Winches platforms, Jetties, Primary crane movement area etc.

- **Zone B: Secondary block breaking area** - Activities in this zone focus on further processing of dismantled blocks into smaller pieces for transport or sorting.
 - Oily block zone
 - Secondary cutting zone
 - Tertiary cutting zone
- **Zone C: Assorting, Segregating, Finishing and Overhauling area** - This zone is designated for cleaning, sorting and preparing materials for recycling or sale.
 - Segregation of hazardous and non-hazardous items
 - Workshop
 - Machinery room
- **Zone D: Storage areas** - This zone provides temporary and secure storage for hazardous and non-hazardous materials.
 - Scrap and steel plates stacking zone
 - Non-Ferrous storage
 - Benign products storage
 - Hazardous products storage
 - Finished products storage area
 - Godowns
 - Storm water tank
 - Fire water tank
 - Oxygen cascade
 - PNG and Plasma storage
- **Zone E: Offices and emergency facilities** - This zone houses administrative operations and emergency response facilities.
 - Admin building (includes security, training room and terrace)
 - Restrooms
 - Canteen and recreation room
 - Emergency assembly point
 - Waiting lounge
 - Parking area
 - Safety room
 - Body shower
 - Oil spill kit: To address spills during dismantling as an emergency preparedness tool.
- **Zone F: Waste disposal and containment facilities**
 - Zone F would typically be facilities like TSDF in Alang that includes areas for waste processing and disposal. Infrastructure for waste treatment e.g. incinerators, ETP and landfills would fall under this zone.
- **Additional facilities** - In addition to the above zones, following systems/facilities are required to be spread throughout the plots

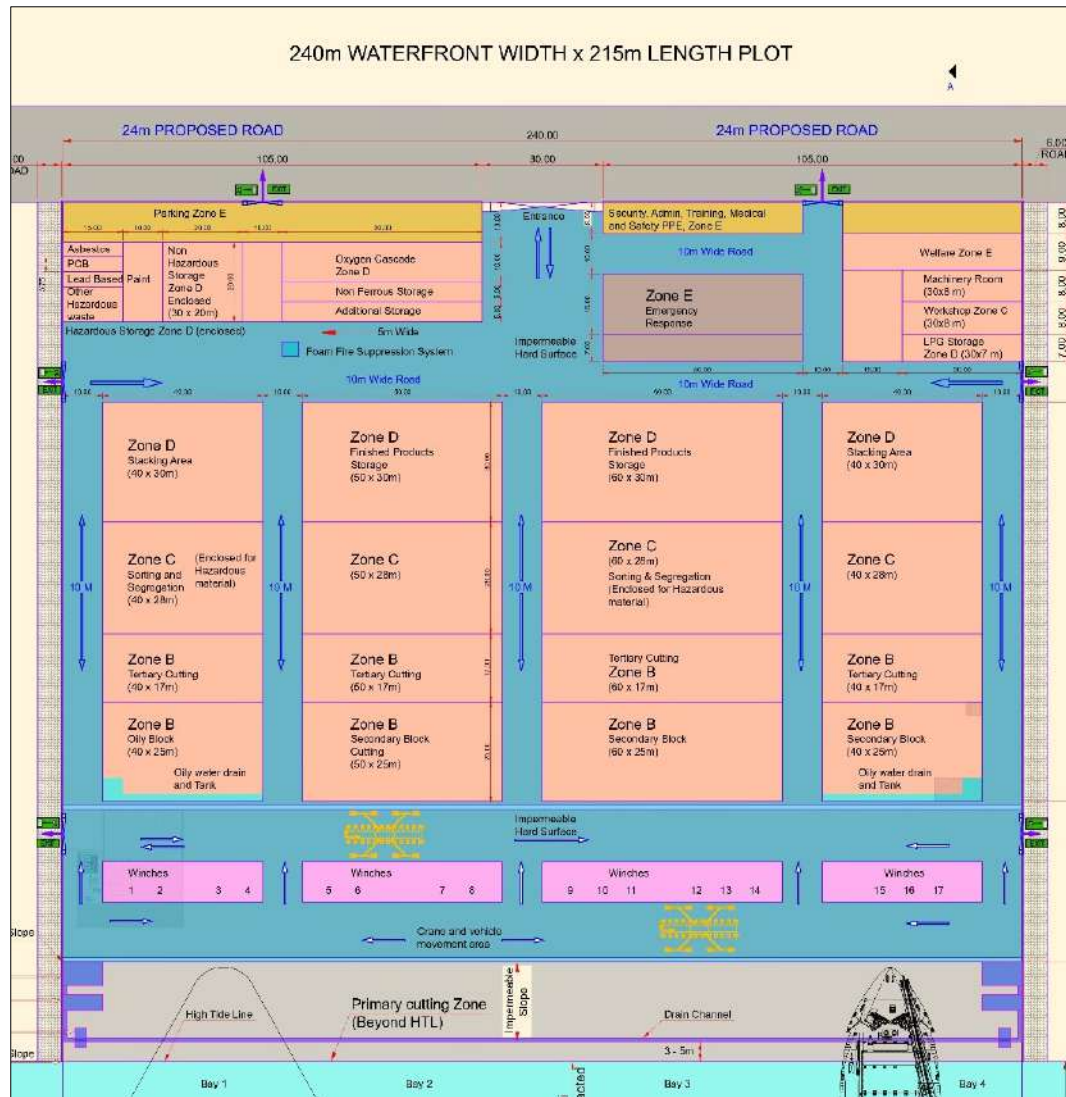
- fire extinguishers, sand buckets, first aid kits, body showers, fire hydrants and drinking water points are to be spread throughout the plots.
- drainage trenches, fire lines and oxygen & PNG lines to provide essential utility connections.
- oily pits and oil spill kits to support environmental safety.
- it is recommended that adequate buffer zones around the cutting area be provided for enhanced safety and pollutant containment.

- **HKC-specific additions**

- Drainage trenches: Expanded system for oil and water separation, drainage and containment to meet spill containment requirements.
- Oily Pits: With adequate capacity for oily waste disposal.
- Dedicated areas for hazardous material storage, including asbestos containment.
- Training rooms: Mandatory under HKC.
- Welfare areas for rest, first aid and safety drills.
- Firefighting systems and extinguishers, body showers and spill kits.

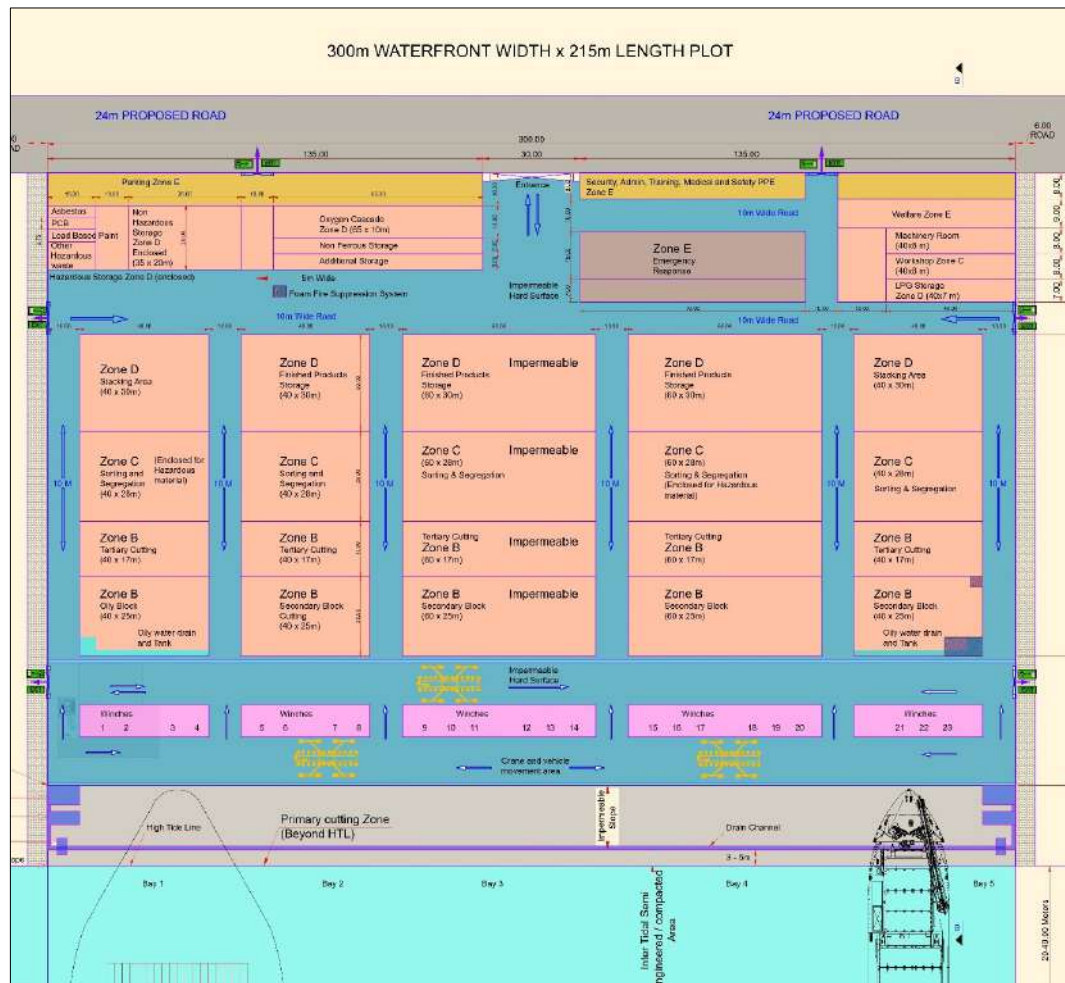
4.5.2 | Proposed plot sizes and compliance strategies

Figure 4-1: Plot layout: 240 m X 215 m



(Note: The internal dimensions in the figure above are indicative and may be optimized by the individual plots as per their operational and implementation strategy)

Figure 4-2: Plot layout: 300 m X 215 m



(Note: The internal dimensions in the figure above are indicative and may be optimized by the individual plots as per their operational and implementation strategy)

Detailed plan and section of the proposed plots are provided at Annexure N.

Figure 4-3: Proposed ship recycling plot view**Figure 4-4: Proposed ship recycling plot view****4.5.2.1 Rationale for proposed mix**

The proposed mix of 300 m and 240 m waterfront plots (each 215 m in depth) is a well-rationalized strategy which is aligned with market responsive scaling, land availability and productivity optimization. It is a balanced, flexible, and future-ready approach.

Below is the detailed rationale:

- **Strategic flexibility for moderate and accelerated scenarios**

- The moderate scenario targets a realistic capacity growth (up to 8.8 M LDT by 2040), while built-in flexibility allows expansion to an accelerated scenario of 11.3 M LDT.
- The proposed mix of plot sizes (300 m and 240 m) allows modular scaling. Plots can be added progressively based on market demand without overcommitting to larger developments.

- **Optimized capacity utilization per meter of waterfront**

- Based on conservative estimates (90% productivity), plot capacity is:
- **300 m plot:** approx. 494,100 LDT/year
- **240 m plot:** approx. 409,860 LDT/year
- 300 m plots offer higher output; however, 240 m plots allow denser deployment in constrained waterfront areas and provide more flexibility in incremental allocation.

- **Land use efficiency and site conditions**

- The available length of around 2.75 km CRZ II and remaining CRZ-I A stretches vary in geography and environmental sensitivity.
- Larger plots (300 m) are suited for less fragmented, uniformly reclaimed areas.
- Smaller plots (240 m) can be fitted into narrower or constrained locations, making full use of irregularly available waterfront land.

- **Staggered plot allocation for risk mitigation**

- By offering two plot sizes, GMB can stagger expansion, minimizing financial, regulatory, and environmental risk.
- For example, under moderate growth: 9 new plots (4 × 300 m, 5 × 240 m) suffice.
- For accelerated growth: 15 new plots fulfil the need of 11.3 M LDT.
- This avoids premature infrastructure oversizing and ensures capex aligns with actual utilization.

- **Alignment with plot optimization strategy**

- All plots are being standardized to 215 m in depth, thereby supporting uniform infrastructure, access roads, drainage, and utility networks.
- The choice of lengths (300 m and 240 m) is to facilitate larger plots aligning with GMB's vision of higher capacity plots which integrates seamlessly into the upgraded plot design, maximizing compatibility.

- **Facilitation of phased infrastructure development**

- Infrastructure (roads, utilities, administrative centres) can be designed in modules to support either 300 m or 240 m plots, reducing initial investment and enabling progressive commissioning.
- This modular approach helps manage land preparation costs (e.g., dredging, slope grading) more efficiently across phases.

- **Suitability for varying operator scales**

- 300 m plots are ideal for larger investors aiming for EU SRR compliance and high-throughput facilities.
- 240 m plots can accommodate both large and mid-sized operators, balancing investment size and regulatory compliance capacity.
- This diversifies plot allotment, allowing participation across operator scales and reducing systemic risk.

- **Enabling technological demonstration and learning**

- The planned “model plot” development before operationalisation phase 1 will inform optimal layout and process flows. Learnings can be more flexibly applied to both plot sizes, enabling tailored deployment of best practices.

4.5.2.2 Recommended facility areas (Suggestive guidelines)

Table 4-8: Facilities and area requirement

	Facility	Approximate area (m ²) 240 m plot	Approximate area (m ²) 300 m plot
Zone A	Impermeable primary shipbreaking zone	6,000	7,200
	Jetties and crane hard, winches and crane buffer area	9,600	12,000
Zone B: Secondary block breaking	Secondary block cutting zone	6,000	7,500
	Tertiary cutting zone		
	Oily block zone (approx. 2000 m ²)		
Zone C Sorting, Segregation and	Sorting and segregation area	10,800	13,000
	Machinery room		
	Workshop		
Zone D Storage areas	Finished product storage	8,400	10,500
	Steel and scrap stacking zone		
	Benign products storage		
	Hazardous stores		
	Non-ferrous storage		
	Oxygen, Plasma and PNG storage		
Zone E: Administrative, Security, Emergency Response, Buffer Zones and Green Areas	Medical room	10,800	13,500
	Canteen and recreation		
	Toilets and bathrooms		
	Admin building (total)		
	Parking and waiting lounge		
	Oil spill kit, firefighting and safety measures		

	Facility	Approximate area (m ²) 240 m plot	Approximate area (m ²) 300 m plot
	Restroom		
	Safety room/emergency point		
	Buffer zones, movement zone and greens		
	Total Area	51,600	64,500

All the Zones except green areas are required to have impermeable flooring in accordance with HKC and EU SRR. Further, it is required to cover all cutting zones (primary, secondary and tertiary) and scrap stacking areas with impermeable flooring to prevent soil and groundwater contamination.

4.5.2.3 Recommended equipment and machinery

This table outlines cutting-edge equipment that aligns with Basel, HKC and EU SRR requirements for environmentally sound ship dismantling practices.

Table 4-9: Equipment capacities

Equipment Category	Quantity/Capacity 240 m plot	Quantity/Capacity 300 m plot
Cranes	20–24 units (2-3 heavy duty Portal/crawler/floating cranes of 150-300 tons, 4-5 heavy duty cranes of 100-150 tons, 7–8 heavy-duty crawler/mobile cranes of 25–100 tons and 7–8 mobile cranes of 10–40 tons).	24–28 units (3-4 heavy duty Portal/crawler/floating cranes of 150-300 tons, 5-6 heavy duty cranes of 100-150 tons, 8–9 heavy-duty crawler/mobile cranes of 25–100 tons and 8–9 mobile cranes of 10–40 tons).
Forklifts	6-10 units (3–5 tons capacity).	8-12 units (3–5 tons capacity).
Excavators with shears	4-5 units (20–40 tons).	5-6 units (20–40 tons).
Magnetic scrap handlers	4–5 units (1.5–4 tons lifting capacity).	5–6 units (1.5–4 tons lifting capacity).
Oxy-Acetylene cutting torches	80-100 units.	Around 100-120 units.
Plasma cutting machines	8-10 units (cutting thickness up to 40 mm).	10-12 units (cutting thickness up to 40 mm).
Hydraulic/cold cutting saws	4-6 units.	5-7 units.
Fire extinguishers	150-180 units (dry powder and foam types).	180-220 units (dry powder and foam types).
Sand buckets	70-90 buckets (50 litres each).	90-110 buckets (50 litres each).
Fire hydrants	Fire hydrants (spaced every 50 m).	Fire hydrants (spaced every 50 m).
Foam-based fire systems	3 foam tanks (10,000- litres each).	3 foam tanks (10,000- litres each).
Fire truck	At least 1 truck equipped with foam and dry powder.	At least 1 truck equipped with foam and dry powder.
Winches	At least 15-18 heavy duty winch units (as per operational requirements) with	At least 20-23 heavy duty winch units (as per operational requirements) with multi

Equipment Category	Quantity/Capacity 240 m plot	Quantity/Capacity 300 m plot
	multi pulley block system for mechanical advantage and necessary accessories.	pulley block system for mechanical advantage and necessary accessories.
Oil-Water separators	At least 4-6 Units 10,000 litres/day each).	At least 5-7 Units 10,000 litres/day each).
Wastewater Treatment Plant (WWTP)	250,000-300,000 Litres/day	300,000-350,000 Litres/day
Mist cannons	4-5 units (20-meter range).	5-6 units (20-meter range).
Noise level	3 units.	5 units.
Spill containment kits	6 kits for oil and chemical containment.	8 kits for oil and chemical containment.
Body showers and Eye wash stations	At least 8-9 stations.	at least 10 stations.
Solar panels (Optional)	100 kW solar setup.	125-150 kW solar setup.
Generators	1 unit (200 kVA each).	
Automated Inventory Management System (RFID Enabled)	One system for tracking of material and waste flow	
Robotic controlled gas or plasma cutting tools(optional)	4-6 Units or appropriate numbers for precision and safe dismantling in hazardous zone	6-7 Units or appropriate numbers for precision and safe dismantling in hazardous zone
Fire alarm system	The fire alarm system should provide coverage to both primary cutting Zone A (on ship) and Zone B	
Accessibility support	manlifts and staging as required	

Notes:

- *The specific selection and quantities depend on the anticipated throughput, budget and environmental compliance needs.*
- *Capacities are suggested for typical medium-capacity operations and can be scaled up or down.*
- *Integration of digital monitoring and management systems is encouraged for real-time tracking of operations and waste.*
- *Some of the novel technology systems as suggested may not be mandatory for compliance, however, their addition will improve safety, environmental compliance and productivity.*

4.5.2.4 Recommendations for fume extraction systems

- **Capacity per unit**
 - Some units of 500-800 m³/h and some larger systems handling 800-1,200 m³/h are preferred to cater to the larger dismantling and processing zones.
- **Number of units**

- 5-7 units are recommended considering the increased activity for 240 m plot in primary, secondary and tertiary cutting zones, machinery areas and non-ferrous processing zones.
- 7-8 units are recommended considering the increased activity for 300 m plot in primary, secondary and tertiary cutting zones, machinery areas and non-ferrous processing zones.

- **System features**

- Centralized extraction systems for continuous operations.
- Higher filtration efficiency to meet stricter environmental standards.

- **Key placement zones**

- Primary cutting zones: Where heavy emissions occur during initial dismantling.
- Secondary and tertiary zones: For managing fumes from secondary cutting and finishing activities.
- Workshops and machinery areas: For indoor operations generating welding and machining fumes.
- Waste handling and sorting areas: To minimize exposure from volatile residues.

4.5.2.5 EU SRR Compliance requirements

The table below lists down EU SRR compliance requirements and recommended solutions for 240 m and 300 m plots.

Table 4-10: Additional EU SRR compliance requirements

Category	Requirement	Details
Environmental protection measures		
Impermeable surfaces	Cover cutting zones including primary cutting zone and storage, segregation and scrap stacking areas	Concretized, reinforced with drain collection system.
Drainage system	Drainage lines plus drainage tanks, filters, traps and separators for 240 m and 300 m plot respectively.	Covers all cutting, stacking and storage zones and connecting to a central treatment facility
Wastewater treatment plant	To treat storm water before pumping into stormwater network	Treats runoff, oily residues and contaminated liquids. includes oil-water separation plants and chemical treatment etc.
Stormwater management	Stormwater tank capacity: approx. 0.77 M litres and approx. 0.96 M litres for 240 m and 300 m plot respectively.	Designed for heavy rainfall for half an hour
Air pollution control	Mist cannons and fume extraction systems	Dust suppression and hazardous gas capture in cutting zones
Worker safety and welfare		
Worker training	Training Rooms for at least 200 and 250 workers for 240 m and 300 m plot respectively.	Ship dismantling, safety, compliances and hazardous material handling training

Category	Requirement	Details
Medical facility	At least 20-bed and 25-bed clinic for 240 m and 300 m plot respectively.	Includes toxicology support and decontamination room
Welfare area	Minimum 2,000 m ² and 2,500 m ² for 240 m and 300 m plot respectively.	Restrooms, showers, changing rooms, mess areas
Safety equipment	PPE for each worker	Helmets, goggles, gloves, respiratory gear, fire extinguishers (1 per 100 m ²)
Emergency response	8-10 exit routes and 10-12 exit routes for 240 m and 300 m plot respectively. Fire hydrants at 40 m intervals	Emergency escape and fire response systems
Waste management infrastructure		
Hazardous waste zone	Approximate 2,000 m ² and 2,500 m ² for 240 m and 300 m plot respectively.	Lined with impermeable surfaces; ventilated storage for hazardous materials
Recycling facilities	Shredding unit and preferably magnetic separator for ferrous and non-ferrous metals	Compacting and processing systems for efficient recycling
Oil spill containment	Oily wastewater pit, 350,000 litres capacity in 2 tanks for 240 m and 300 m plot respectively.	Spill kits and containment systems
Certification and record-keeping		
Auditable records	Track waste quantities and destinations through digital tracking or maintaining auditable records.	To ensure environmentally sound recycling and disposal records are auditable.
Third-Party audits	Quarterly audits	Ensure compliance with EU SSR and ISO 30000 standards

4.5.2.6 Compliance audit

- **Key HKC and EU SSR compliance areas and corresponding inclusions**
 - Environmental protection
 - HKC compliance focuses on the safe handling of hazardous materials, impermeable floors, pollutant collection and the prevention of environmental contamination.
 - EU SSR compliance includes additional measures like stricter drainage systems, wastewater treatment and air pollution control.
 - Inclusions
 - Impermeable surfaces covering all cutting, segregation and storage zones.
 - Drainage systems connected to a wastewater treatment plant with oily-water separation and chemical treatment modules.
 - Mist cannons for dust suppression and fume extraction systems in cutting zones.
 - Stormwater management tanks for heavy rainfall.
 - Monitoring systems for soil, air and water quality in real time (specific to EU SSR).
- **Worker safety and welfare**

- **HKC compliance:** Requires worker safety measures such as PPE, training and basic medical facilities.
- **EU SSR compliance:** Extends to welfare areas, training in hazardous material handling and emergency response plans.
- Inclusions:
 - On-site clinics with emergency care and decontamination facilities.
 - Restrooms, showers, changing rooms and mess areas proportionate to the workforce.
 - Comprehensive PPE kits for all workers.
 - Biannual training for safe ship dismantling and handling hazardous materials.
 - Emergency exits, fire-fighting equipment and hydrants at regular intervals.
- **Waste management**
 - **HKC compliance** requires proper storage and disposal of hazardous wastes (asbestos, PCBs, oily residues).
 - **EU SSR compliance needs** detailed requirements for waste tracking, recycling facilities and third-party audits.
 - Inclusions:
 - Dedicated hazardous waste zones with impermeable surfaces and ventilation.
 - Oily waste pits as per plots size (approx. 3,50,000 litres capacity).
 - Certification and record-keeping for asbestos and other hazardous waste handling.
 - Third-party audits for compliance with HKC, EU SSR and ISO 30000 standards.
- **Firefighting and emergency preparedness**
 - **HKC Compliance** calls for fire extinguishers and basic firefighting equipment.
 - **EU SSR Compliance** requires enhanced fire suppression systems and emergency preparedness.
 - Inclusions:
 - Mandating fire compliance certification for the plot with frequent audits to encourage plot owners to maintain robust firefighting system
 - Fire extinguishers, foam tanks, fire hydrants and fire trucks.
 - Emergency exit routes and safety showers at appropriate locations.
 - Fire suppression systems for high-risk areas.
- **Monitoring and certification**
 - **HKC compliance** needs inventory of hazardous materials (IHM) and compliance audits.
 - **EU SSR compliance** also emphasizes on tracking, real-time monitoring and detailed certifications.
 - Provided measures
 - Systems for tracking waste quantities, recycling and final disposal.

- Agencies involved in preparation of IHM, removal and disposal need to be regularly audited and certified by the authority.
- Monitoring for air, water and soil quality.
- Quarterly audits for compliance with EU SSR and ISO standards.

- **Additional EU SSR recommendations (Voluntary basis)**

- **Energy efficiency:** Use of solar panels and electric driven cranes/machinery may be considered to reduce emissions.
- **Green belt development:** Tree plantations to create green buffer zone around industrial areas and minimize air and noise pollution.

4.5.2.7 Compliance with ILO Guidelines¹²

Table 4-11: ILO Compliance for plots

Category	Requirement/ Feature	240 m plot	300 m plot
Occupational safety	Worker welfare space	Approx. 2,000 m ² for 1100 workers	Approx. 2,500 m ² for 1500 workers
	Restrooms, showers, changing rooms	Included	
	On-site medical facility	20-bed clinic with toxicology support	25-bed clinic with toxicology support
	Emergency exit routes	8-10 well-marked exits	10-12 well-marked exits
	Fire hydrants	Every 40 m	
	PPE kits	One per worker	
	Training programs	Biannual safety training in training rooms.	
Emergency preparedness	Fire suppression systems	For Cutting zones, hazardous material areas	
	Emergency response routes	To be well-marked and maintained	
Hazardous material management	Hazardous waste storage zones	>2,000 m ²	>2,500 m ²
	Asbestos management protocols	Sealed containers, third-party certified disposal protocol.	
	Training for handling hazardous materials	Training facilities included.	
Worker welfare	Welfare zones	Minimum 2,000 m ²	Minimum 2,500 m ²
	Noise pollution control	Noise- meters and noise suppressions ear protection kits	

¹² <https://webapps.ilo.org/public/english/standards/relm/gb/docs/gb289/pdf/meshs-1.pdf>

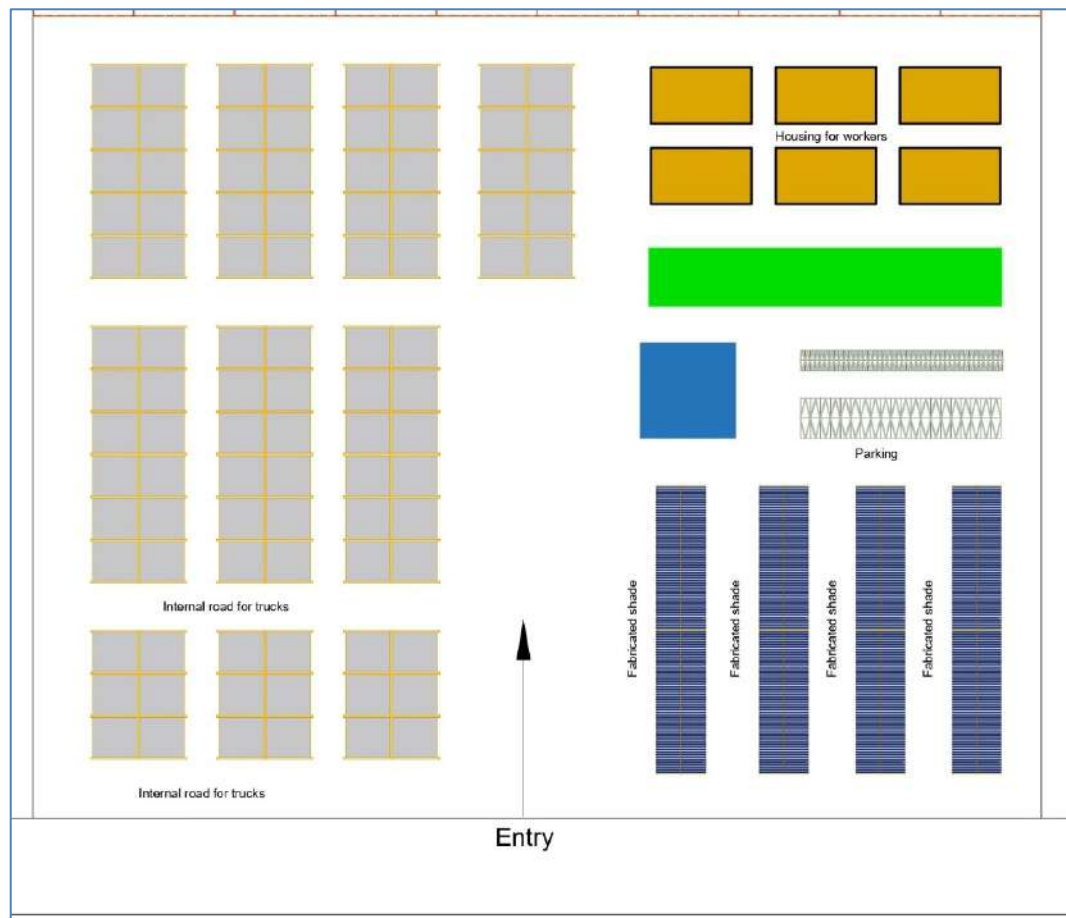
4.5.2.8 Compliance With ISO 30000:2009**Table 4-12: Compliance with ISO 30000:2009**

Category	Requirement/Feature	240 m plot	300 m plot
Environmental management	Impermeable flooring	Provided for cutting, segregating, stacking, storage zones	
	Drainage system	5-6 km drainage lines	6-7 km drainage lines
	Wastewater treatment plant	>250,000 litres/day	>300,000 litres/day
	Stormwater tanks	0.77 M Litres	0.96 M Litres
	Air pollution control	Mist cannons, fume extraction systems	
Waste management	Hazardous waste storage Zone	>2,000 m ² with ventilation	>2,500 m ² with ventilation
	Oil spill containment	oily waste pit (350,000 litres) and Oil Spill Kits	oily waste pit (350,000 litres) and Oil Spill Kits
	Segregation and recycling facilities	Shredders, compactors, magnetic separators	
Traceability and records	Waste tracking	Digital systems for waste type, quantity, destination	
	Third-party audits	Quarterly audits	
	Certifications	Asbestos and hazardous material handling certifications	
Energy efficiency	Renewable energy	Solar panels optional	
	Electric cranes	Optional	
Monitoring systems	Air, water and soil monitoring	digital real-time systems	
Green belt development	Green buffer zones	Appropriate green buffer belt	

4.6 Additional backup yard facility

In addition to the designated ship recycling plot, an additional depth of approximately 200 m is proposed to be allocated as a backup yard. This area can be utilised by the plot operators for scrap sorting, storage, and other operational requirements, as well as for developing worker welfare facilities, including housing.

The provision of this supplementary space will enable plot operators to maintain adequate storage space for both ferrous and non-ferrous scrap, particularly during periods of market slowdown, thereby enhancing operational flexibility and economic resilience.

Figure 4-5: Backup yard indicative layout

5 Proposed Master Plan

The preparation of a master plan for the proposed Alang-Sosiya Ship Recycling Yard involves a systematic and data-driven approach, combining spatial analysis, field validation, stakeholder engagement, and infrastructure planning. This exercise not only considered the expansion into new areas but also focused on the improvement and optimization of existing operational zones within Alang. The process was rooted in understanding planning principles and adapting globally relevant, locally suitable strategies to suit the unique geographical, economic, and environmental context of Alang.

As part of the master plan, a detailed conceptual road network and land use plan was developed, emphasizing compatibility, optimal land utilization, and long-term sustainability. Furthermore, integrated infrastructure development strategies were identified, encompassing transportation systems, industrial and utility infrastructure, and essential social amenities to support future growth and regulatory compliance.

The master planning exercise included the following key components:

- Preparation of base map
- Market study inputs
- Population and employment estimates based on market potential
- Vision statement
- Planning principles and development objectives
- Area estimations under various land use categories
- Concept development framework
- Road network and public transport proposals
- Land use proposals
- Infrastructure proposals (water supply, sewerage, power, etc.)
- Social infrastructure proposals (health, education, housing, etc.)
- Phasing and implementation strategy

5.1 Base map

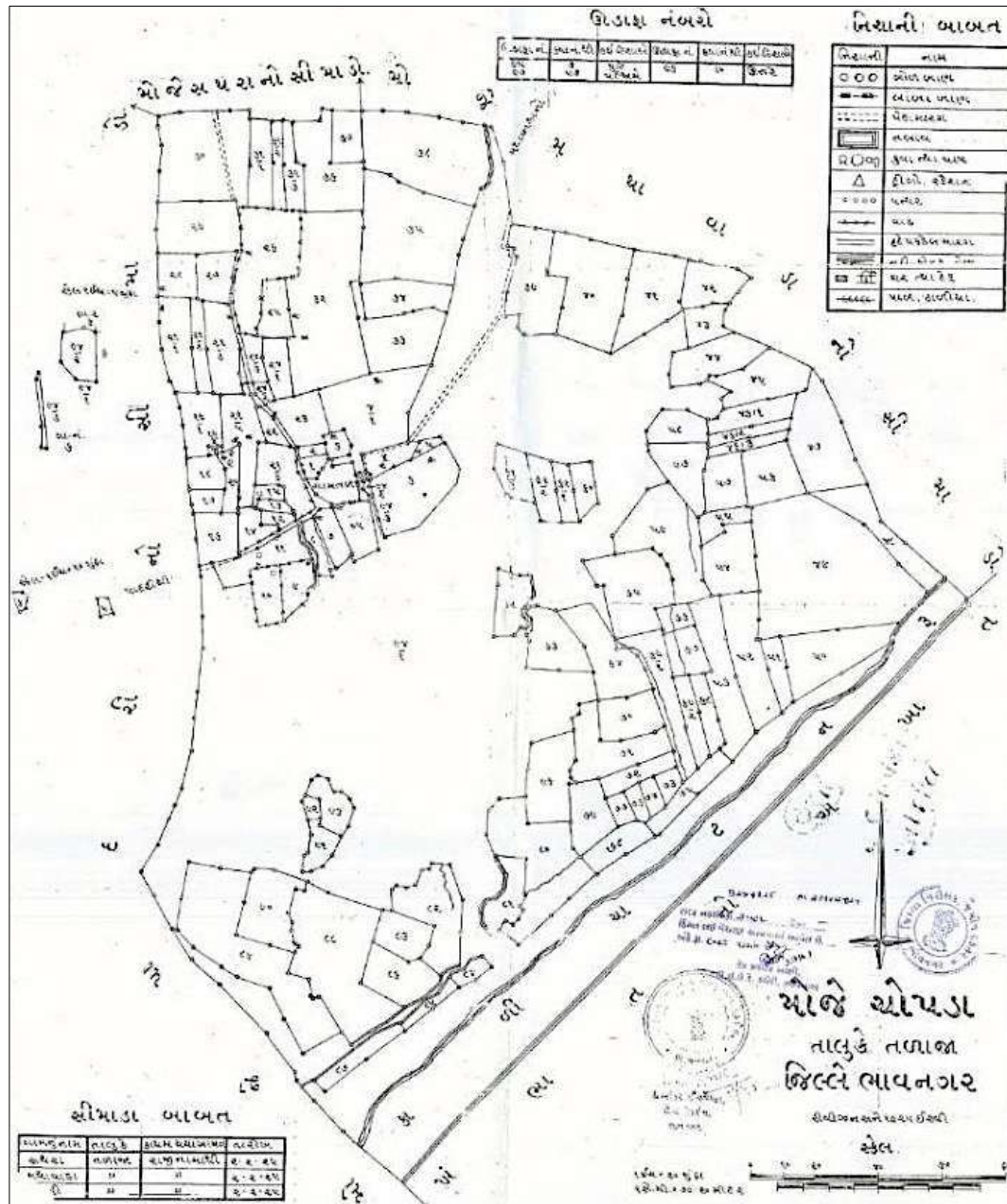
The preparation of the base map formed the foundational step in the development of the land use plan. The methodology adopted involved several stages, including the procurement and rectification of high-resolution imagery, drone surveys, DGPS surveys, and ground truthing. The process further included digitization and vectorization of spatial data, geo-referencing of village maps, and compilation of secondary data from relevant departments.

- Field survey and spatial verification
 - The existing land use map was prepared by undertaking an actual physical survey of the project area. Existing use of land was surveyed primarily based on Base map, satellite imagery and drone survey images. The field survey

team visited different parts of the project area and observed all the land parcels, buildings, and other spatial features using satellite images for visual reference.

- A primary survey was conducted to document the area's existing land use, which included the types of land use such as residential, commercial, mixed land uses, public and semi-public, recreation and open space, and so on.

Figure 5-1: Village map



- **Village map acquisition and digitization**

- Village revenue maps (Tikka sheets) of all eight villages within the proposed Alang-Sosiya Ship Recycling Yard boundary were obtained from the District Land Inspector of Records (DILR), Bhavnagar.
- These included:

- | | |
|----------------|------------|
| 1. Sosiya | 5. Chopda |
| 2. Alang-Manar | 6. Padri |
| 3. Bharapara | 7. Tarsara |
| 4. Mathavada | 8. Jaspara |

- The maps were scanned, scaled, and digitized, and then geo-referenced using visible ground features (field boundaries, roads, etc.) collected during the survey. This ensured accurate overlay on satellite imagery and proper spatial alignment.

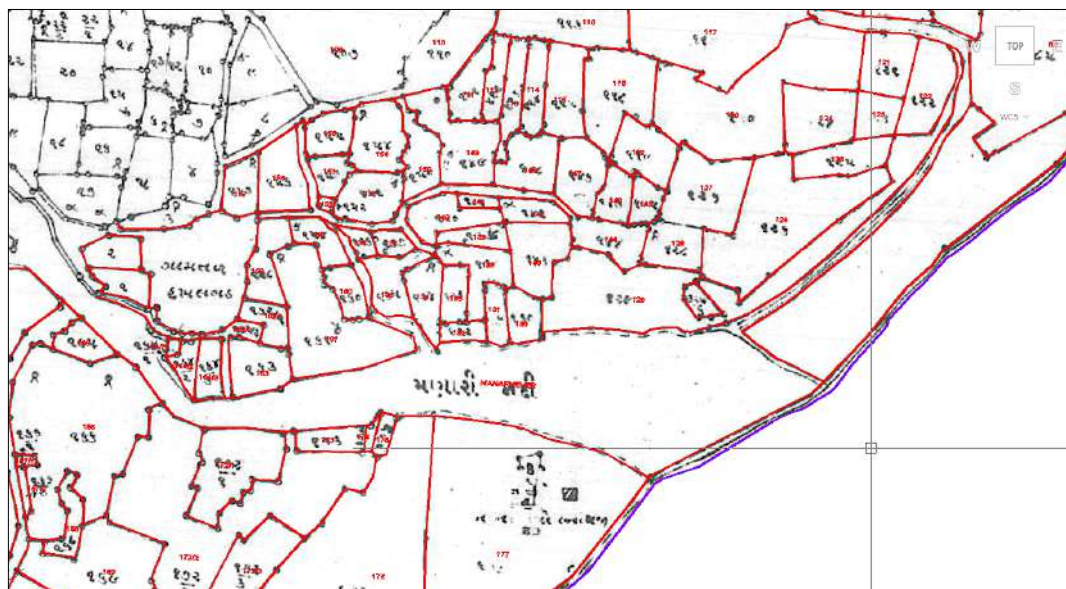
- **Ground verification and spatial attribute collection**

- All visible structures and features were validated on site. Each building footprint, land parcel, and utility feature was physically checked, and newly observed elements were incorporated into the final base map. This extensive validation and attribute collection activity spanned approximately one and a half months, ensuring the integrity of the data used for the master plan.

- **Digitization and updating of missing features**

- Missing features such as roads, water bodies, and important landmarks, not captured in the initial NRSC field maps were digitized and integrated into the base map. This process ensured a complete and accurate spatial representation of the project area.

Figure 5-2: Digitization of village maps



- **Final base map preparation**

- A GIS-based base map was developed by integrating all survey inputs, spatial data, and ground verification findings. This map includes administrative boundaries, built-up areas, transportation networks, natural features, and the location of key public facilities such as schools, police stations, government offices, markets, and bus stands.

- **Survey and geo-referencing of village maps**
 - Accurate coordinates of identifiable features were used to geo-reference each digitized village map, enabling precise integration into the base map. Superimposition and adjustment were done through visual alignment and field control points.
- **Rubber sheeting and edge matching**
 - Due to the age and inaccuracies of some village maps, rubber sheeting and edge matching techniques were applied to resolve mismatches, overlaps, and gaps in boundary lines. This ensured consistency across all village-level datasets.

Figure 5-3: Georeferencing of village map

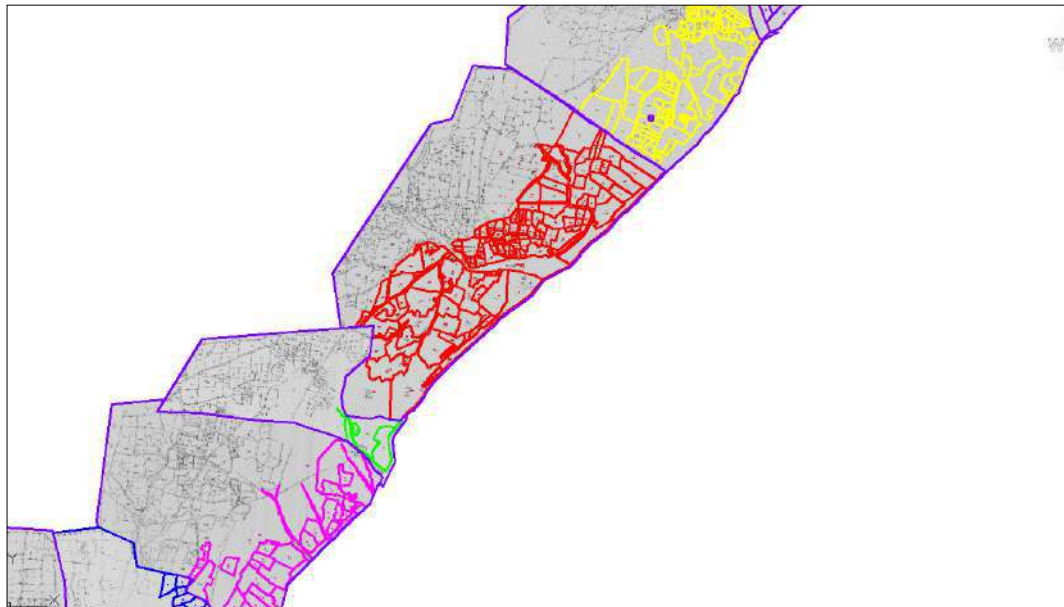
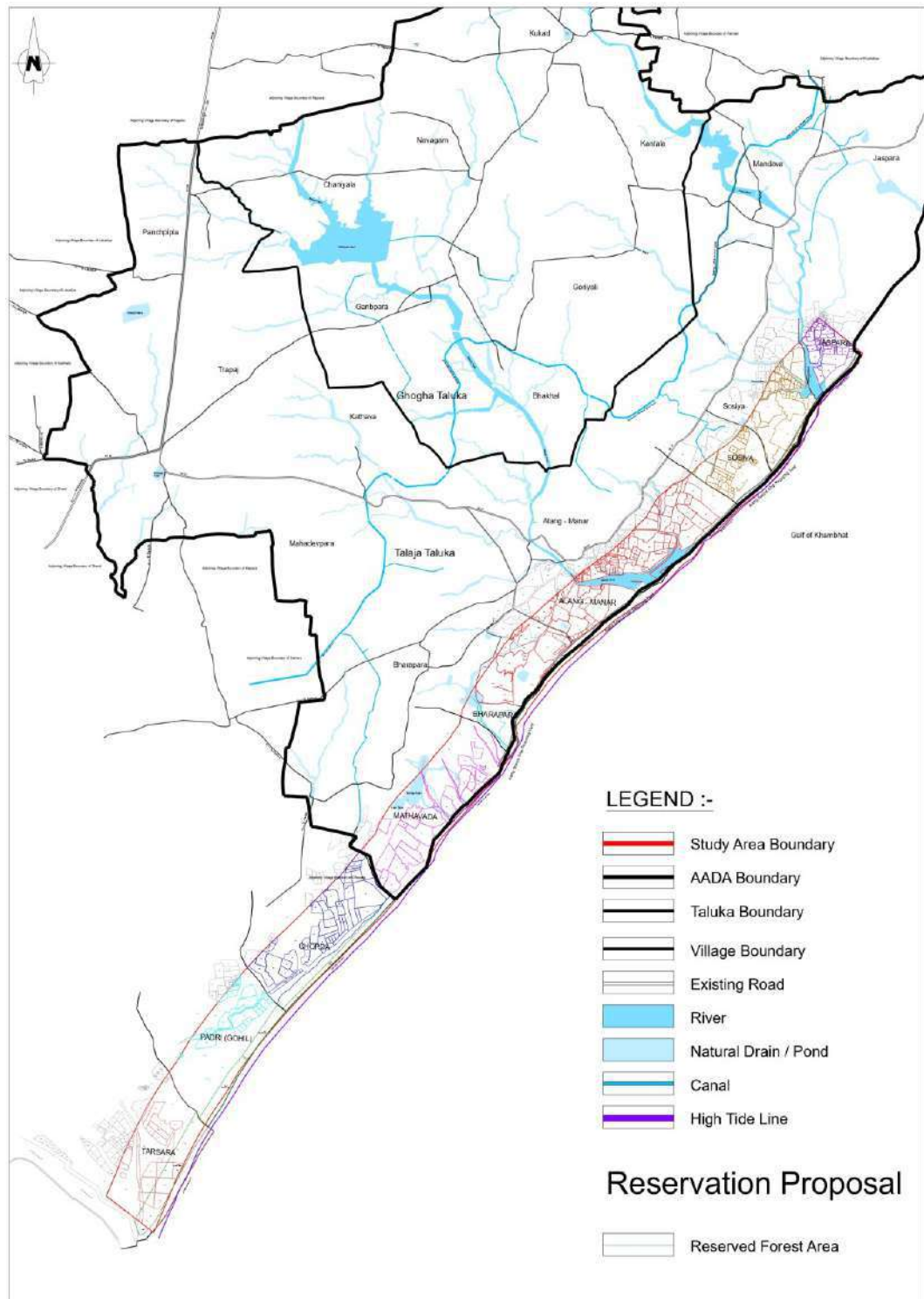


Figure 5-4: Preparation of base map

- Area statement and ownership mapping
 - 7/12 land records were collected for all villages to prepare a detailed area table. Key details such as survey numbers, ownership, tenure, and area remarks were recorded and linked to the spatial database. Maps showing GMB-owned land and government land parcels were also generated.

Figure 5-5: Area table

ઓરિયા પત્રક						
ગામ :- જસપરા, તળાજા, અલંગ						
અનુ. નં.	જમીન માલિકનું નામ	સત્તા પ્રકાર	સર્વે નં	૭/૧૨ રેકર્ડ મુજબ ક્ષેત્રફળ		
				કુલ	ખરાબો	લાયક
૧	૨	૩	૪	૫	૬	૭
				ચો.મી.	ચો.મી.	ચો.મી.
૧	બલવંતભાઈ પુસાભાઈ કોઈ(૧૮૩૧)	જુની શરત (જ.શ.)	૧૬૦ પેકી ૧	૧૬૮૦૬	-	૧૬૮૦૬
	દુર્ગાબેન વાઘરામભાઈ કોઈ(૧૬૬૬)					
	મધુબેન વાઘરામભાઈ કોઈ(૧૬૬૬)					
	દવલબેન વાઘરામભાઈ કોઈ(૧૬૬૬)	જુની શરત (જ.શ.)	૧૬૦ પેકી ૨	૧૬૮૦૬	-	૧૬૮૦૬
	ભાવનાબેન વાઘરામભાઈ કોઈ(૧૬૬૬)					
	મવીતાબેન વાઘરામભાઈ કોઈ(૧૬૬૬)					
	મનસુખભાઈ વાઘરામભાઈ કોઈ(૧૬૬૬)					
	તાલસીભાઈ વાઘરામભાઈ કોઈ(૧૬૬૬)					
	જિજ્ઞાસુભાઈ વાઘરામભાઈ કોઈ(૧૬૬૬)					
	શ્યામક પાલકભાઈ કોઈ(૧૬૬૬)	જુની શરત (જ.શ.)	૧૬૦ પેકી ૩	૧૬૮૦૬	-	૧૬૮૦૬
	મતીલાલબેન વાઘરામભાઈ કોઈ(૧૬૬૬)					
	માધુભાઈ પંનાભાઈ પાંડવ	જુની શરત (જ.શ.)	૧૬૦ પેકી ૪	૧૬૮૦૬	-	૧૬૮૦૬
	દેવગજભાઈ કાનાભાઈ(૦૭)					
	ભાગવાનભાઈ કાનાભાઈ(૫૩)	જુની શરત (જ.શ.)	૧૬૦ પેકી ૫	૩૩૩૦૧	-	૩૩૩૦૧
	પુરુષોત્તમભાઈ કાનાભાઈ(૭૮)					
	વિદ્યુતભાઈ કાનાભાઈ(૧૧૦૭)					
	રામકુબેન છગનભાઈ કોઈ(૧૦૭)					
	ભાગવતભાઈ છગનભાઈ કોઈ(૧૦૭)					
	ભાવનાબેન છગનભાઈ કોઈ(૧૦૭)	જુની શરત (જ.શ.)	૧૬૦ પેકી ૬	૩૩૩૦૦	-	૩૩૩૦૦
	જિજ્ઞાસુભાઈ છગનભાઈ કોઈ(૧૦૭)					
	લીલીબેન છગનભાઈ કોઈ(૧૦૭)					
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	મનસુખભાઈ છગનભાઈ કોઈ(૧૦૭)					

Table 5-1: Area statement table

ઓરિયા પત્રક						
ગામ :- તરસરા, તળાજા, અલંગ						
અનુ. નં.	જમીન માલિકનું નામ	સત્તા પ્રકાર	સર્વે નં	૭/૧૨ રેકર્ડ મુજબ ક્ષેત્રફળ		
				કુલ	ખરાબો	લાયક
				ચો.મી.	ચો.મી.	ચો.મી.
૧	સરકારી બિન આકારી	સરકારી પડતર	૧૦૨/૧	૨૪૨૮	-	૨૪૨૮
	સરકારી બિન આકારી	સરકારી પડતર	૧૦૨/૨	૧૫૧૮	-	૧૫૧૮
	સરકારી બિન આકારી	સરકારી પડતર	૧૦૨/૩	૩૧૩૬	-	૩૧૩૬
	સરકારી બિન આકારી	સરકારી પડતર	૧૦૨/૪	૬૨૪૨૩	-	૬૨૪૨૩
૨	સરકારી બિન આકારી	સરકારી પડતર	૨૨૮ પેકી ૧	૩૧૪૨૦૦૭	-	૩૧૪૨૦૦૭
	શ્રી સરકાર(૧૪૦૮)	સરકારી પડતર	૨૨૮ પેકી ૧/૧ પેકી ૧	૭૦૦૦૦	-	૭૦૦૦૦
	ગામતળ(૩૨૫)	સરકારી પડતર	૨૨૮ પેકી ૧/૨ પેકી ૨	૧૬૧૮૮	-	૧૬૧૮૮
૩	ગૌચર(૫૦૦)	જુની શરત (જ.શ.)	૨૨૮ પેકી ૩	૮૭૦૦૭૮	-	૮૭૦૦૭૮
૪	ફોરેસ્ટ રીઝર્વ(૭૦૭)	સરકારી પડતર	૨૨૮ પેકી ૪	૬૩૭૩૮૪	-	૬૩૭૩૮૪
૫	ગામતળ(૩૨૫)	જુની શરત (જ.શ.)	૨૨૮ પેકી ૫	૩૪૮૦૪	-	૩૪૮૦૪
૬	સરકારી આકારી પડતર(૯૬૭)	સરકારી પડતર	૨૨૮	૨૩૬૭૪	-	૨૩૬૭૪

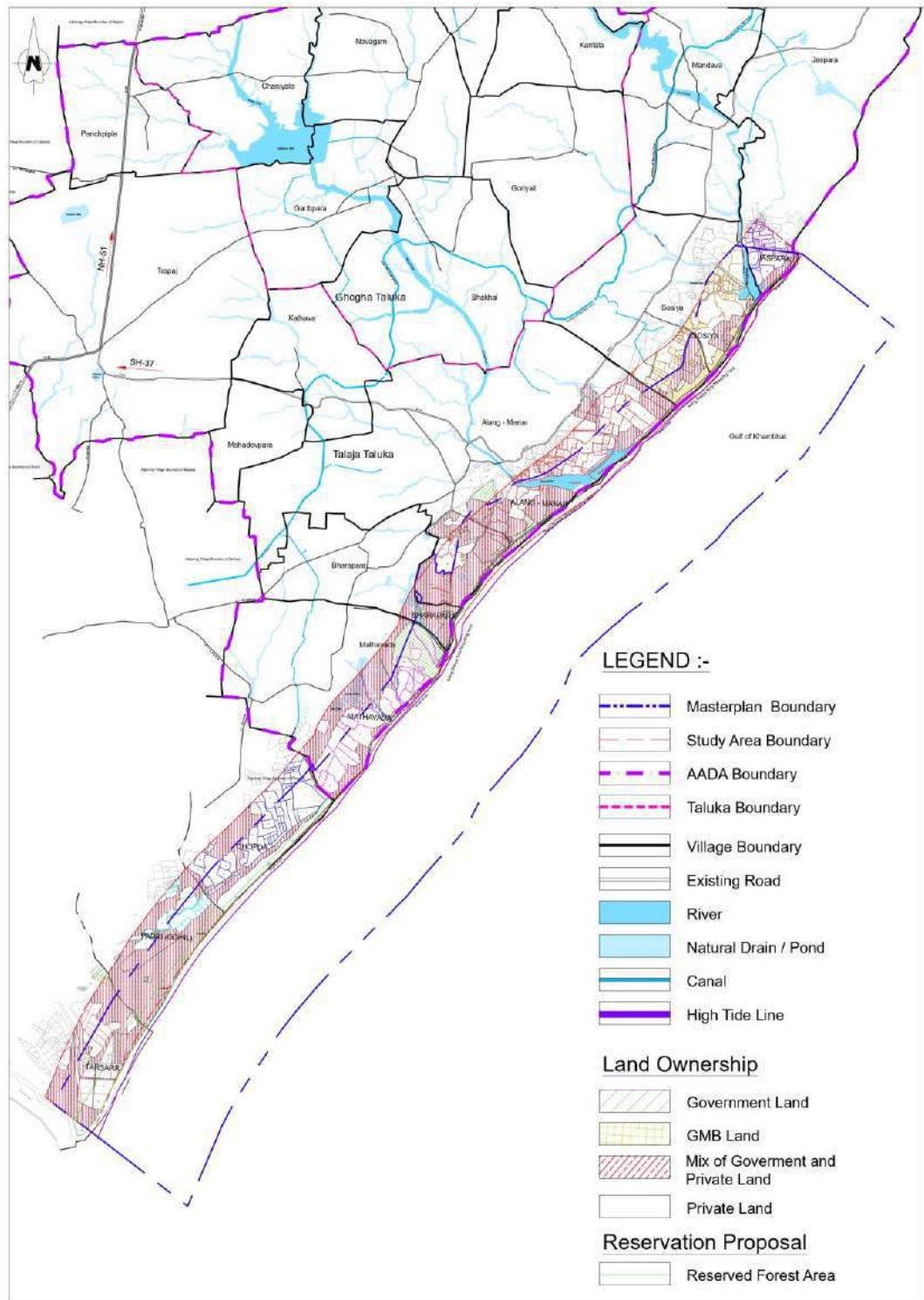
એરિયા પત્રક						
ગામ :- તરસરા, તળાજા, અલંગ						
અનુ. નં.	જમીન માલિકનું નામ	સત્તા પ્રકાર	સર્વે નં	૭/૧૨ રેકર્ડ મુજબ ક્ષેત્રફળ		
				કુલ	ખરાબો	લાયક
				ચો.મી.	ચો.મી.	ચો.મી.
ઢોટલ				૪૮૬૩૬૪૦		

- Project boundary delineation
 - The proposed master plan extent for the Alang-Sosiya Ship Recycling Yard was delineated based on ground realities and planning considerations. On the seaward side, a 20 km coastal stretch was suggested by GMB to align with existing and proposed ship recycling plots. On the landward side, the boundary follows the proposed 24-meter-wide Alang Area Development Authority development plan road, providing a structured development corridor.

5.1.1 Final master plan boundary

Delineation of final master plan boundary from the provided study area for master plan extent of 20 km coastal stretch with 500 m width from the existing road has been carried out with reference to the AADA Development Plan, The 24 m road proposed along the coast behind the primary road is considered and the periphery road running across the yard forming a ring road to the facility helping in improving the access. The same road has been extended beyond the DP boundary towards the expansion stretch extending till the end of the proposed master plan stretch for connectivity.

This helps in delineation and development as well, as it requires minimum disruption or changes to the approved Development Plan.

Figure 5-6: Master plan base map with delineated boundary

5.1.2 Existing land use

The existing land use indicates a linear concentration of scrap processing units along the main road and State Highway-37 extending up to Trapaj. The proposed master plan incorporates designated zones within the facility to accommodate the anticipated increase in ship scrap generation in the future. This planned allocation of space will promote organized and consolidated development within the designated area, thereby discouraging

further ribbon development along the road corridors. The expansion stretch is mostly virgin land consist of agriculture land and waste land.

Figure 5-7: Existing land use map

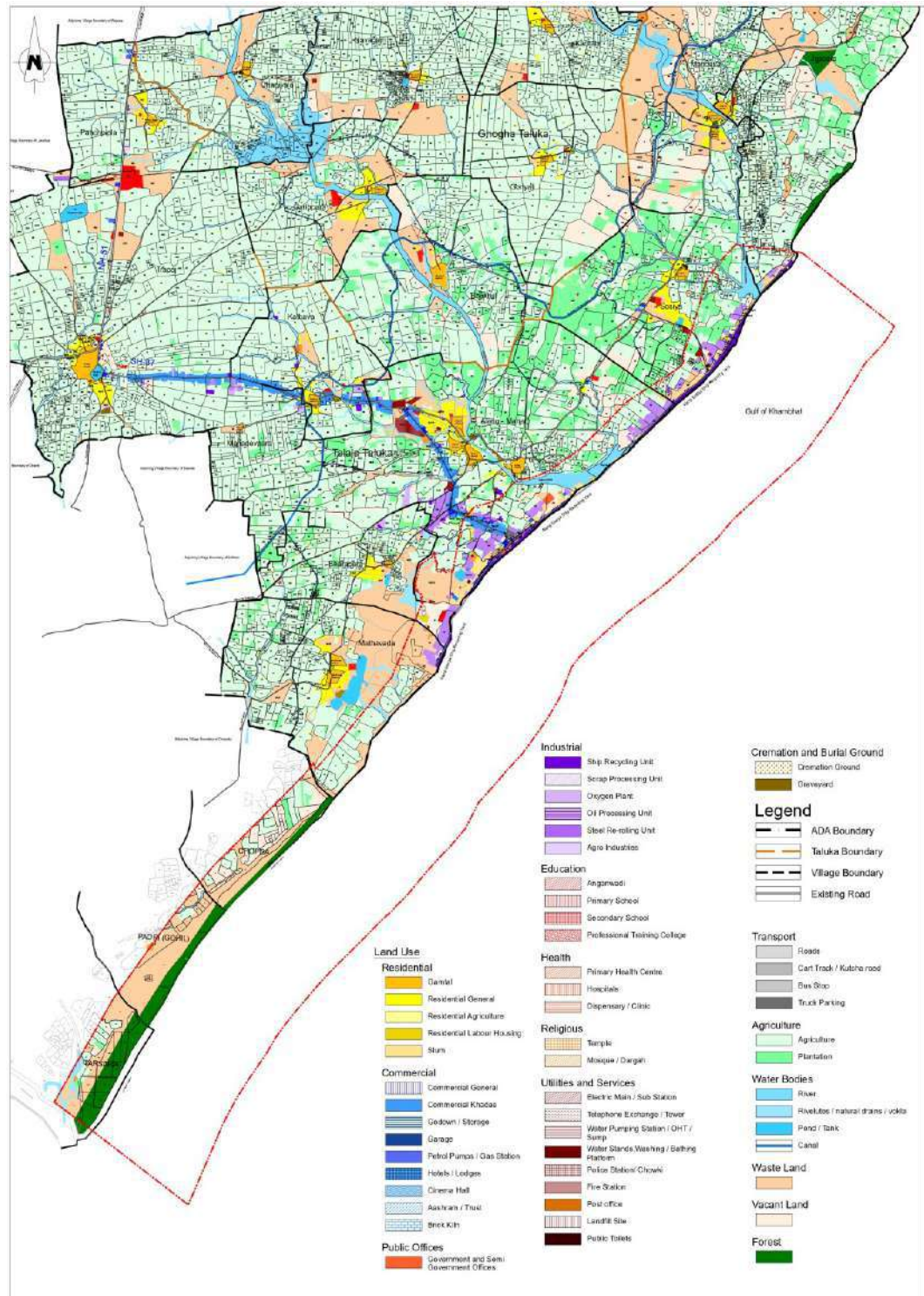


Table 5-2: Existing land use breakup

Existing Land use	Area (Ha)	Percentage
Residential	40.30	3%
Commercial	18.77	1%
Public and Semi-Public	2.84	0%
Industrial (Ship recycling plots)	192.72	13%
Education	1.77	0%
Health	1.39	0%
Religious	1.70	0%
Utilities and Services	3.11	0%
Cremation and Burial Ground	0.19	0%
Transport	13.81	1%
Agriculture	437.77	31%
Water Bodies	84.18	6%
Waste Land	228.27	16%
Vacant Land	59.56	4%
Forest	121.01	8%
Inter tidal beach	226.45	16%
Total	1433.83	100%

The total assessed planning area comprises 1,433.83 hectares, characterized by a dominant industrial coastline supported by rural settlements, agricultural land, environmentally sensitive zones, and significant intertidal stretches. The land use pattern reflects the organic evolution of the ship recycling ecosystem rather than a formally planned structure.

5.1.2.1 Industrial dominance

Ship recycling activities (Industrial) occupies 192.72 ha (13%) of the planning area and represents the core economic function of Alang, primarily associated with ship recycling activities and allied operations. The concentration of industrial use along the coastline indicates functional dependence on direct sea access. However, the industrial areas have evolved incrementally, resulting in fragmented support infrastructure.

The absence of clearly demarcated logistics, storage, and utility zones within industrial areas creates operational inefficiencies and environmental management challenges.

5.1.2.2 Residential and supporting uses

Residential land constitutes 40.30 ha (3%), accommodating workers, local communities, and associated service populations. The relatively small share of residential land indicates that settlements have developed in a dispersed manner primarily as slums, largely responding to employment opportunities rather than planned habitation.

Commercial areas cover 18.77 ha (1%), functioning primarily as secondary steel reselling centres (Khadas). Public and semi-public uses, including education (1.77 ha) and health facilities (1.39 ha), occupy negligible proportions, suggesting limited availability of organized social infrastructure relative to the workforce size.

This imbalance highlights the need for improved social infrastructure planning aligned with industrial activity intensity.

5.1.2.3 **Agriculture and rural landscape**

Agricultural land represents the largest single category at 437.77 ha (31%), indicating that significant portions of the expansion stretch of facility retain rural characteristics. However, increasing industrial influence may exert conversion pressure on agricultural lands if growth is not strategically guided.

5.1.2.4 **Underutilized and degraded land**

Waste land (16%) and vacant land (4%) together constitute nearly one-fifth of the planning area. These lands present significant opportunities for planned expansion, infrastructure development, and environmental improvement without disturbing ecologically sensitive zones.

5.1.2.5 **Infrastructure and utilities**

Transport infrastructure occupies 13.81 ha (1%), indicating limited formal mobility networks relative to industrial intensity. Utilities and services account for only 3.11 ha, reflecting inadequate spatial allocation for waste management, treatment facilities, and essential service infrastructure required for a globally compliant ship recycling ecosystem.

5.2 **Market analysis and population projection**

The market and demand considerations are very important in planning, specifically for maximum attractiveness as the demand considerations is the source of basic inputs for realistic assumption of support facilities such as infrastructure or presuming any other important investments.

A proposed product mix that specifies the number and size of standard ship recycling plots, were worked out based on the ship recycling market consideration.

Table 5-3: Capacity planning/optimization summary

Phase	Years	Target capacity (M LDT/year)	Actions	Capacity achievements	Additional waterfront required (m)
1	2025-2027	9.0	Add 9 plots south of existing facility 04 x 300 m plots 05 x 240 m plots	Added capacity: 4.519 M LDT/year Total: 9.019 M LDT/year	2705 m

Phase	Years	Target capacity (M LDT/year)	Actions	Capacity achievements	Additional waterfront required (m)
2	2028-2038	11.3	Expand into remaining waterfront (CRZ-IIA zone): 03 x 300 m plots 03 x 240 m plots	Added capacity: 2.3 M LDT/year Total: 11.319 M LDT/year	1675 m (Total: 4380 m including buffers)
3	2039+	11.3 +	Extend plots further south as required	Capacity matching market demand	Additional approx. 5385 m

Key takeaways from phase wise capacity expansion & planning exercise:

- **Baseline capacity:** 4.5 M LDT/year (current).
- **Expansion phases:** Southwards towards Mathwada (2.7 kms CRZ-II, then 7.1 kms CRZ-IA zones).
- **Challenges:** Administrative, legal, environmental (CRZ clearances).
- **Productivity gains:** Higher through training, technology, better layouts (20-30% potential improvement).
- **Master plan alignment:** Phased expansion matches the long-term master plan vision.
- Overcapacity is consistently planned through conservative estimates to handle uncertainties and underperformance.
- Expansion of plot lengths are highly recommended to unlock potential of existing plots and new plot allocations are critical to meeting future targets.
- Compliance with international regulations (EU and HKC) and technological upgrades will ensure optimal productivity.

The market study suggested phase wise development to cater to the demand which will rise in the coming years, and which has been illustrated in below figures:

5.2.1 Population estimation (based on market study)

Based on the market study and assuming a full build-out scenario, the Alang-Soshiya Ship Recycling Yard is projected to generate approximately 28,000 to 29,000 direct employment opportunities. This estimated population forms the basis for planning housing, social amenities, and essential infrastructure within the development area.

The phased development, aligned with ship recycling capacity expansion, will yield the following employment:

Table 5-4: Employment generation (adjusted to accelerated scenario)

Phase	By year	Target capacity (M LDT/year)	Approximate workers projection
Phase 1 (including existing plots)	2027	9	22,000-24,000
Phase 2	2038	11.3	28,000- 29,000
Phase 3	2038 +	11.3 +	53,339

Floating employment and workforce sourcing

For planning purposes, full built-out scenario with 53,339 workers have been. Some of the assumptions considered to determine total population that is expected to reside within Alang master plan area,

- Out of 53,339 workers around 20 % are expected to commute from surrounding villages, reducing the demand for on-site accommodation.
- From the remaining workers that are expected to stay in Alang around 20% of the workers are expected to shift with family of size 3.
- Based on the assumptions total populations across the phases have been worked out.

Table 5-5: Population estimation

	Phase 1	Phase 2	Phase 3
Employment generated	12,000	5,000	24,339
Workers expected to stay in Alang (80%)	9600	4000	19471
Floating population (20%)	2400	1000	4868
Total population in Alang (20% of the workers expected to come with family of 3)	13440	5600	27260

Planning implications:

For calculation of infrastructure demand, only the population envisaged in expansion is considered in phased approach and the enhancement of existing infrastructure shall be taken parallelly to expansion.

This estimated population of approximate 46,300 for expansion in 3 phases forms the planning benchmark for:

- Residential housing provision (family housing clusters and worker accommodation).
- Supporting infrastructure (water, sanitation, transport, and utilities).

Infrastructure proposals required for the existing stretch to match with the population expected at its peak capacity is provided separately which GMB can develop parallelly to the phases proposed.

5.3

Vision and planning principles

- **Vision**

- Gujarat Maritime Board (GMB) envisions to place Gujarat prominently on the international maritime map using its strategic advantage of India's longest coastline.

- **Planning principles**

- In the competitive environment prevailing today, it is imperative to develop an area that provides high quality infrastructure and high-quality production and service space. At the same time, social impact and environmental sustainability in such proposed high intensity investment areas are important considerations for planning. The area has been planned to use multi-dimensional approach to its planning, designing and development.

- **Planning considerations**

Spatial planning considerations used while preparing the master plan have been listed and described below. These considerations provide the basic framework for developing the area.

- Plot layouts follow international standards like Hong Kong Convention, EU guidelines and others.
- The existing development, roads and water bodies to be retained.
- Conformity of land use. Base map submitted to GMB for review and validation.
- GMB shall acquire entire land required for development within phase 1, 2 & 3.
- 24 m proposed road under the Alang Area Development Authority DP considered.
- The CRZ line
- Integration with the existing urban and developed areas
- Recreation promotion
- Higher level of industrial and public safety
- Sustainable housing and social amenities
- Co-existence of industrial space and natural environment
- Integration with the existing urban and developed areas

- **Internalizing applicability of the planning considerations as per site realities**

- All the important site-specific parameters (i.e. topographical / geological / climatic / hydrological / ecological / facts of the existing built environmental conditions) were considered while evolving the Master Plan.

- **Participatory planning**

- Participation through consultation is the foremost requirement for formulating development strategies reflecting local aspirations and for greater acceptability. It is also important for making people aware of the innovations and new introductions required for assuring a greater level of competitiveness.

- **Infrastructure considerations**

- The success of the area largely depends on the availability of high-quality infrastructure and logistics considerations. Hence, this necessitates us to explore carefully various aspects related to infrastructure, i.e. quality of available infrastructure, perception on quality of infrastructure needed, etc.

- **Environmental and social considerations**

- It is required to maintain ecological balance and carve out strategies for mitigating any negative impact on environment. Under this aspect, the issue of existing environmental features and settlements are integrated.

- **Implementation considerations**

- Implementation strategies are proposed for implementing the development projects identified by the master plan.

5.4

5.4.1

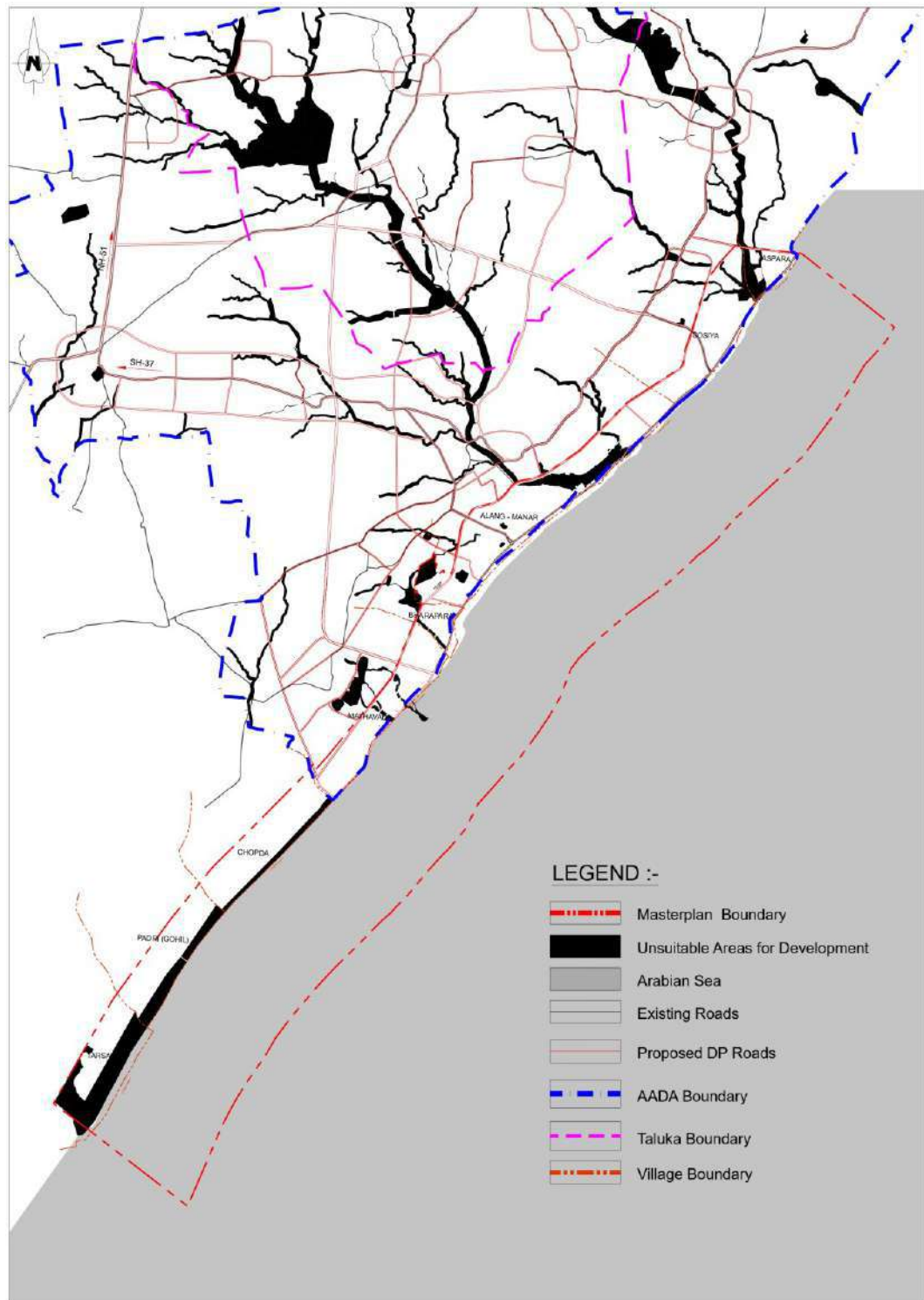
Development suitability and potentiality

Development suitability analysis

The development suitability analysis of the project area reveals that certain zones are restricted from development due to environmental, regulatory, or community considerations. Specifically, the areas classified under the following categories are not suitable for development:

- Water bodies
- Green buffer zones
- Forested areas
- Gamtal (existing village settlements)

These areas have been marked distinctly (in black) on the suitability map to denote their protected status. All remaining areas, outside these restricted zones, are deemed suitable for future development in accordance with planning norms and regulatory guidelines.

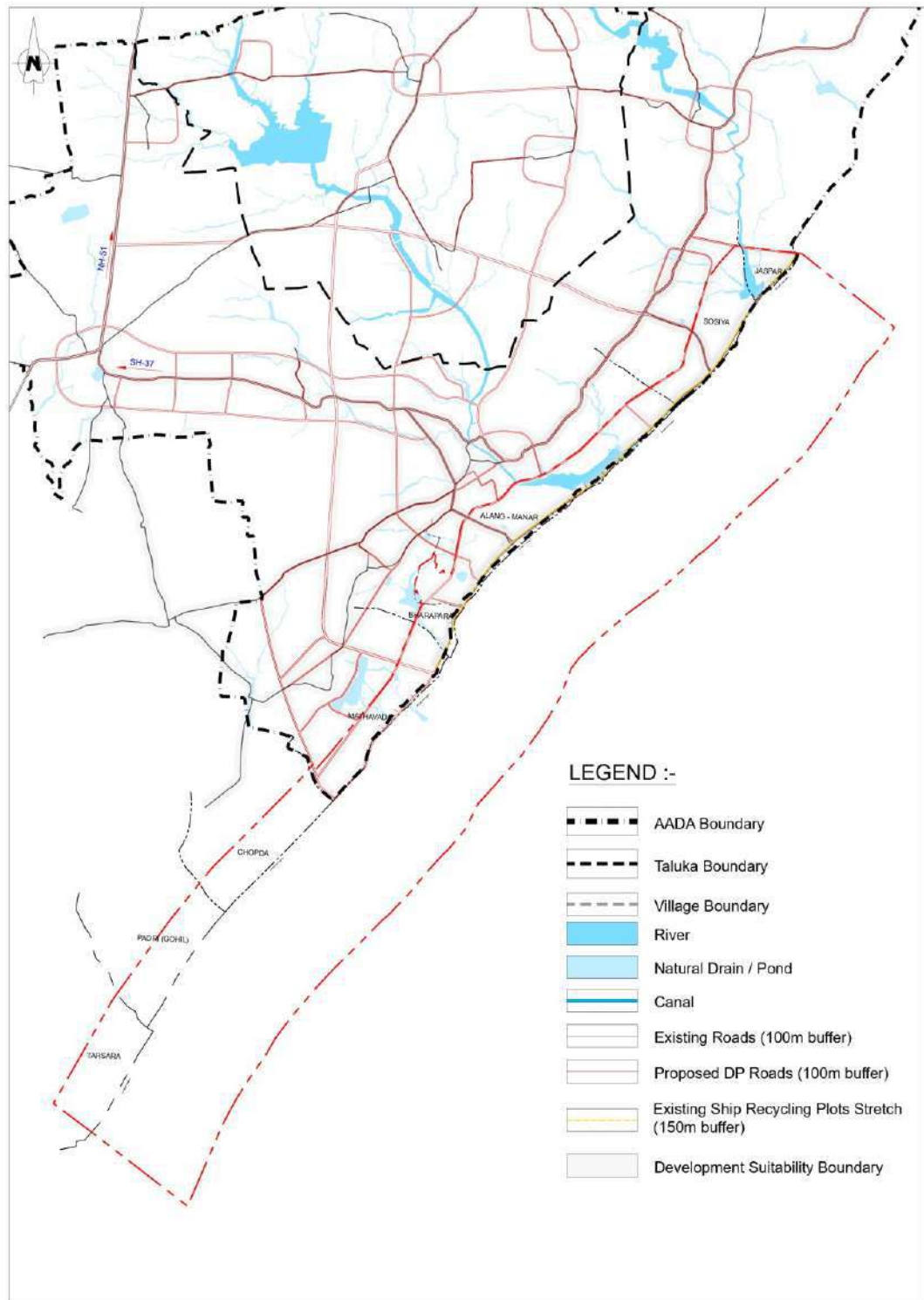
Figure 5-8: Development suitability map

5.4.2 Development potentiality analysis

The development potentiality map identifies zones with the highest suitability for future development. These areas are highlighted in dark grey on the map and are strategically located based on proximity to key infrastructure. Specifically, the high-potential development zones fall within the following buffered regions:

- A 150 m buffer surrounding the existing ship recycling plots, is most suitable for ship breaking and recycling related activities.
- A 50-100 m buffer along the existing 24 m wide roads traversing the site, most suitable for residential, health and education related activities.
- A 100 m buffer along the proposed 20.0 m development plan road, most suitable for ancillary industries (e.g., scrap processing & resellers etc.)

These zones offer enhanced accessibility, infrastructure linkage, and proximity to key activity nodes, making them prime candidates for phased development interventions.

Figure 5-9: Development potentiality map

5.5

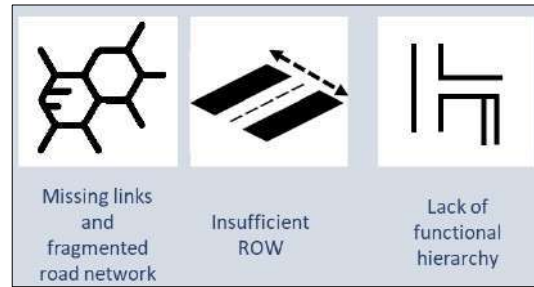
5.5.1

Concept development

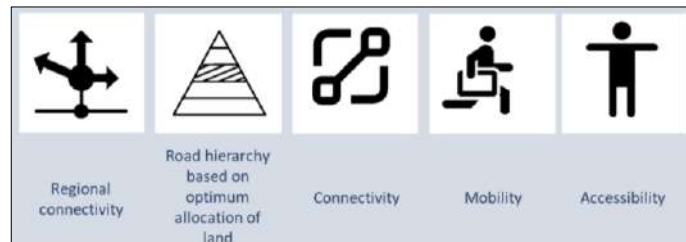
Road network

The following issues, planning parameters and strategies were implied in developing the concept layout for the site:

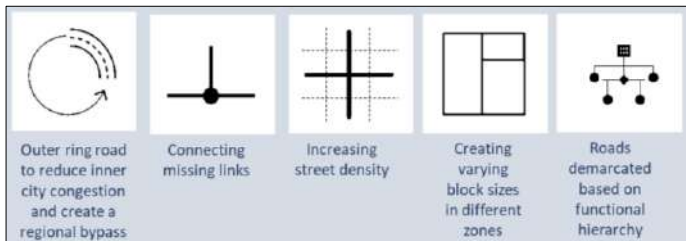
- **Issues** - A well-planned road network is essential for efficient transportation, urban development, and economic growth. However, several key issues can hinder the effectiveness of a road system, leading to congestion, inefficiencies, and poor connectivity. The following are some major challenges:



- **Planning parameters** - Implementing these planning parameters leads to a well-structured, efficient, and inclusive road network, supporting sustainable urban and regional growth.



- **Strategies** - The road network planning aims at improving mobility and reducing congestion. Key strategies include developing an outer ring road to distribute traffic and create a regional bypass, connecting missing links to enhance road connectivity, and increasing street density to improve accessibility.



Rational for proposed road network

The proposed road network for the project area has been developed based on a comprehensive analysis of existing road, future development needs, and planning principles.

The following key considerations form the basis of the road network strategy:

- Integration with existing road network

The proposed road layout respects and integrates with the existing hierarchy of roads, including the 24-meter-wide arterial roads that currently serve as the primary connectors within the region. This ensures continuity, minimized disruption, and cost-effective development by leveraging existing infrastructure.

- Alignment with proposed development plan (DP) roads

The network aligns with the development plan's proposed road alignments, maintaining coherence with broader regional planning objectives and enabling seamless connectivity beyond the immediate project area.

- Considering natural topography and water bodies

The road alignment has been carefully planned to avoid major contours, natural drainage paths, and existing water bodies, ensuring minimal environmental disturbance and reducing the need for costly earthwork or drainage realignment.

- Traffic management and segregation

The proposed road hierarchy distinguishes between arterial, collector, and local roads to ensure efficient traffic flow, reduce congestion, and enable safe movement of both vehicular and pedestrian traffic. Industrial and service traffic is strategically segregated from residential and pedestrian areas to maintain functional harmony.

- East-West connectivity

Special attention is given to East–West linkages to enhance cross-site mobility and reduce travel distances within the site. These connections also facilitate better access to public amenities and enhance site permeability.

Initial stakeholder discussion feedback

Over discussions, GMB has expressed its objective to create the Alang ship recycling yard as a Ship Recycling Park, with all the necessary ecosystem of ship recycling including creating zones for scrap resellers.

Figure 5-10: Discussing proposed ship recycling method and plot sizes with CRDF and GMB representatives



5.5.2 Zoning and amenities

The exercise aimed to assess development possibilities that support sustainable growth within the planning area. The concept is formulated based on recent spatial growth patterns, with a strong emphasis on accessibility and sustainability in land-use planning. Key factors such as existing land use, road networks, settlement patterns, terrain topology, spatial expansion trends, eco-sensitive areas, and land availability have been carefully considered in the proposed land-use zoning.

The site provides strong connectivity with Bhavnagar and Mathawada via the road network, with notable growth observed along the highway leading to Bhavnagar, particularly around Manar and Sosiya. Therefore, in addition to the spatial growth pattern and existing land

use, both the current road network and the proposed development plan road network have been incorporated into the zoning strategy.

The zoning has been conceptualised based on nuisance base approach. A nuisance-based zoning approach regulates land use based on the level of disturbance or negative impact an activity may have on its surroundings, rather than strictly separating uses into fixed categories. This method focuses on managing externalities such as noise, pollution, traffic, and other disruptions to ensure compatibility between different land uses. Unlike traditional zoning, which rigidly classifies areas as residential, commercial, or industrial, nuisance-based zoning allows for greater flexibility by permitting a mix of uses as long as they meet predefined performance standards. This approach promotes sustainable and adaptable urban development while reducing conflicts between different activities

The proposed concept is designed to minimize disruptions caused by industrial activities. The main ship-recycling activities are positioned alongside the expansion area designated for similar functions. This zone allows to expand storage and processing of scrap reducing load on the limited space in the existing ship recycling plots.

Behind the ship recycling plots across the road, a 200 m deep plots for backup yards have been envisaged to address the need to develop additional space for storage, sorting and segregation facilities for the ship recycling plot. As per the requirement/request from the plot owner each recycling plot will get a backup plot for developing it on their own.

Behind this backup yards, secondary scrap market zone is proposed for the traders and resellers that are currently spread across the road connecting Alang from Trapaj.

Rational for proposed zoning

The proposed zoning strategy for the project area has been developed with a focus on integrated development, liveability, and compatibility with existing land uses. The zoning framework is informed by several key parameters:

- **Alignment with proposed development plan (DP) zoning**

The zoning layout aligns with the proposed development plan zoning, ensuring regional consistency and policy compliance. This helps in maintaining continuity with broader urban planning goals while enabling localized flexibility where needed.

- **Consideration of existing development patterns**

The zoning reflects the existing built environment, including ship recycling plots, residential clusters, and institutional facilities. By recognizing the current land uses, the plan facilitates a smoother transition and integration of new developments with minimal displacement or conflict.

- **Walkable access to amenities and workplaces**

Zones have been structured to promote walkability between residential areas, amenities, and employment hubs. This enhances day-to-day convenience for workers and residents, reduces vehicular dependency, and supports a more sustainable urban form.

- **Environmental buffers and protection zones**

Buffer zones have been incorporated along water bodies, forests, and recreational spaces to protect environmentally sensitive areas and to enhance the quality of open spaces. These zones help preserve ecological integrity while contributing to the overall liveability of the area.

- **Promotion of mixed-use development**

To foster vibrant, multifunctional neighbourhoods, mixed-use zoning has been proposed in selected areas. This allows for a blend of residential, commercial, institutional, and light industrial uses, encouraging round-the-clock activity and economic diversity. Dedicated zoning has been proposed along and around the **existing ship recycling plots** to facilitate the **expansion and modernization** of yard-related activities.

5.5.3 Land-use planning considerations

- The development plan prioritizes the existing land-use and settlement patterns.
- A dedicated zone for scrap resellers & future industrial expansion has been identified behind the ship recycling plot and its backup yard, leveraging proximity for future growth.

Figure 5-11: Concept layout



This layout integrates commercial, social, and infrastructure development while adhering to CRZ norms. It ensures environmental sustainability by preserving CRZ-IA zones and facilitating regulated urban expansion in CRZ-II zones. The inclusion of hospitals, housing cluster, training centres, and accommodation facilities indicates a well-planned self-sustaining area.

Figure 5-12: Planning concepts

Eco Buffers	Access and Road Network	Shipbreaking Areas	Residential and Worker Amenities
Buffer zone: buffer zones around eco sensitive areas	24 m Ring Road Proposed 24 m Internal Roads 36m wide road to Mathwada	Existing and new Ship recycling plots: 300 m x 215 m 240 m x 215 m	De-Centralized Housing Complex for Worker Accommodation
TSDF (Waste Management)	Healthcare and Commercial Facilities	Drainage and Water Management	Future Expansion Potential
Two TSDF Units: Existing and Proposed.	Multi-specialty Hospital & PHC, social and commercial complex reservations	Stormwater drainage systems Rainwater harvesting systems	5.3 km additional area in phase 3 beyond 11.3 M capacity for future expansion

As per the concept and population estimation through market study, the following estimation of the areas has been derived for different land uses.

Table 5-6: Estimation of areas under different land uses

Land requirement - Expansion (Estimated for 46,300 Population)			
Sr. No.	Amenity	Area in m ²	Area in Ha.
1	EWS and affordable housing	435,000	43.5
2	Land for local commercial	100,000	10
3	Health facility	4,000	0.40
4	Education facility	140,000	14
As per URDPFI Norms		Total	67.9

5.6 Road and transport proposals

A well-planned road network is essential for efficient freight movement, urban development, and economic growth. The master plan emphasizes a **multi-layered road hierarchy** for accessibility and circulation:

- 24-meter-wide arterial roads as the primary backbone.
- Integration of two parallel road corridors, consistent with the AADA Development Plan.
- Proposed arterial road connecting to the main road connecting Trapaj and to National Highway for efficient evacuation.

Several planning parameters in context to Alang have been considered. These parameters ensure that transportation systems meet the needs of regional development.

- Integrating road network proposed in the AADA Development Plan.
- The regional connectivity in the yard is strengthened through the provision of 24 m wide ring road (as per DP) around the ship recycling park.
- Series of 24 m wide North-South roads will help easy movement of vehicles and cargo.

5.6.1 Proposed road network

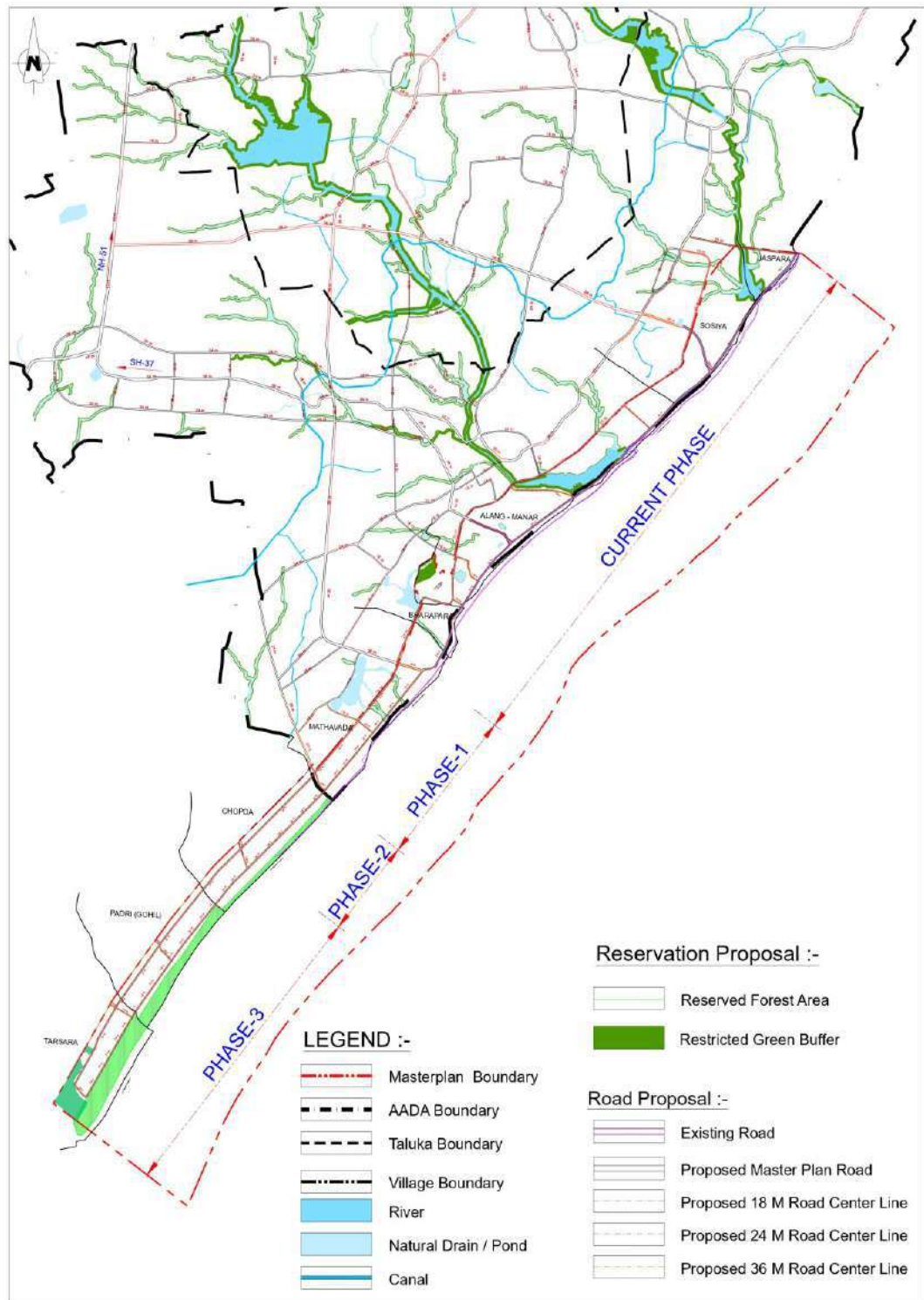
Road network connecting all the ship recycling plots in the existing stretch is proposed to 4-lane road with 24m road and the SH-37 to a 6-lane road with 36 m RoW aligning with DP proposal. Redevelopment of the existing road with underground utility networks and the bridge along the Manari River to be carried out simultaneously.

Road network of around 22.7 km has been proposed in the expansion stretch of Alang to connect it with the proposed ship recycling plots and backend infrastructure, the main evacuation is expected to be through existing State Highway-37.

Table 5-7: ROW & Road length within the expansion

Sr.no	RoW (m)	Total length (km)
1	18	2.55
2	24	19.72
3	36	0.44
Total		22.71

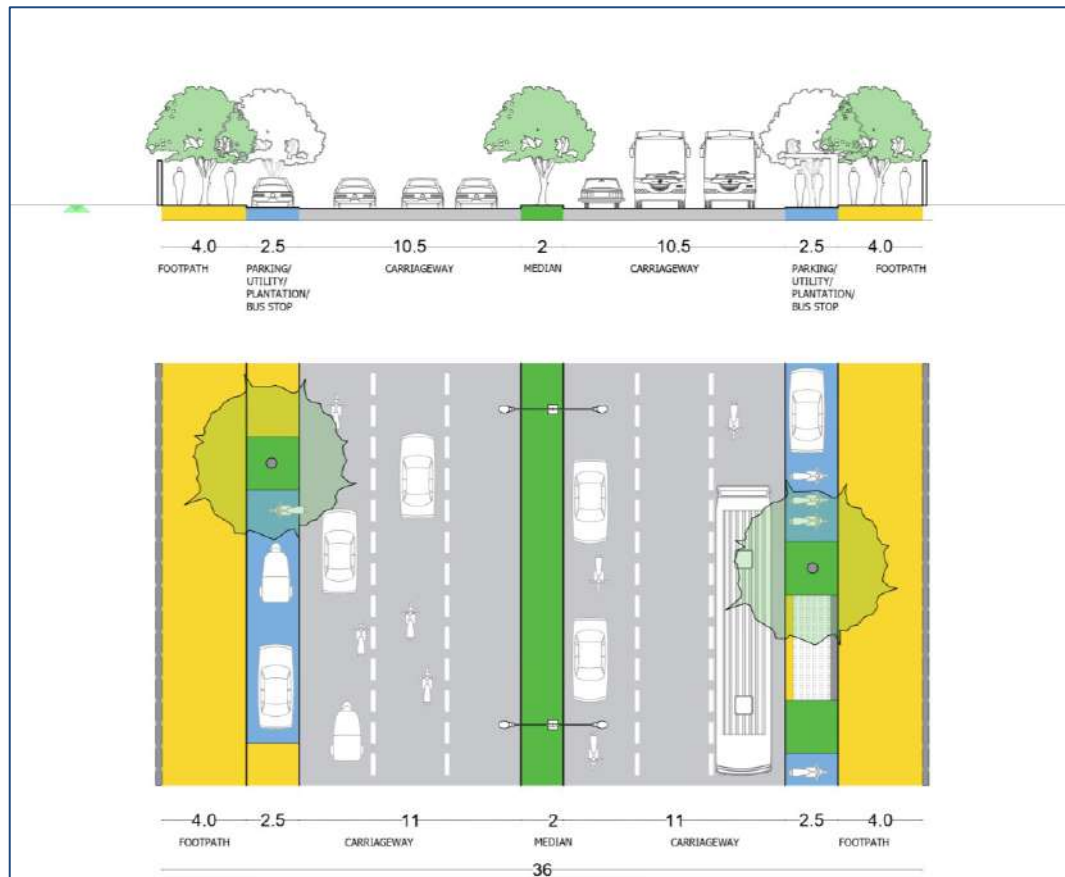
The implementation of the road development is expected to be in phases aligning with market.

Figure 5-13: Proposed road network

These roads have been proposed with 3 - 3 lanes both ways out of which 1-1 lane can be a service lane/on street parking lane. The road will have 1.0 m median for necessary street lighting and landscaping.

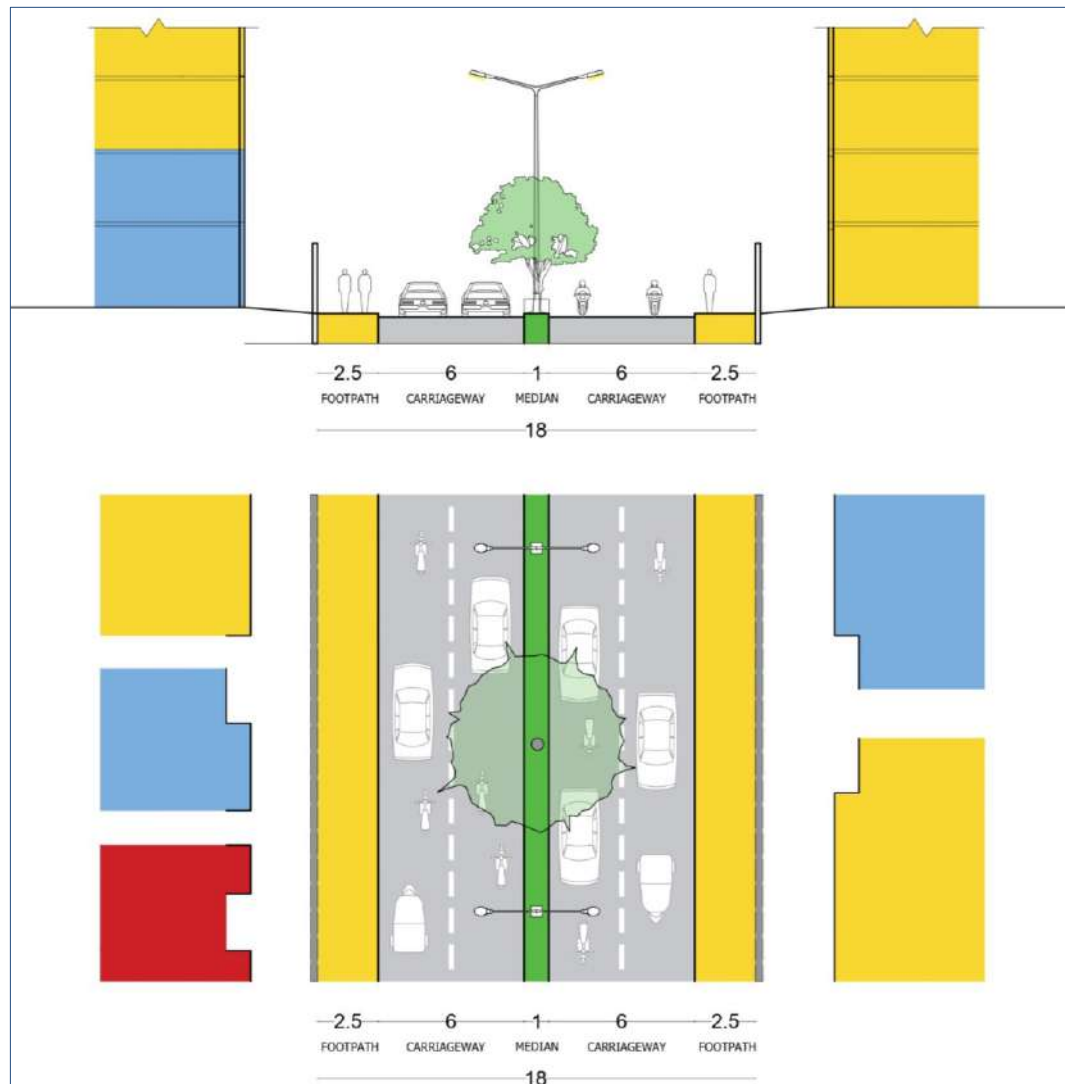
5.6.1.1 36 m ROW

The road connecting Alang to the National Highway is being proposed to expand to a 6-lane road with 36 m ROW for efficient transportation of recycling by products out of Alang.

Figure 5-14: Proposed 36 m street section**Figure 5-15: Proposed 36 m street view****5.6.1.2 24 m ROW**

All the North – South roads connecting all the plots and other facilities to the main 36 m road. This category of the road is an arterial road, which is a 24 m wide road. These roads connect the rest of the area to the arterial and collector roads, providing easy access to major industrial and residential areas.

Figure 5-16: Proposed 24 m street section**Figure 5-17: Proposed 24 m street view**

5.6.1.3 18 m ROW**Figure 5-18: Proposed 18 m street section**

All the North – South roads will be connected by 18.0 m East – West roads. This 18-meter-wide street design effectively balances vehicular movement, pedestrian accessibility, and green infrastructure. It features two 6-meter-wide carriageways on either side, ensuring smooth traffic flow, while a 1-meter-wide landscaped median with trees enhances aesthetics and environmental quality. 2.5-meter-wide footpaths on both sides provide safe and comfortable pedestrian movement. The adjacent buildings, marked with distinct colour coding, suggest a mix of commercial and residential land use, promoting a vibrant urban environment. Overall, the design prioritizes functionality, safety, and sustainability, creating a well-integrated streetscape that supports both mobility and urban life.

Figure 5-19: Proposed 18 m street view

This street design promotes a complete street approach, ensuring a balanced allocation of space for different users. It encourages walkability, accessibility, and sustainable mobility while incorporating green infrastructure to enhance the urban environment. The mix of functions around the street suggests a dynamic and lively corridor.

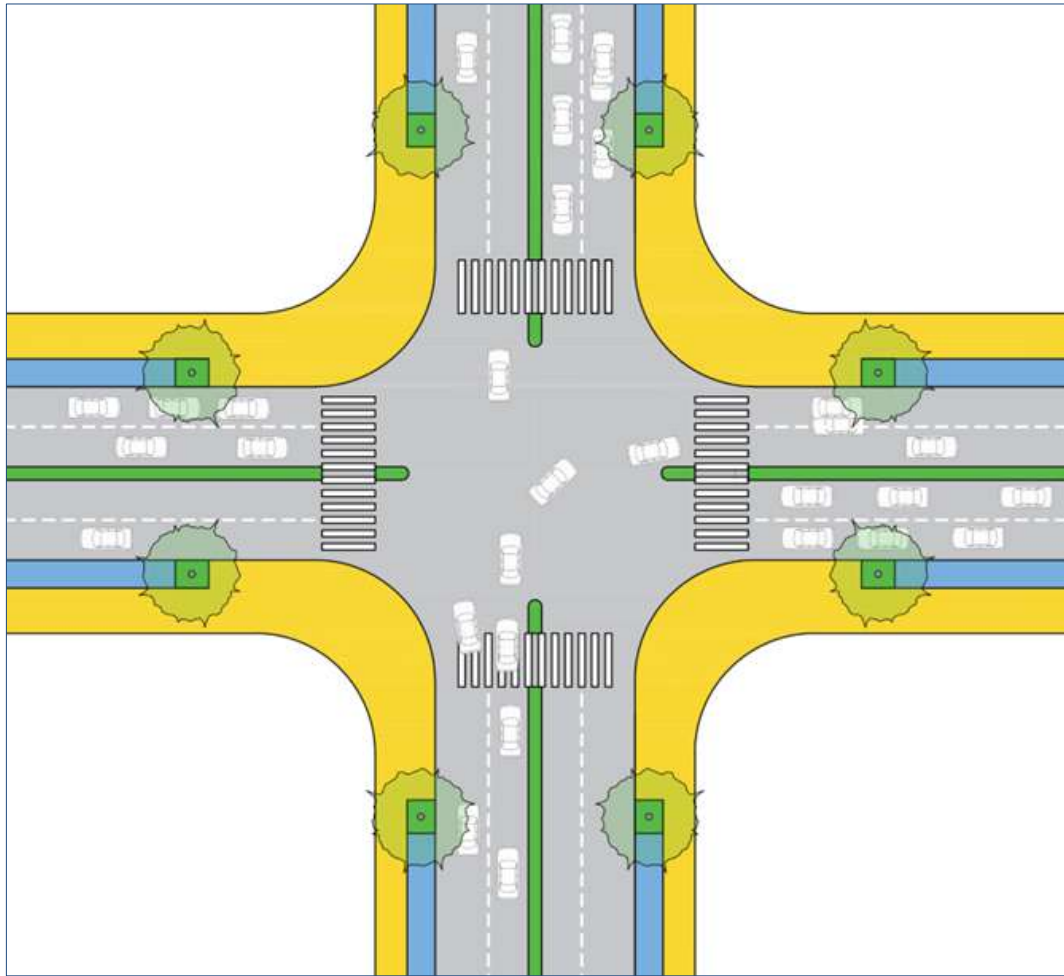
Figure 5-20: Proposed 24 m-24 m Junction

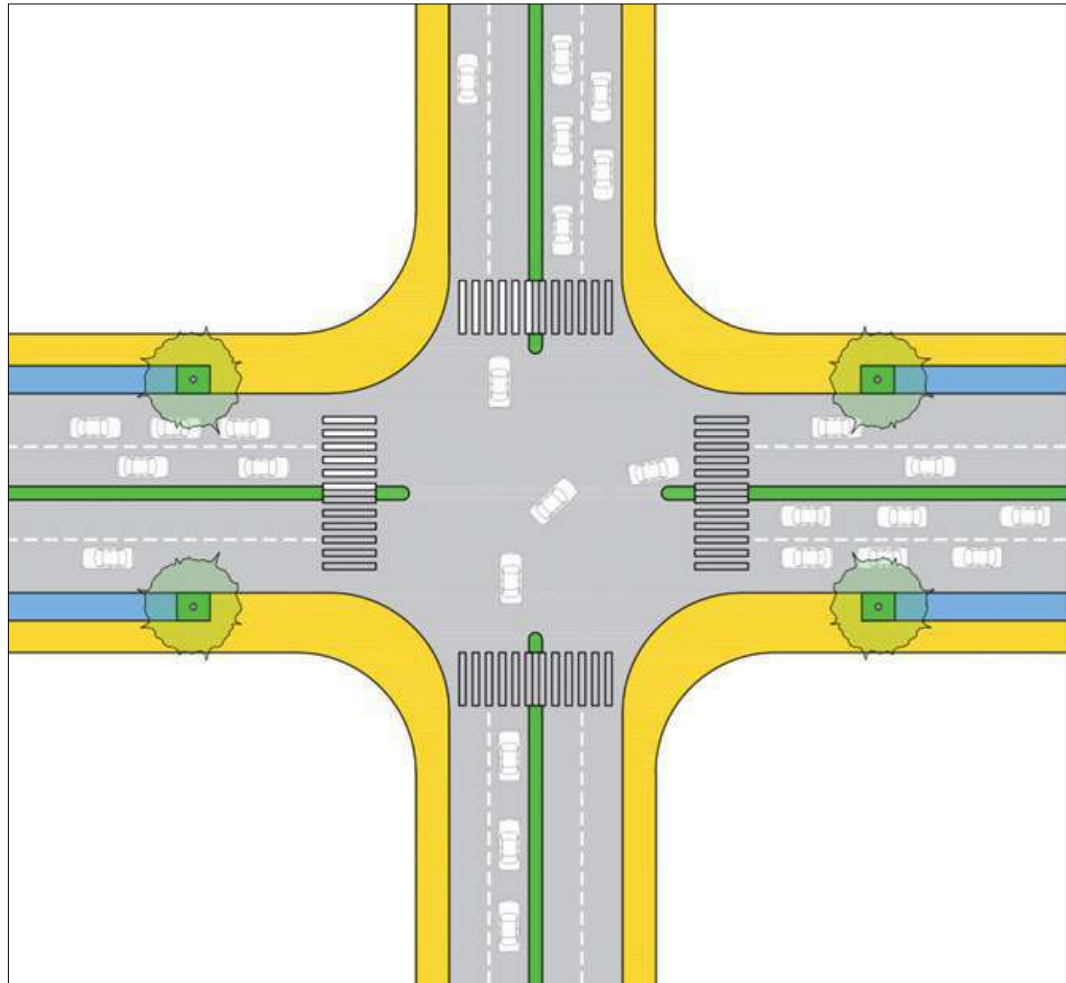
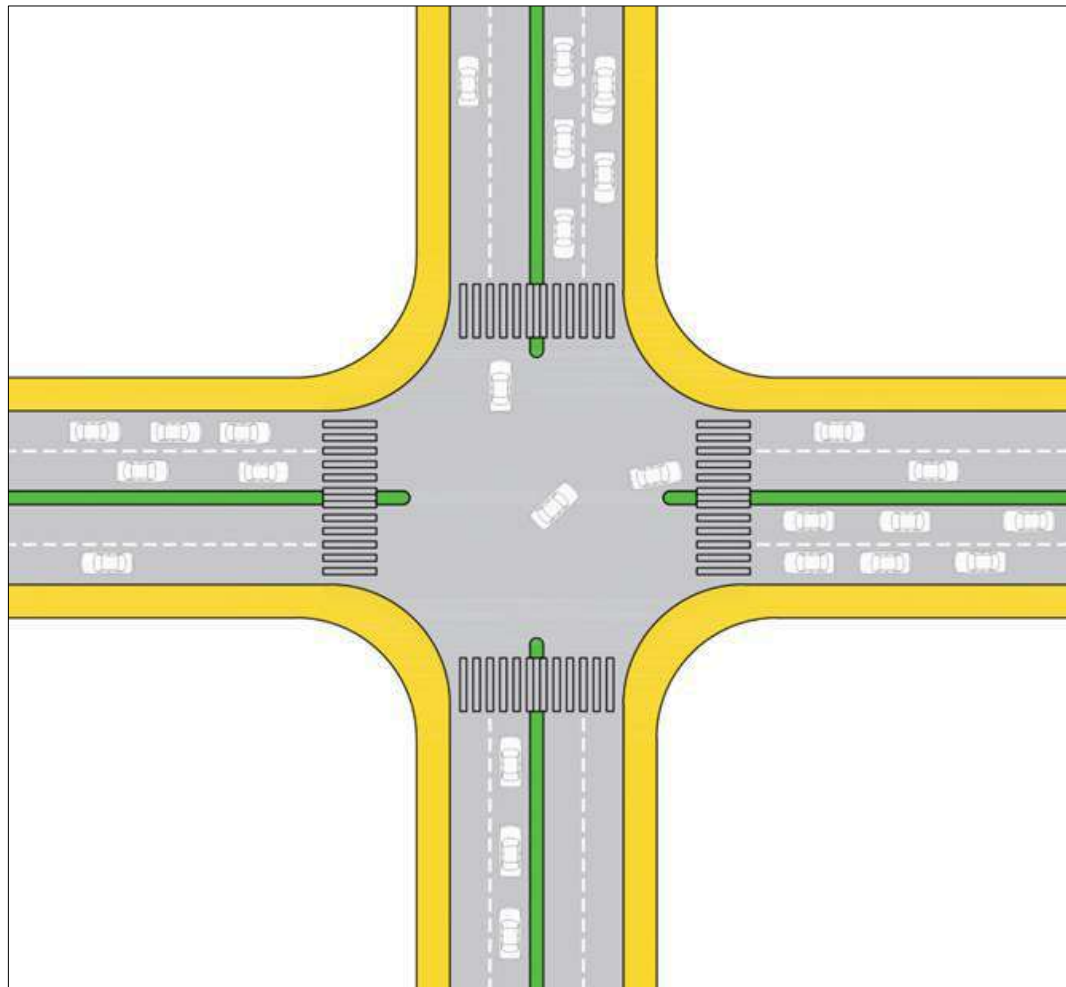
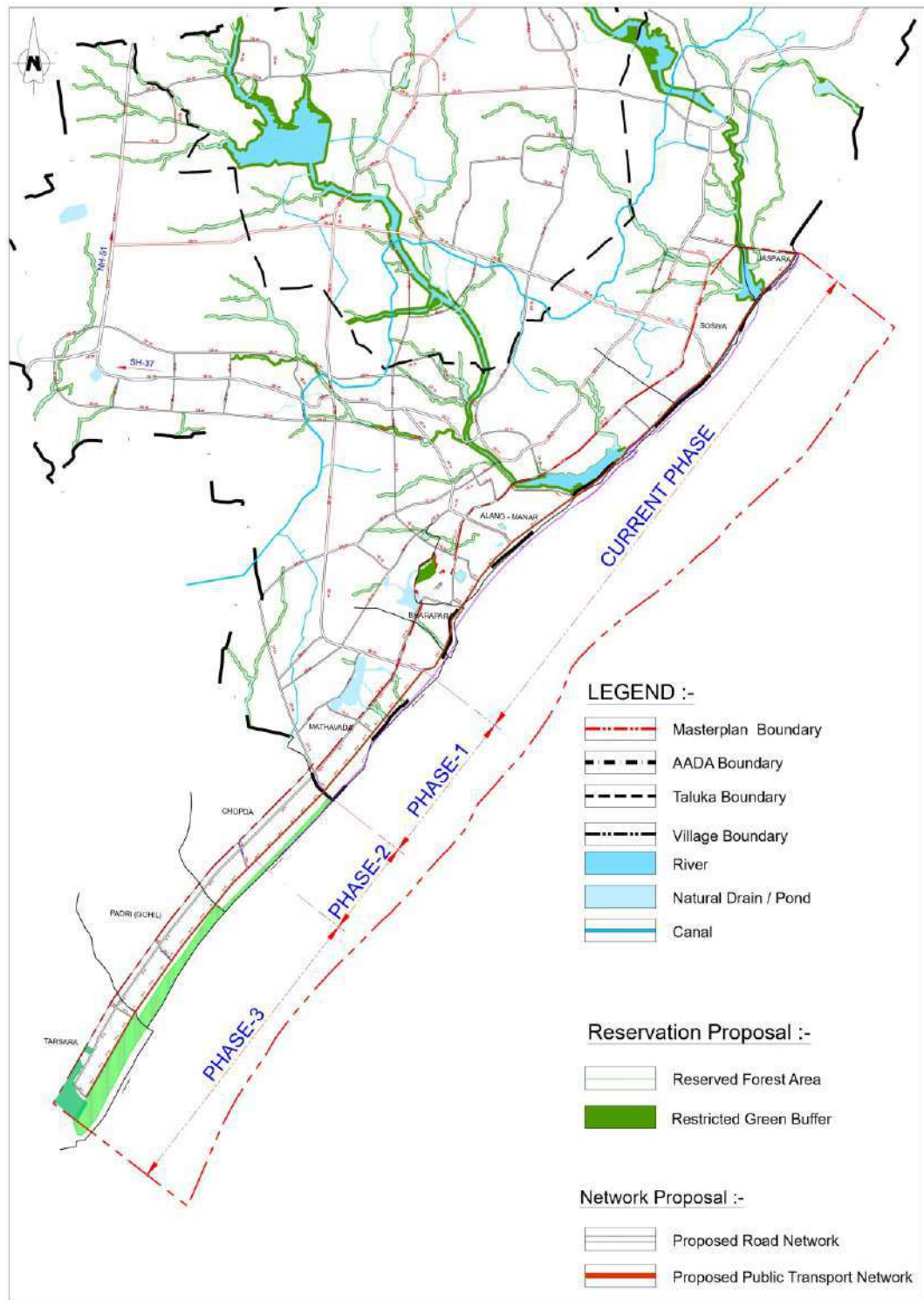
Figure 5-21: Proposed 18 m-24 m Junction

Figure 5-22: Proposed 18 m-18 m Junction

5.6.2 Public transportation

Master plan aims to improve public transport connectivity to the working and residing population within the park. New concepts like electric buses can be explored by the administration to facilitate smooth and convenient movement of stakeholders. EV buses can be envisioned along the main 24 m road connecting all the ship recycling plots. This will ease the pressure on roads, minimise parking provision and providing cost effective transit option to the residents.

All the major road intersection will have bus stops to make the public transit easily accessible and walkable from the housing clusters.

Figure 5-23: Proposed road network/public transport proposal

5.7

Land use proposals

The Master Plan is based on the application of spatial planning principles that ensure a consistent and coherent urban structure while providing flexible and economic development. The Land use proposal is envisioned to promote economically vibrant and environmentally sustainable Industrial city with a good quality of life. The land use proposals area spread across below mentioned zones

Along with studying the existing land use, the team also conducted discussions with stake holders including locals, local government officials who helped understand the issues faced by the yard in terms of development. As per the discussions, the issues conflicting or inefficient uses and the parameters placed by the physical environment and community infrastructure were identified.

The land use approach balances industrial activities with infrastructure provisions:

- Dedicated scrap reseller zone in 100-meter-wide strips, adjacent to arterial roads.
- Continuity with the existing master plan, while adapting to evolving functional requirements.
- Streamlined zoning framework, removing outdated or redundant provisions for clarity.

Uses permissible in yard expansion all types of storage, tertiary cutting, facilities related to ship breaking and construction of labour housing.

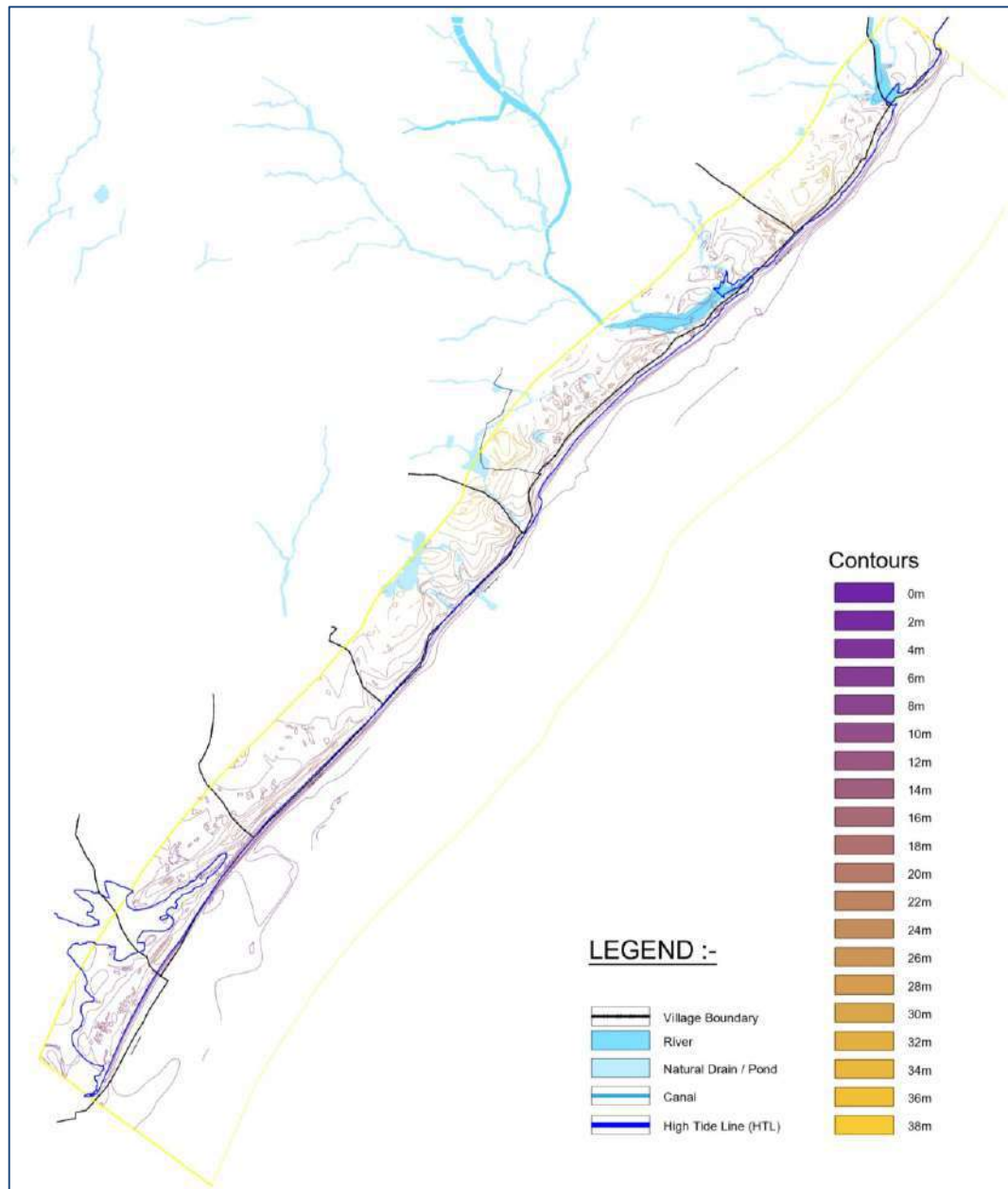
Advantages of this framework:

- Clear segregation of industrial and circulation zones.
- Flexibility for future expansion without disrupting road hierarchy.
- A phased and adaptable land use system aligned with AADA's broader development goals.

5.7.1

Response to site topography & environmental features

The expansion site is uneven with a gentle slope towards the sea. There is a need for cutting in phase 1 and filling in Phase 2 & 3. As a response towards site topography major road network has been aligned along the direction of slopes. For environmental conservation, it is proposed that green zones are developed around water bodies allowing development of public parks and gardens.

Figure 5-24: Contour map

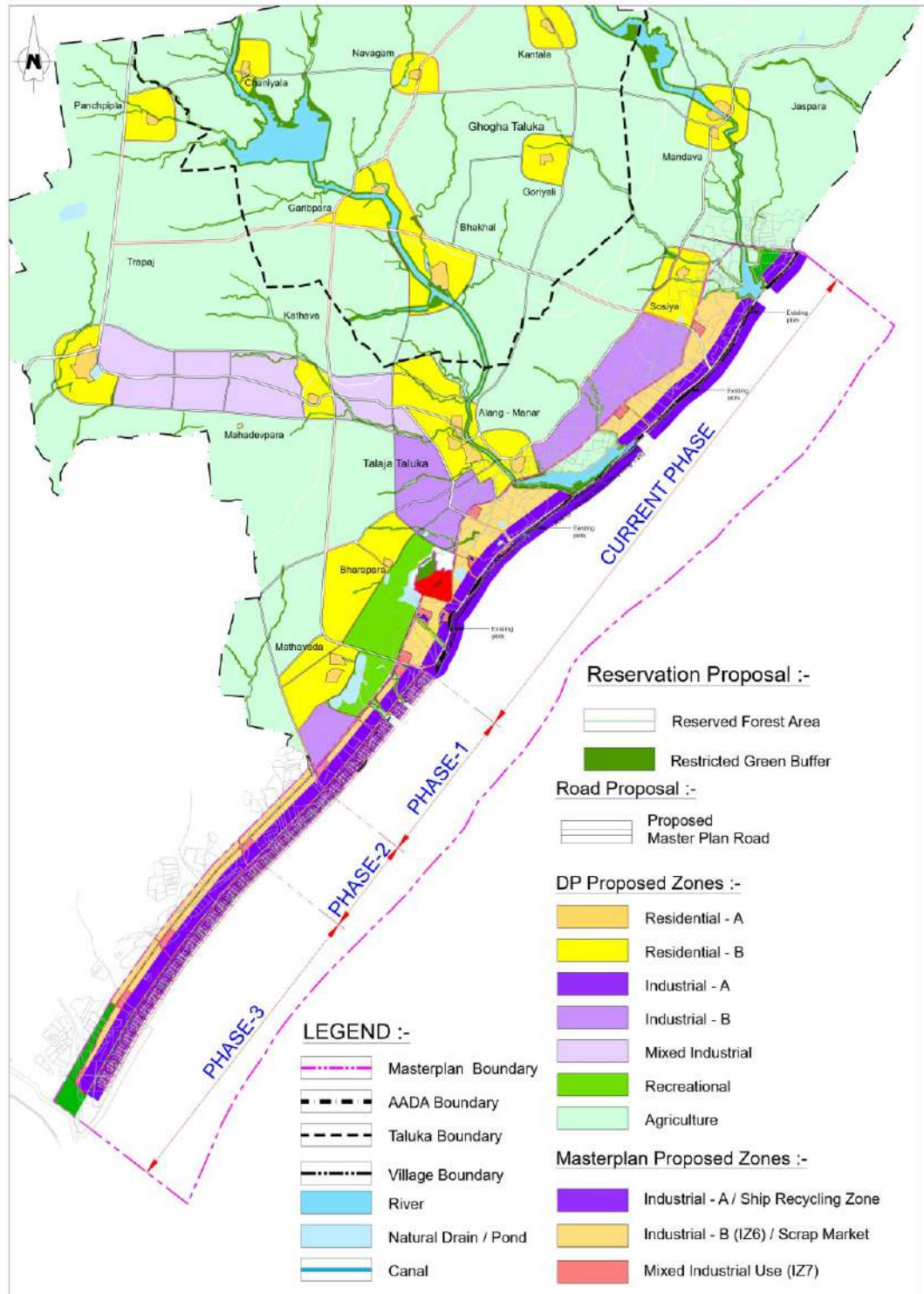
5.7.2 Land use integration

The land use strategy follows a **layered functional zoning principle**, designed to accommodate diverse activities related to ship recycling and its ancillary functions:

- **Primary Layer (Yard Zone):** The innermost plots are reserved for **ship recycling activities**, ensuring that the core industrial functions are concentrated in a controlled and accessible environment.
- **Secondary Layer:** The second tier of proposed plots is allocated for **secondary and tertiary activities**, including processing, storage, and support services. This transitional layer creates a buffer between heavy industrial activities and other functional uses.

- **Tertiary Layer (Peripheral Zone):** The outermost band of plots is designated for “Khadas” (yards for recyclers and sorting activities), supporting recycling, segregation, and material management functions. This arrangement facilitates efficient movement of materials and optimizes land use along the periphery.

Figure 5-25: Proposed zoning map



5.7.3 Industrial – A / Ship Recycling Zone

The industrial zones are planned strategically along the express corridor to ensure efficiency. The expansion zone for yard is planned adjacent to existing yard for accommodating all spillover activities of ship recycling in a structured manner. In context with regional connectivity and the proposed road network, this zone is well connected with other zones.

Permissible uses:

In line with the AADA Development Plan, "Industrial - A" allows for:

- Primary activities: Ship-breaking, hull dismantling, and large-scale metal scrapping.
- Ancillary activities: Oxygen/Acetylene plants, smelting units, steel rolling mills, and warehousing for recovered ship machinery.
- Labor facilities: Industrial housing or worker dormitories are permitted within the zone provided they meet the specific safety and health norms for industrial workers.

Industrial - A (AADA) / Ship recycling

Parameter	Regulation detail (Industrial - A)	CGDCR reference
Base FSI	1	Table 6.16
Max. permissible FSI	1.0 (Standard for D5 Special Project areas)	Table 6.16
Max. building height	18 m (Industrial sheds/structures)	Regulation 8.2
Ground coverage	Max. 50% (To ensure space for heavy machinery movement)	Regulation 12.4
Marginal setbacks	Front: 6.0 m (Min.)	Table 8.4
	Side/Rear: 6.0 m (Standard for large industrial units)	
Min. road width	24.0 m (For Express Corridor connectivity)	Section 10.4
Parking (Industrial)	10% of BUA for total parking area	Regulation 13.4

Additional specifications

1. Strategic connectivity & road width

The Industrial - A zone is specifically tied to the main 24 m corridor. Industrial - A requires a minimum abutting road width of 18.0 m to accommodate oversized heavy-duty trailers and cranes used in ship recycling.

- Entrance gates: Must have a minimum width of 6.0 m to ensure safe entry/exit of heavy vehicles without disrupting corridor traffic.

2. Setbacks and safety buffers

Given the spillover activities (such as steel storage, oxygen plant operations, and heavy metal operations), the setbacks are more rigid:

- Fire safety: A clear marginal space of 6.0 m must be maintained around the building for fire tender movement.

- Storage: No permanent or temporary hazardous storage is permitted within the marginal setbacks.

3. Ground coverage and open spaces

- Ground coverage: Limited to 50% to provide the necessary "buffer" required for the manoeuvrability of heavy lifting equipment (crawler cranes) which is vital for ship recycling operations.
- Common plot: For layouts exceeding 2,500 m², a 10% Common plot is mandatory, often used for centralized firefighting water tanks or administrative security hubs.

5.7.4 Industrial -B (IZ6) / Scrap Market

This zone offers secondary & tertiary activities, including scrap storage, selling of salvaged goods from the ship recycling. All the trading activities across the main road between Alang and Trapaj are anticipated in this zone.

Permissible uses: IN1, IN2, those permissible in C1, DW2 & DW3 both up to max. of 20% of utilized FSI with affordable housing units as defined under the CGDCR. (the definition of the mentioned uses are given in the annexure O).

1. Principal permissible uses

The following uses shall be **permitted as of right** in the Industrial-B Zone:

- General industrial uses classified as **IN-1 and IN-2**, including:
 - Manufacturing and processing units
 - Ship scrap yards and associated industrial activities
 - Workshops, fabrication yards and service industries
 - Warehousing, storage and godowns
 - Utility installations, substations, water and waste management facilities
 - Logistics, loading/unloading and material handling areas
- Industrial offices directly related to the functioning of the industrial unit.

2. Ancillary and supporting uses

The following uses may be permitted subject to limits:

- Commercial uses permissible under C-1 category, limited to:
 - Administrative offices
 - Canteens
 - First-aid centres
 - Small service establishments supporting industrial operations
- Limited dwelling units under DW-2 / DW-3 category, intended only for:
 - Watch & ward
 - Essential operational staff

Industrial – B (IZ6 Zone)

Parameter	Regulation detail (IZ6 - Industrial zone)	CGDCR reference
Base FSI	1	Table 6.16
Max. permissible FSI	1.0 (Chargeable FSI is not typically granted in D5 Industrial)	Table 6.16
Max. building height	18 m (subject to road width)	Regulation 8.2
Ground coverage	Max. 50%	Regulation 12.4
Marginal setbacks	Front: 6.0m (Road $\geq$ 18m) or 4.5m (Road < 18m)	Table 8.4 / 12.4
	Side/Rear: 4.5m (unit < 1000 sqm) or 6.0m (unit $\geq$ 1000 sqm)	
Min. road width	18.0 m	Regulation 10.4
Parking (Visitor)	10% of the total required parking area	Regulation 13.4

Additional specifications

1. Building height

As per AADA (Category D5), the building height is strictly governed by the abutting road width:

- 9 m to 12 m road: Max height allowed is often capped at 10m (G+2).
- 12 m to 18 m road: Max height is 15 m.
- 18 m and above: Max height is 18 m.

Note: For industrial buildings, if the process requires greater height (e.g., specialized machinery), a "Certificate of Requirement" from the Factory Inspector can allow for additional height.

2. Parking standards

Unlike residential zones where parking is calculated per unit, IZ6 parking is based on Total Built-up Area (BUA):

- Requirement: Typically, 1 Equivalent Car Space (ECS) per 100 sqm of BUA.
- Loading/Unloading: In IZ6, you must provide a dedicated loading/unloading space of at least 3.5m x 7.5m for every 1000 sqm of BUA.

3. Common plot

- For any industrial layout/sub-division in IZ6 exceeding 2500 sqm, a common Plot of 10% of the total land area is mandatory.
- The minimum side of any such common plot must not be less than 10.0 meters.

5.7.5 Mixed Industrial Use (IZ7)

To integrate community needs and provide for essential services, mixed industrial use nodes are strategically planned along the road corridors. These nodes will be located at the intersections of north-south and east-west roads and will recur approximately every 1.5 km across the site.

This nodal approach ensures equitable distribution of services, enhances accessibility, and creates focal points for community life within the larger industrial fabric specifically addressing development of housing and amenities cluster for workers of ship recycling plots.

Permissible uses: AS2, AS3, AS4, DW1, DW2, DW3, EDU2, H1, H2, H3, IN1, IN2, M1, M2, M3, PI, PU, REC, REG, SP&L, SE, ST and TEMP. (As per CGDCR 2017) (the definition of the mentioned uses is given in the annexure O)

Mixed industrial use (IZ7 Zone)

Parameter	Regulation detail (IZ7 - Industrial zone)	CGDCR reference
Base FSI	1.0 (Standard for Industrial Zones in D4/D5 categories)	Table 6.16
Max. permissible FSI	1.0 (Usually, no chargeable FSI is permitted in IZ7 unless specialized)	Table 6.16
Max. building height	Up to 15-18 m (typically Ground + 2 or 3 floors for industrial)	Regulation 8.2
Ground coverage	Max. 50% of the building-unit area	Regulation 12.4
Marginal setbacks	Front: 6.0 m (for roads $\geq$ 18m) or 4.5m (roads < 18m)	Table 8.4 / 12.4
	Side/Rear: 4.5 m (unit < 1000 sqm) or 6.0m (unit $\geq$ 1000 sqm)	
Min. road width	12.0 m for industrial approach (Internal)	Regulation 10.4
Parking (Visitor)	50% of required visitor parking must be at Ground Level	Regulation 13.4

Additional specifications

1. FSI & Height regulations

For AADA (Category D5), industrial zones are capped at a lower density compared to urban residential zones.

- Calculation: Building height is generally limited to $2 \times (\text{Road Width} + \text{Setback})$, but industrial safety usually dictates a lower cap (18 m) for the IZ7 zone to facilitate fire-fighting access.

2. Setbacks (Marginal open spaces)

Setbacks in IZ7 are all-around to ensure fire safety and ventilation between industrial sheds.

- Building-unit $\geq$ 1000 m²: Requires a minimum of 6.0 m clear margin on all sides.
- Building-unit < 1000 m²: Requires a minimum of 4.5 m margin.

3. Parking requirements

Parking for industrial units in AADA is calculated based on the Total Built-up Area (BUA):

- Industrial use: Typically, 1 space per 100 m² of BUA or as per the specific factory license requirement.
- Car vs. Two-Wheeler: 50% of the total parking area must be reserved for cars.

- Ramps: If a basement or multi-level parking is used, the ramp width must be at least 6.0 m for two-way traffic.

4. Road width & access

- For any industrial development in IZ7, the abutting road must be a minimum of 12.0 meters.
- If the industrial unit handles hazardous materials (common in ship-breaking zones), the access requirements may increase to 18.0 m to allow for heavy vehicle turning radii (typically 9.0 m to 12.0 m radius).

Housing & amenities cluster

At these nodes, land is earmarked for **housing & amenities clusters**, including:

- **Public housing** (where proposed by GMB).
- **Social amenities** such as schools, healthcare centres, and community facilities.
- **Physical infrastructure** such as water, sanitation, and utility services to support the population and workforce.
- **Commercial activities such as convenient shopping**- Provision of small- to medium-scale retail outlets and service establishments to cater to the daily needs of residents and workers. These may include grocery and vegetable shops, pharmacies, stationery stores, bakeries, eateries, ATMs, and personal care services. Convenient shopping facilities are strategically located to ensure walkable access, reduce dependence on long-distance travel, and promote a self-sufficient and vibrant community environment.

Figure 5-26: Proposed housing & amenities cluster in mixed industrial zone (IZ7) (indicative)



5.7.6

Development control regulations

All the proposed developments are considered to adhere to the Development Control Regulations framed under the Alang Area Development Authority (AADA) Development Plan. These guidelines provide the regulatory framework for building heights, setbacks, floor space index (FSI), and other planning parameters. Compliance with these regulations is essential to ensure that the proposed infrastructure and land use align with statutory planning norms and facilitate coordinated development across the region.

These regulations ensure orderly and sustainable urban development while maintaining consistency with broader planning objectives.

All the necessary/mandatory permissions and NOCs has to be obtained from the appropriate authorities at the time of development. Regardless of the permissible uses in the zone only the development granted with the required permissions from CRZ, environment and other related norms will be allowed.

Figure 5-27: Development based on the proposed land use (indicative)



5.7.7

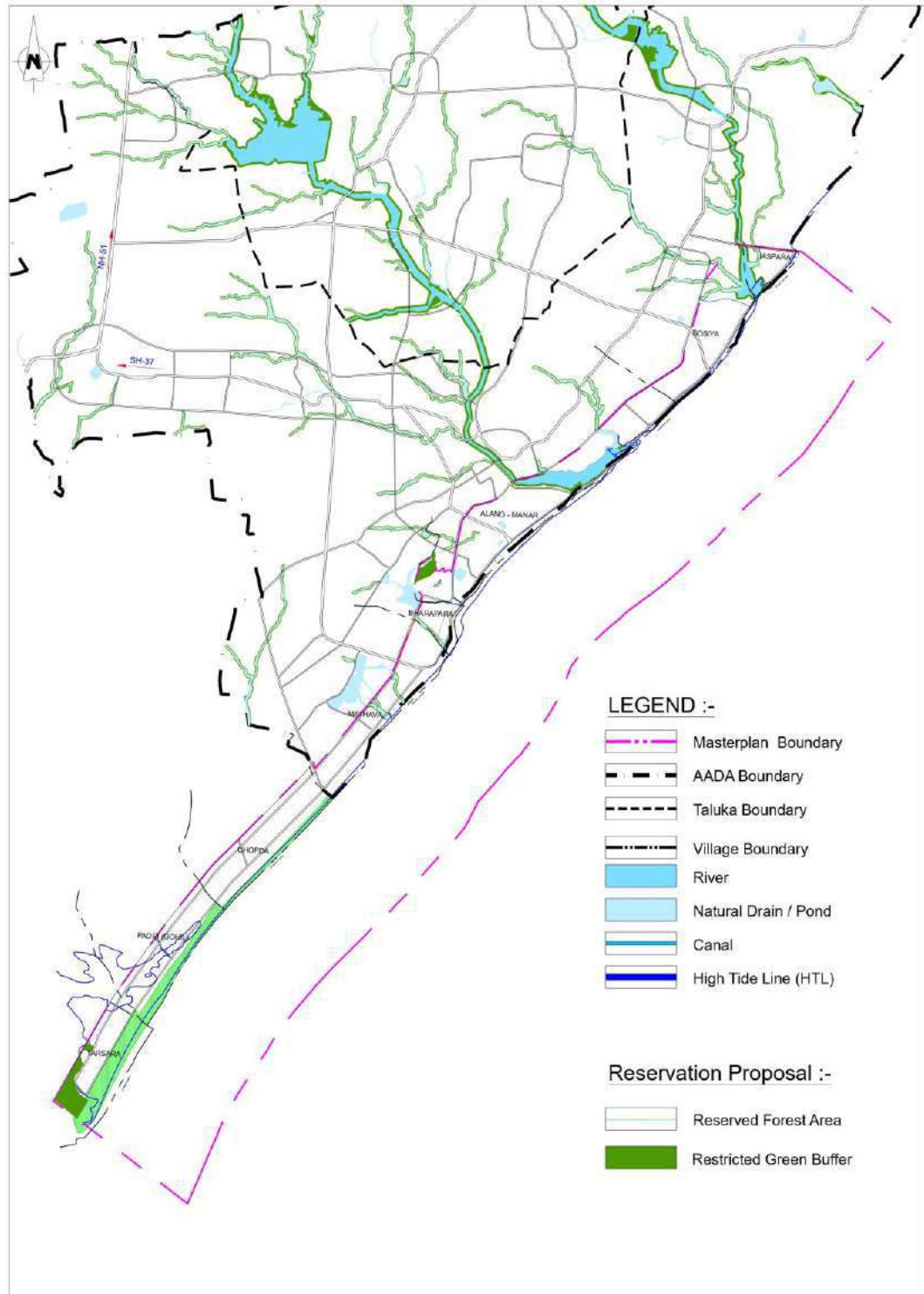
Conservation and eco-sensitivity zone

Waterbody and waterbody buffers are earmarked as a conservation zone, 10 m of no development buffer (green buffer) is kept surrounding the water bodies. Forest land are also proposed as conservation/eco sensitive areas in the proposed land use zoning map and can only develop any facility after de-notification and clearance from respective authorities.

The Development Plan for the Alang Area Development Authority (AADA) outlines a strategic zoning and road network framework to guide future urban and industrial growth. The map highlights various land-use categories using color-coded zones, ensuring a balanced distribution of industrial, residential, commercial, and green spaces.

The road network proposal includes highways, arterial roads, and internal road networks, ensuring seamless connectivity between industrial areas, residential settlements, and natural zones. Reserved forest areas and water bodies are also marked, indicating the need for sustainable development practices that minimize environmental impact.

Figure 5-28: Eco sensitive area map- green and blue



Overall, this development plan aims to enhance regional connectivity, support industrial expansion, and provide organized urban growth while ensuring environmental conservation and infrastructure upgrades.

5.8 Infrastructure proposals

5.8.1 Physical infrastructure

Based on the URDPFI and other standard regulations the following demand for water supply, sewerage, storm water drainage and electricity demands has been calculated.

5.8.1.1 Water supply

The water treatment and supply system are designed to effectively meet the water demands of a population of 46,300 people, with provisions for future growth and capacity expansion. The system includes key infrastructure components, such as the water treatment plant, elevated and ground service reservoirs, pumping stations, and the land required for each of these facilities. The proposed system ensures reliable and sustainable water supply while accounting for current and future demand.

As per URDPFI guidelines, 135 LPCD is considered 46,300 population who are assumed to reside in Alang and 45 LPCD is considered for the remaining 8,268 floating population. A total of 7.3 MLD is the demand required for the 10 km stretch of enhancement.

Table 5-8: Water supply demand calculations

Water supply demand					
Sr. No.	Particulars	Phase 1	Phase 2	Phase 3	Unit
1	Population	13440	5600	27260	Persons
2	Domestic consumption	135			LPCD
	Floating population	2400	1000	4868	Persons
3	Total domestic consumption	18,14,400	7,56,000	36,80,100	LPD
4	Institutional/commercial consumption (45 Lpcd) for floating population	1,08,000	45,000	2,19,060	LPD
5	Total requirement (assuming 10% loss)	2.11	0.88	4.29	MLD
		7.28			

5.8.1.2 Sewerage

The sewerage generation and treatment system has been designed to meet the wastewater management needs of a population of 46,300 people. With an estimated sewage generation of MLD, the system includes a Sewage Treatment Plant (STP) with the same capacity, alongside necessary infrastructure such as pumping stations. The total land requirement for the STP and pumping stations is 2,760 m², ensuring adequate space for all operational and maintenance needs, thus ensuring efficient sewage treatment and compliance with environmental standards.

Table 5-9: Sewerage treatment plant capacity calculation

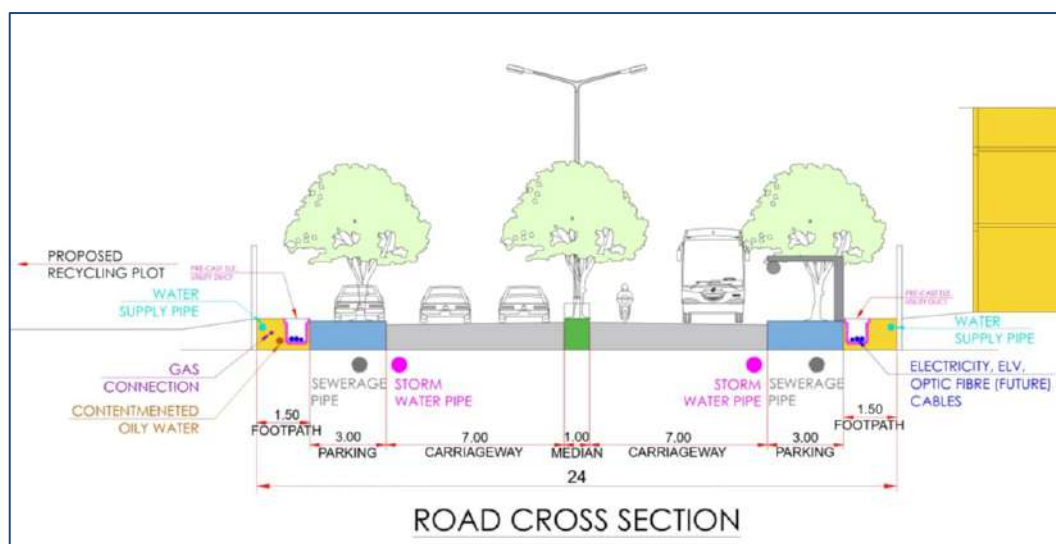
Sewerage generation & treatment					
Sr. No.	Particulars	Phase 1	Phase 2	Phase 3	Unit
1	Population	13,440	5,600	27,260	Persons
2	Total water consumption	2.11	0.88	4.29	MLD
3	Sewage generation	1.69	0.70	3.43	MLD (80%)
4	STP capacity	2	1	3	MLD
		6			

5.8.1.3 Electricity

Referring to National Electricity Policy 2005, the domestic demand for electricity has been calculated. kWh is converted into kVA considering the total power is supplied 24 hours with a power factor of 0.8.

Table 5-10: Electricity demand calculation

Sr. No.	Particulars	Phase 1	Phase 2	Phase 3	Unit
1	Population	13,440	5,600	27,260	Persons
2	Demand	2.74	2.74	2.74	kWh per capita per day
3	Total electricity demand	36825.6	15344	74692.4	kWh per day
4	Total electricity demand	1918	799.2	3890.2	kVA
5	Proposed compact substations	1 Nos. 2000kVA	1 Nos. 2000kVA	2 Nos. 2000kVA	

Figure 5-29: 24 m road cross section with utility lines - typical

An underground utility chamber has been proposed on both sides of the road which will carry electricity lines, data cables and any other ELV cables in future. This utility trench provides flexibility to install any other cables in future.

5.8.1.4 Solid waste management

The solid waste generation and disposal system is designed to manage the waste produced by a total population of 46,300 people across phases.

The landfill capacity for each phase has been planned based on the projected operational timeline and market growth. Phase 1 is proposed to operate from 2028 to 2037; therefore, the landfill facility (SLF) developed under this phase has been designed to provide sufficient capacity for 10 years. Phase 2, expected to commence in 2038 with an enhanced facility capacity of 19,000 population (including phase 1), includes landfill planned to meet requirements for the subsequent 2 years till 2039. For Phase 3, the SLF capacity has been estimated to remain adequate for at least 4 more years. These assumed durations form the basis for landfill capacity calculations across phases.

Assuming landfill height of 10 m and an area of 1,630 m² is proposed to handle this waste effectively, ensuring proper waste management and environmental health for the community. All the domestic solid waste generated will also be sent to the SLF provided in the TSDF site.

The Municipal Solid Waste (MSW) cell of existing TSDF still has capacity to handle the quantities expected from the existing stretch of yard. Any additional requirement can be developed parallelly.

Table 5-11: Solid waste management proposal

Solid waste generation & disposal					
Sr.no	Particulars	Phase 1	Phase 2	Phase 3	Units
1	Population	13,400	19,000	46,300	Person
2	Solid waste generation	0.5	0.5	0.5	kg /capita / day
3	Density of waste	400	400	400	kg / m³
4	Total waste generated	6113.75	8668.75	21124.38	m³/year
5	Proposed height of landfill	10	10	10	m
6	Landfill size per year	611.38	866.88	2112.44	m²/year
		0.06	0.09	0.21	Ha/year
7	No. of years	10	2	4	years
8	Size of landfill	0.61	0.17	0.84	Ha
		1.63			

5.8.1.5 Centralised Treatment, Storage, and Disposal Facilities

Ship recycling operations generate a wide range of waste materials, including hazardous substances like asbestos, waste oil, contaminated sludge, paint, glass, cement tiles, e-waste. These materials require dedicated and compliant treatment, storage, and disposal systems to ensure environmental safety and worker protection.

Upgrading existing centralised TSDF facility in accordance with the EU Ship Recycling Regulation (EU SRR), CPCB guidelines is essential to raise the standards of environmentally safe recycling within Alang ship recycling facility. Upgrading facility this

way will enable the yard to independently manage the full waste lifecycle from generation and segregation to treatment and safe disposal without relying on external infrastructure.

Primary objective for upgradation of TSDF

- To upgrade the capacity of existing waste management facilities to accommodate projected waste volumes based on future operational estimates.
- **To ensure the safe and compliant handling, treatment, and disposal** of all hazardous and non-hazardous waste streams generated during ship recycling operations, in line with EU SRR, CPCB, and HKC requirements.
- **To support circular economy principles** through waste recovery, resource reuse, and energy generation.
- **To establish a long-term, environmentally sound waste management framework** that integrates monitoring, worker safety, and sustainable practices into the yard's daily operations.

Waste processing and disposal methods

The management of waste generated from ship recycling activities demands a systematic and environmentally sound approach due to the diverse nature of materials involved. The selection of an appropriate processing or disposal method is determined primarily by the composition, hazardous characteristics, and resource recovery potential of each waste stream.

Some of the key waste processing and disposal technologies, along with their suitability for different waste types:

1. Landfilling (Secured Landfill or Engineered Sanitary Landfill)

Landfilling is employed for final disposal of inert or stabilized waste that cannot be further recycled, reused, or processed. In ship recycling operations, the following waste types are majorly sent to secured landfill facilities:

- Asbestos-containing materials
- Stabilized sludge and residues from treatment plants
- Inert mineral waste such as contaminated Glasswool or ceramic insulation
- Non-recyclable, low-calorific-value debris from dismantling operations

2. Incineration

Incineration is used for waste that is hazardous in nature and cannot be safely recovered or co-processed. This method ensures volume reduction and detoxification through high-temperature oxidation. Typical wastes sent for incineration include:

- Paint residues and sludge
- Oil-contaminated rags and absorbents
- Certain types of plastic and rubber that contain hazardous additives.

WtoE incineration plants utilize combustion or other thermal treatment technologies to generate energy from waste that is not recyclable but possesses significant calorific value.

3. Effluent Treatment Plant (ETP)

Effluent Treatment Plants play a critical role in managing liquid waste generated from various processes within the ship recycling yard, especially during cleaning, washing, and decontamination of ship components. These effluents may contain oil residues, heavy metals, suspended solids, and other toxic contaminants which, if left untreated, can pose serious risks to marine and terrestrial ecosystems.

The ETP is designed to treat such wastewater to permissible discharge standards as specified under the Environmental Protection Rules, SPCB norms, and CPCB Guidelines. The treated water can either be safely discharged or reused within the yard for non-potable purposes such as dust suppression or equipment washing.

- Bilge water and slop from ship tanks
- Wash water and first flush water from ship recycling plots
- Leachate from temporary waste storage areas

Effluent transfer system

Bilge water from the vessel contains seawater, freshwater, oils, and other pollutants from a ship's machinery and other onboard activities, often corrosive mix that can include hydraulic and lubricating oils, solvents, detergents, heavy metals, and other chemicals.

These bilge water needs to be treated through API Oil water separator in the ship recycling plot to separate all the scum which contains corrosive mix of oils that has tendency to solidify during winters, the remaining contaminated oily water still needs to transfer to CETP for further treatment, so it is good to discharge safely.

The other key contaminant water from ship recycling plot is wash water/first flush which will have heavy metals, oils that are spread over the impermeable surface that also needs to be treated before discharge.

These water too shall be treated through API Oil water separator first at the ship recycling plot to filter out any metals and oils and the water coming out will still contains phenols and shall be transferred to central effluent treatment plant to further treat so the parameters will be below safe discharge limits as per CPCB guidelines.

Both these Bilge water and Wash water will have collect in a common tank post treatment through Oil water separator and the tank is connected to an outlet chamber outside the plot with pumps.

Transfer of effluent is carried out through underground pipe network where the effluent is transferred from the contaminated oily water tank from the plot to intermediate sumps connecting multiple plot outlets through gravity. And further through pipes from the sump to ETP through pumping.

This effluent transfer through pipe network will increase efficiency of the whole system.

Sustainable waste management

4. Co-Processing

Co-processing refers to the use of waste materials in industrial processes (commonly in cement kilns) as alternative fuels or raw materials. This method offers simultaneous waste disposal and energy/material recovery without generating secondary waste.

Co-processing is suitable for:

- High-calorific-value waste such as contaminated rubber, plastic scraps, and oily textiles
- Paint sludge and solvent residues
- Packaging waste with residual hazardous content

5. Recycling and Material Recovery

Recycling is the most preferred method for non-hazardous, segregated materials with recoverable value. It reduces the overall environmental footprint of ship recycling operations. Recyclable wastes include:

- Ferrous and non-ferrous metal components (cables, pipes, sheets)
- Glasswool
- Glass, wood, and packaging cardboard (if uncontaminated)
- E-waste, to be processed through authorized e-waste recycling agencies
- Cement and brick debris for use as construction material or filling

6. Oil Re-refining and Alternative Fuel Recovery

Waste oil and used lubricants, if not heavily contaminated, can be treated through re-refining processes to recover fuel-quality hydrocarbons. This is a preferred method over incineration, as it enables resource recovery while minimizing emissions.

Capacity estimations

It can be noted from the facility operational data provided by GMB, the rate of material recovered and sent to the recycling market has reached as high as 98.5% over some time due to the amendment of various waste management rules during the past decade. However, it can be observed from the operational data that the specific hazardous waste generation has increased from 2.9 kg/LDT to as high as 10.63 kg/LDT in 2024. Hence, for the estimation of hazardous waste disposal infrastructure, Latest value 10.63 kg/LDT will be considered. In terms of waste segregation between secured land fill, effluent treatment plant and incinerator, average of ratios from the operation data is being considered that will be in the order of 6.38 kg/LDT, 1.06 kg/LDT, and 3.19 kg/LDT of waste to be sent to the secured landfill, incinerable waste and bilge wastewater respectively.

Sustainable Alternatives for Waste Management:

In alignment with sustainable and low-carbon waste management practices, the proposed TSDF site shall incorporate alternative treatment and disposal options that promote resource recovery and emission reduction. These alternatives are intended to reduce dependency on traditional landfill and incineration systems, thereby optimising the overall waste handling capacity and extending the life of key infrastructure components.

As per the waste data analysed, Glasswool has been identified as a non-hazardous material currently directed towards landfilling. Considering its non-hazardous nature and potential for resource recovery, **recycling of Glasswool** is proposed as a sustainable alternative. This would help in reducing the volumetric burden on landfill cells.

Further, with reference to incinerable waste, it is proposed that materials with high calorific value (such as contaminated plastics, rubber, and oily sludge) be diverted to **co-processing** in cement kilns.

The adoption of such practices not only contributes to circular economy goals but also aligns with India's national commitment toward net-zero emissions and helps build a global image for Alang in ship recycling industry as environmentally safe ship recycling facility.

Table 5-12: Waste generation and disposal at TSDF Site

Waste generation and disposal at TSDF Site, Alang (up to 30/09/2024)						
Sr. No	Year	SLF	Solidification & Stabilisation	Incinerable	Bilge water	Total
1	13-14	73.085	5210.385	358.895	1863.525	7505.89
2	14-15	70.765	4541.57	545.095	2121.965	7279.395
3	15-16	50.585	2499.65	843.8	1602.275	4996.31
4	16-17	47.735	4313.87	407.435	1799.165	6568.205
5	17-18	44.355	4851.935	610.395	2286.775	7793.46
6	18-19	56.265	4377.94	593.875	1680.06	6708.14
7	19-20	53.56	5335.56	636.095	1871.92	7897.135
8	20-21	37.58	4045.98	758.96	2038.97	6881.49
9	21-22	62.305	6426.45	1124.715	2132.74	9746.21
10	22-23	31.625	4318.235	923.175	1981.565	7254.6
11	23-24	36.64	5753.045	909.905	2215.095	8914.685
12	24-25	5.615	1252.525	323.09	2074.765	3655.995
			60%	10%	30%	100%
Specific waste generation			6.3792	1.0632	3.1896	10.632

Source: Environment cell, GMB

Based on the additional waste management options, revised Kg/LDT to be worked out based on assumptions.

	Facility	Existing waste handled (kg/LDT)	Proposed waste handled (kg/LDT)
1	Landfill	6.38	4.47
2	Incinerator	1.06	0.53

Assumptions:

- It is assumed that approximately 40% of the waste currently sent to the landfill comprises insulation materials, primarily glass wool, which is no longer classified as hazardous waste. This material is considered recoverable and reusable, and hence, is proposed to be diverted from landfill disposal.
- It is also assumed that around 50% of the incinerable waste can be utilized for co-processing in cement kilns or other industrial units. This includes high-calorific value waste streams such as slop oils, solvents, and similar materials, which are suitable for energy recovery through co-processing.

Infrastructure

1. Centralised ETP

The treated wastewater complying with marine discharge standards shall be disposed to sea. Bilge wastewater from ship recycling facilities contains oil, metalworking fluids, surfactants, and has high salinity (15–30 g/L). It includes hydrocarbons like toluene, benzene, and polycyclic aromatic hydrocarbons, as well as metals and detergents. Treatment methods encompass physicochemical processes such as oil separation, coagulation, chemical oxidation, and membrane filtration, alongside biological treatments. Electrocoagulation using mild steel electrodes can achieve significant removal efficiencies: 93% for biochemical oxygen demand (BOD), 95.6% for oils and greases, and 99.4% for hydrocarbons ranging from n-C10 to n-C50. Additionally, bilge oil separators can reduce oil content to below 5 ppm, surpassing International Maritime Organization Standards.

Capacity of centralised effluent treatment plant is proposed based on the peak flow across the seasons. Considering the first flush volumes of 630 m³ per plot is significantly higher than bilge water or wash water (112 m³). CETP capacities have been propose considering peak flow of First flush water of all the plots per day with a retention period of 15 min additional to average bilge water quantities, considering 80% facility occupancy factor.

Table 5-13: Effluent treatment plant proposal

Phase	No of plots	Peak first flush volumes (m ³ /day)	CETP Capacity required in KLD	Proposed Capacity in MLD
Phase 1	9	5670	7087.5	8
Phase 2	6	3780	4725	4
Phase 3	17	10710	12387.5	12

2. Secured landfill

Considering 4.47 kg/LDT of waste shall be disposed of at to secured landfill, about 50,511 TPA of waste shall be sent to the secured landfill when the facility is operated at a full capacity of 11.3 million Tons by phase 2. Considering the density of the waste as 0.6 T/m³ of the waste, about 13,77,017 m³ of waste shall be disposed of in the secured landfills till phase 2. Assuming the height of the secured landfill as 20 m, the net area required for disposing of the hazardous waste to the secured landfill will be in the order of 5.5 ha by the end of phase 2, including existing stretch.

Calculations regarding landfill site requirement for phase 3 is calculated based on the full capacity of the yard and the development of SLF for phase 3 needs to be

based on the evaluation of market and expected recycling demand while proceeding for development.

The phasing of the facility has been planned similarly as municipal landfill calculations. Phase 1 is proposed to operate from 2028 to 2037; therefore, the landfill facility (SLF) developed under this phase has been designed to provide sufficient capacity for 10 years. Phase 2, expected to commence in 2038 with an enhanced facility capacity of 19,000 population (including phase 1), includes landfill planned to meet requirements for the subsequent 2 years till 2039. For Phase 3, the SLF capacity has been estimated to remain adequate for at least 4 more years. These assumed durations form the basis for landfill capacity calculations across phases.

For these quantities the SLF requirement is calculated as below:

Table 5-14: Secured landfill proposal

Description	Phase 1	Phase 2	Phase 3
Scrap volumes estimated (M LDT)	9	11.3	19.8
Landfill waste per annum in Tonnes	40,230	50,511	88,506
Landfill waste generated in each phase	4,02,300	1,01,022	3,54,024
Considering density of waste as 0.6 T/m ³	6,70,500	1,68,370	5,90,040
Area required for SLF in Ha	3.4	0.8	3.0
Area required for SLF including domestic waste (in Ha)	3.66	1.02	3.80
Proposed area (in Ha)	4	2	3

It is noted that the existing TSDF has around 1,00,000 m³ of volume space left for hazardous and industrial solid waste to cater for any additional minor requirement.

3. Incinerator

Considering the incinerable waste quantity generation as 0.53 kg/LDT, the capacity for the incinerator has been calculated for three phases as below:

Table 5-15: Incinerator proposal

Description	Phase 1	Phase 2	Phase 3
Scrap volumes estimated (M LDT)	9	11.3	19.8
Incinerable waste per annum in TPA	4,770	5,989	10,494
Capacity of incinerator in TPD	13	17	29
Proposed capacity (TPD) excluding existing capacity	8	4	5

A waste-to-energy-based incinerator is proposed to ensure efficient utilization of energy recovered from hazardous waste, with the electricity generated being fed into the grid. Given that high-calorific hazardous waste is being diverted for co-processing, the incinerator is primarily intended to treat the remaining low-calorific waste.

Assuming a calorific value of approximately 2000 kcal/kg for the incinerated waste and an energy conversion efficiency of 20%, the incinerator is expected to generate approximately 400 kWh/ton of waste till phase 2.

The proposed incinerator is not anticipated to contribute much of the total electricity demand for the facility. Therefore, no revisions to the current electricity supply and demand proposals are envisaged considering the proposed incinerator installation.

Calculations regarding Incinerator requirement for phase 3 is calculated based on the full capacity of the yard and the development of WtoE Incinerator for phase 3 needs to be based on the evaluation of market and expected recycling demand while proceeding for development.

4. Sorting & Co-processing facility

Segregation of waste is carried out at the source. Each plot is required to maintain designated storage areas for different categories of segregated waste, ensuring primary-level separation before collection.

The centralized TSDF operator shall be responsible for collecting the segregated waste from each plot. Upon arrival at the TSDF, a semi-mechanized sorting facility will be employed to carry out secondary sorting. This step is essential to ensure proper classification of waste streams before they are directed to appropriate treatment, recycling, co-processing, or disposal facilities.

Additionally, the co-processing unit shall be equipped with mechanical pre-processing systems such as crushers and shredders, specifically for handling high-calorific value waste. This will ensure that such waste is suitably conditioned and homogenized before being transported to cement kilns or other industrial co-processing facilities.

Provision shall also be made for a designated storage area within the co-processing unit to safely store pre-processed waste prior to dispatch.

Policy-level recommendations

- **Capacity expansion of existing facilities**

It is recommended to periodically assess and upgrade the capacity of core waste management infrastructure including the ETP, incinerator, and landfill to handle future waste loads as per estimated ship arrivals and dismantling volumes.

- **Compliance, monitoring and certification**

Adoption of environmental and occupational certifications (such as ISO 14001 and ISO 45001) should be encouraged across yard operators. Third-party monitoring, periodic audits, and integration of a digital waste manifest system can enhance transparency and traceability of waste handling activities.

- **Worker training and occupational safety**

Policy support should also focus on skill development and **hazard management training** for workers handling hazardous materials. GMB may collaborate with Institutions such as GPCB and MoEFCC to establish structured training modules on safe practices and updated regulatory requirements at training institute.

5.8.1.6 Fire fighting

URDPFI recommends to one fire station for 2 lakh population with a catchment of 5-7 km radius. The strategic location of the existing fire station in Alang located beside the GMB office covers entire existing ship recycling plots as well as more than 5 km of extension area which can accommodate more than 11.3 M LDT per year in the whole facility which is the expected in the next 15 years.

Table 5-16: Equipment at Alang fire station

Sr. No	Item	Number of Items
1	Water Bowser	2
2	Water Tanker	2
3	Fire Hoses – 15 m	18
4	Fire Hoses – 30 m	35
5	BA Sets	2
6	Fire Suits	4
7	Mini Fire Tender	1
8	Portable Fire Pumps	1

Source: District Disaster Management Plan-2024 Bhavnagar

It is recommended to provide sufficient fire tenders in the existing fire station facility.

Figure 5-30: Fire personnel at Alang fire station**5.8.2 Social infrastructure**

The Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines provide recommendations for the provision of social infrastructure based on population size. For a 46,300 population within the expansion phases, the required social infrastructure can be estimated based on these guidelines.

Table 5-17: Proposed social infrastructure

Facility	Area Required (as per URDPFI)	Number of facilities required (for 46,300 population)
Pre-primary school	0.10-0.25 Ha	19
Primary school	0.20-0.50 Ha	9
Senior secondary school	1.60 Ha	6
Dispensary	0.20 Ha	3
Health sub-centre	0.10-0.20 Ha	9
Primary Health Centre (PHC)	0.50- 0.60Ha	2
Neighbourhood parks	0.50 Ha (Minimum)	9

The proposed infrastructure facilities are calculated as per the projected population and by subtracting the existing facilities in the project area and 500 m buffer from project boundary.

GMB housing & amenities clusters

GMB housing & amenities clusters in the master plan have been provided to address the issue of the existing labour colony being far from the ship recycling plots, by decentralising the housing clusters spread across the Alang ship recycling park, accessibility for the workers to their workplace as well as all the amenities such as public and commercial place.

40 m² of area is considered for each housing unit following DCR provided in the existing development plan has been considered while calculating area requirement.

As ship recycling plot owners are also facilitated to develop their own housing for their workers in the backup yard provided, it is assumed that GMB housing cluster will only have housing units for around 10% of the total expected population. The rest of the workers will stay in housing provided by their plot management.

Each housing & amenities cluster to have 230 units accommodating 2 person per unit and additional 50 units for workers with family accommodation a total around 600 person per cluster. The Mixed Industrial Use Zone in the master plan has been provided to address the issue of the existing labour colony being far from the ship recycling plots. By decentralising housing clusters across the Alang Ship Recycling Park, accessibility to workplaces and amenities (public and commercial) will be improved.

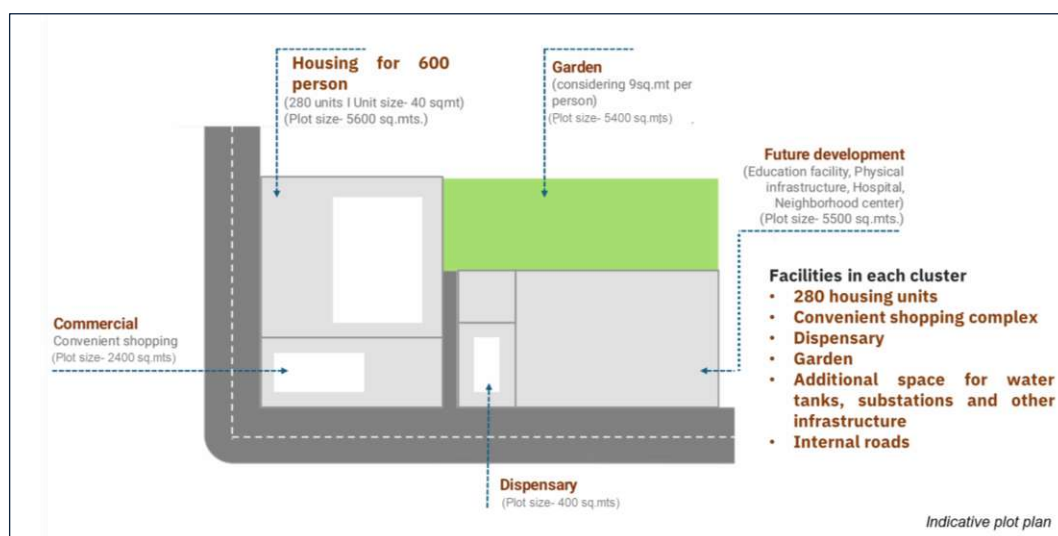
For the calculation of housing area:

- 40 m² of area per unit has been considered, following the DCR provisions of the existing development plan.
- 1 unit per household has been assumed.
- An average household size of 3 persons is adopted for the estimation.

Each clusters will also have convenient shopping, Open spaces and parks, Dispensary and additional land for future development of any other common facilities such as schools, Hospitals etc. All the physical infrastructure components such as overhead tanks, pumping stations, Compact sub stations are also proposed in the cluster.

Table 5-18: Area distribution

Facility	Basis	Built up area
Housing units	40 m ² /unit	11,200 m ²
Convenient shopping	4 m ² /person	2400 m ²
Open space	9 m ² /person	5,400 m ²
Dispensary	400 m ²	400 m ²
Roads (Internal)	15% of total housing cluster area	1,260 m ²

Figure 5-31: GMB housing & amenities cluster**Table 5-19: Housing & amenities cluster proposal**

Facility	Phase 1	Phase 2	Phase 3
Housing & amenities cluster	2	1	3

Training institute

The existing training institute with two training halls with a capacity of 60 trainees each plays a pivotal role in ensuring that ship recycling workers are equipped with essential knowledge and practical skills related to safe ship recycling practices. With a well-structured two-week training program, the institute imparts comprehensive training on safety, use of protective equipment, and standard operating procedures.

Certain gaps and opportunities for improvement were identified during assessment. One of the issues is the financial burden to the trainees during the 2-week training period, as they are expected to arrange their own accommodation. Especially as most of them come from economically weaker backgrounds. In addition, while the current curriculum ensures a basic level of preparedness, A more future-oriented recycling workshops for ship recycling managements and workers to encourage and create awareness on the rapidly evolving ship recycling technologies and emphasis on environmental and worker safety standards will help Alang stay on top of safe recycling.

- **Curriculum enhancement and modular training**

The curriculum should be periodically updated to include modules on hazardous material handling, environmental compliance, and advanced cutting and dismantling techniques. Specialized modules could be introduced for mid-level and supervisory staff, enabling tiered skill development across worker categories.

- **Accommodation and support infrastructure for trainees**

Dormitory or worker housing facility located near the training institute should be provided to trainees subsidized or free accommodation during the training period. This would significantly ease the financial burden on workers and ensure greater participation, especially from out-of-state and low-income workers.

- **Expansion into an advanced training institute**

The training institute can be expanded into a centre for advanced training in ship recycling. This institute not only deliver mandatory basic training but also act as a hub for continuous skill development across ship recycling worker and management category in terms of technological demonstrations, environmental safeguards and international compliance standards.

5.8.3 Enhancement of existing facility

Apart from the above proposals focused on the expansion of Alang Soshiya Ship Recycling Park in phases, enhancement of existing facility is also to be carried out in parallel to make it ready for the bullish period.

5.8.3.1 Physical infrastructure

For the enhancement of the existing ship recycling yard, the infrastructure demand has been assessed based on the projected peak employment in the area. Water supply, sewerage, and electricity requirements have been estimated in accordance with the URDPFI Guidelines to ensure adequate provisioning for future operational needs. The development of the same can be carried out simultaneously as required.

As provided in section 5.2.1, the total population expected in existing stretch at its peak capacity of 4.5 MLDT is around 13,440. The demand assessment carried out based on the same population with similar assumptions considered in section 0.

Table 5-20: Physical infrastructure proposal within existing stretch

Component	Required capacity	Units	To propose
Water storage tanks	4.2	M Liters	1.5 ML
Sewerage (STP)	1.7	MLD	2 MLD
Electricity (Substation)	1912	kVA	-

As the existing stretch consists of 3 million liters capacity tanks, it is proposed an additional 1.5 million liters capacity including underground and elevated tank for a 2-day water storage capacity.

As the existing stretch does not have any sewerage network and sewerage treatment system, an underground sewerage network with an STP of 2 MLD is proposed to cater to the existing facility, improving waste management. And electricity lines in the existing yard

are through overhead poles, the same is proposed through underground utility lines as the expansion phases.

5.8.3.2 Social infrastructure

For the peak population anticipated in the existing stretch of the site will require adequate social infrastructure for a healthy livelihood of the workers.

GMB Housing & Amenities clusters

Additional to the existing housing colony, 3 more housing clusters have been proposed across the existing facility to address the issue of the existing labour colony being far from the ship recycling plots.

5.9 CRZ and reserve forest area

Alang is within the Coastal Regulation Zone (CRZ), a designated area under the Coastal Regulation Zone Notification by the Ministry of Environment, Forest and Climate Change (MoEFCC). This regulation aims to protect the coastal environment by limiting industrial activities and development near the coastline.

Coastal Regulation Zone

As the project site within phase 2 & 3 area falls under CRZ-IA and CRZ-III as per the approved CZMP 2011. Ship recycling activities are not permissible within these categories; the proposed development cannot be undertaken without modification of the CRZ classification and obtaining environmental clearance. To ensure statutory compliance and enable planned expansion, the affected land parcels require conversion to an appropriate CRZ category where port-related and ship recycling activities are permissible, subject to safeguards.

Coastal Regulation Zone conversion

1. Verification of CRZ classification

It is advised to demark CRZ mapping for the entire 20 km stretch by authorised agency/National Centre for Sustainable Coastal Management as per CRZ 2019 for the CRZ classification and HTL/LTL markings.

2. Submission of proposal for Re-classification / Amendment

A formal request for CRZ conversion be submitted to the State Coastal Zone Management Authority (GCZMA) with justification for the proposed change, including project necessity, socio-economic benefits, and environmental safeguards.

3. Environmental studies and impact assessment

Conduct HTL-LTL mapping, CRZ mapping, and a focused environmental assessment including forest conversion request to demonstrate that the proposed activity will not adversely impact ecologically sensitive areas, specifically for CRZ-IA stretches.

4. Appraisal and recommendation by GCZMA

GCZMA will review the proposal, carry out site inspection (if required), and forward its recommendation to MoEF&CC for approval.

5. Approval from MoEF&CC

The Ministry will evaluate the proposal and may approve amendments to the CZMP or provide specific CRZ clearance with conditions.

Implementation of environmental safeguards

As informed by GMB, the CRZ conversion request has been submitted and is in review process, Phase 2 & 3 shall only be taken up after receiving the approval from CZMA & EC.

Forest diversion clearance

Obtaining forest diversion clearance from the Ministry of Environment, Forest and Climate Change (MoEFCC) involves a series of structured steps to ensure compliance with the Forest (Conservation) Act, 1980.

Table 5-21: Methodology for de-notifying reserve forest area

Below is a table outlining the key tasks, methodologies, responsible agencies, and indicative timelines:

Task	Methodology	Responsible agency	Indicative timeline
Site inspection and data collection	Conduct field surveys to assess forest area, document flora and fauna, and gather baseline environmental data.	User Agency	2-4 weeks
Preparation of proposal	Compile Form-A with details of the project, justification for forest land use, and maps. Include the proposed Compensatory Afforestation plan.	User Agency with Accredited Consultants	4-6 weeks
Submission to nodal officer	Submit the proposal to the State Forest Department's Nodal Officer for initial scrutiny.	User Agency	1 week
State forest department review	Evaluate the proposal's completeness and accuracy. Conduct site verification and assess the feasibility of Compensatory Afforestation.	State Forest Department	4-6 weeks
Forwarding to state government	Upon satisfactory review, forward the proposal with recommendations to the State Government.	State Forest Department	2 weeks

Task	Methodology	Responsible agency	Indicative timeline
State government examination	Review the proposal, seek clarifications if necessary, and decide on forwarding it to MoEFCC.	State Government	4-6 weeks
Submission to MoEFCC via PARIVESH portal	Upload the complete proposal on the PARIVESH portal for MoEFCC's consideration.	State Government	1 week
MoEFCC scrutiny and FAC review	MoEFCC examines the proposal and may refer it to the Forest Advisory Committee (FAC) for detailed evaluation.	MoEFCC and FAC	8-12 weeks
Stage-I (In-Principle) approval	If found suitable, MoEFCC grants Stage-I approval, outlining specific conditions to be met, such as payment of Net Present Value (NPV) and creation of Compensatory Afforestation.	MoEFCC	2 weeks
Compliance with stage-I conditions	Fulfill the stipulated conditions, including financial payments and legal formalities.	User Agency	Variable (depends on compliance)
Submission of compliance report	Provide documented evidence of compliance with Stage-I conditions to MoEFCC.	User Agency	1-2 weeks
Stage-II (Final) approval	Upon satisfactory compliance, MoEFCC grants final approval, allowing for the legal diversion of forest land.	MoEFCC	2-4 weeks
Handover of land and commencement of work	Post-approval, the forest land is officially handed over for the approved non-forest use, and project activities can commence.	State Forest Department and User Agency	As per project schedule

Note: The timelines provided are indicative and can vary based on project complexity, responsiveness of agencies, and completeness of the submitted documents. Engaging with experienced environmental consultants and maintaining proactive communication with the relevant authorities can facilitate a smoother clearance process.

5.10

Land use breakdown

Table 5-22: Proposed land use breakdown

Name	Area (ha)	Percentage (%)
Industrial – A / Ship Recycling Zone	715.03	49.87%
Industrial B (IZ6)	367.62	25.64%
Mixed Industrial Use (IZ7)	42.73	2.98%
Agriculture	66.10	4.61%
Water – River/Natural Drain/Pond	68.90	4.81%
Green Buffer/Restricted	88.07	6.14%
Roads	85.38	5.95%
Total	1,433.83	100.00%

The land use distribution presented in the table provides a clear overview of how the 1433 Ha planning area is allocated among different functional zones. This breakdown also consists of the ship recycling plots (Industrial – A) that are beyond HTL. The largest share of land, accounting for 49.87%, is occupied by ship recycling plots and backup yards for storage and processing of scrap, reflecting the core operational nature of the region and its role in ship recycling and related activities. The scrap resellers / Industrial-B forms the second-largest component, covering 25.64% of the total area, further emphasizing the dominance of industrial and processing functions within the master plan.

Water bodies and natural drainage systems account for 4.81%, representing essential ecological and environmental features that aid in flood management and natural recharge. Agricultural land occupies 4.61%, showing the presence of residual or buffer agricultural parcels within the planning boundary.

Meanwhile, Public amenities and public housing zones together form 2.98%, providing essential social infrastructure for workers and the surrounding communities. The Green Buffer/Restricted Zone contributes another 6.14%, functioning as a protective ecological and safety buffer between industrial operations and nearby land uses.

Overall, the land allocation demonstrates a planning structure that prioritizes industrial operations, logistics, and supporting infrastructure, while still incorporating essential environmental, residential, and public utility zones. The percentage distribution ensures a balanced and functional layout consistent with the operational needs of a ship recycling and industrial region.

5.11

Key drivers of the planning process

Stakeholder driven planning

The master planning process for the Alang-Soshiya Ship Recycling Yard was guided by extensive stakeholder engagement, incorporating feedback from recyclers, plot owners, workers, and regulatory authorities. The survey findings played a critical role in shaping the

infrastructure strategy to ensure that the proposed interventions are responsive, inclusive, and sustainable. The chart presented summarizes how each key concern or recommendation from the stakeholder interactions & site surveys directly informed a corresponding infrastructure proposal within the master plan. For instance, the demand for scientific waste handling has led to the provision of a centralized TSDF, while issues related to worker well-being influenced the inclusion of dedicated worker housing with associated healthcare and recreation facilities.

By aligning proposed infrastructure components with the expressed needs of stakeholders, the master plan not only addresses existing challenges but also strengthens the yard's preparedness for future regulatory and operational demands. This participatory approach ensures long-term sustainability, regulatory compliance, and improved working and living environments at Alang.

Table 5-23: Proposals based on survey findings

Survey finding	Proposed infrastructure response	Intended impact
Tidal and Bathymetric survey outcome	Placement of proposed ship recycling plot strategically based on Tidal data and Bathymetry at the site	Minimize mud and sea water reaching into the plot.
Topography survey of the site	Aligning proposed road with the current topography to avoid excessive cutting and filling	Reduced elevation differences
Demand for improved healthcare and living conditions for workers	Worker housing with healthcare facilities, dormitories, and social infrastructure	Enhanced worker welfare and retention
Traffic congestion and unsafe circulation patterns	Redesigned road network, truck holding zones, and shuttle services	Efficient and safe transport of goods and personnel
Insufficient water supply, sanitation, and power distribution	Upgraded utilities: water, sewage, and power grid	Basic service reliability and improved hygiene
Feedback on inefficient plot sizes and fragmentation	Reconfiguration into larger modular plots (small, medium, large)	Increased operational efficiency and scalability
Inadequate space for large vessels and operational congestion	Reconfiguration and expansion of plots into larger categories (up to 70,000+ m ²)	Accommodates bigger ships; reduces congestion; boosts throughput
Demand for better worker living conditions and hygiene	Integrated worker, clinics, and recreational spaces	Improved worker welfare and productivity; compliance with social standards
Fragmented logistics and internal access issues	New internal road grid, redefined access hierarchy, and truck parking areas	Smoother movement of materials and improved operational flow

Integration of planning principles in the Alang Master Plan

The Alang-Soshiya Ship Recycling Yard Master Plan has been structured around a robust set of planning principles aimed at enhancing functionality, efficiency, sustainability, and

global compliance. These principles not only guide spatial structuring but also respond to environmental, infrastructural, and socio-economic challenges faced by the region.

A core aspect of the master plan is the zoning and functional clarity, wherein recycling plots, worker housing, utility areas, TSDF facilities, and administrative units are clearly demarcated. This ensures efficient land use and minimizes operational conflicts. Furthermore, the phased development strategy allows for the yard's progressive transformation starting with optimization of current operations and moving toward comprehensive restructuring and expansion.

The principle of infrastructure integration has been addressed through the provision of essential amenities such as centralized waste treatment (TSDF), emergency services, road networks, and utility buildings placed strategically for optimal accessibility. To ensure environmental sustainability, the master plan incorporates buffer zones, green belts, and eco-compliant waste systems that collectively support environmental health.

Addressing the need for efficient operations and safety, mobility and circulation have been restructured through a hierarchical road network that separates industrial and pedestrian movements. Dedicated parking and transport facilities help streamline logistics. In addition, worker welfare and liveability are prioritized through the inclusion of planned residential zones with access to healthcare, education, and recreational spaces creating a humane and inclusive working environment.

Safety and emergency planning is reinforced by dedicated fire stations, emergency response infrastructure, and secure zones within high-risk operational areas, ensuring disaster readiness and regulatory compliance. To support long-term operational viability, flexibility for future growth is embedded into the design through modular plot layouts and adaptable infrastructure grids.

Collectively, the thoughtful application of these planning principles ensures that the Alang master plan is future-ready, efficient, sustainable, and responsive to both stakeholder needs and international benchmarks.

Table 5-24: Proposals based planning principles

Planning principle	Where/How Addressed in the Master plan	Section Reference
Zoning and functional clarity	Distinct zones for recycling plots, worker housing, utilities, TSDF, and administration zones have been designated to minimize land-use conflict and improve operational efficiency	Spatial Structure & Zoning
Phased development	The plan follows a phased approach Phase 1 focuses on optimization of current capacity, followed by restructuring, and gradual expansion in Phases 2 & 3	Phasing Strategy
Infrastructure integration	Provision of centralized TSDF, ETP, road networks, and support buildings placed based on accessibility and need	Infrastructure Framework

Planning principle	Where/How Addressed in the Master plan	Section Reference
Environmental sustainability	Introduction of buffer zones, green landscaping, dedicated waste management systems, and environmentally compliant expansion zones	Environmental Management
Mobility and circulation	Hierarchical road network ensures separation of heavy vehicle movement from pedestrian and worker transit; truck parking and access roads optimized	Transport and Circulation
Worker welfare and livability	Provision of dormitories, healthcare, recreation areas, and schools in the residential zone located away from heavy operational zones	Worker Habitat Planning
Safety and emergency planning	Fire station, emergency response systems, safety zones, and secure perimeters have been allocated in high-risk operational areas	Safety Infrastructure
Flexibility for future growth	Plots restructured to accommodate variable ship sizes; road and infrastructure grid allows modular expansion without disruption	Master plan Layout Approach

6

6.1

Engineering Feasibility

Design criteria – Buildings & structures in individual recycling plots

This section applies to all the proposed new buildings within the ship recycling plot.

6.1.1

Design life

The design life of the buildings and other civil works shall be 50 years. The design life of the buildings and other civil works details shall be as mentioned in Table 6-1.

Table 6-1: Design life

Element	Design Life (years)	Maintenance Interval (years)	Acceptable Routine Maintenance	Unacceptable Repair or Maintenance
Reinforced and mass concrete	50	None	None	Cutting out/ replacement of defective/ cracked/ spalled concrete and corroded reinforcement.
Primary Structural Steel Works	50	15	Re-coating of protective treatment system.	Cutting out/ replacement of defective/ corroded steel or its fixings. Welding of steel plates onto existing steel structures/ elements.
Secondary structures, such as ladders, hand railings, etc.	30	10	Annual inspection of painting and protective coating with repair to damage	Any removal/ replacement of any items or parts.

6.1.2

Site preparation and surface levels

The site at the proposed ship recycling plots has clayey sand with the presence of steep fill material across various locations. In order to develop the ship recycling plots as per the proposed layout, the site requires substantial earthwork, including both cutting and filling, to achieve the recommended finished levels. Given the topography, the volume of cutting is greater than filling in phase 1 and filling is higher in phase 2 & 3. The excavated material generated from the cutting operations is proposed to be reused as fill material in low-lying areas, thereby optimising material use and does not require to source the filling material. For additional filling requirements in phase 2 & 3, murrum soil is to be used.

Earthwork quantities have been estimated for the proposed development of ship recycling plots. The objective of the earthwork is to achieve a finished surface level as per the proposed levels, ensuring appropriate slopes for drainage and operational efficiency.

The calculations are based on the existing topography and the finished levels proposed across the site. To facilitate this, the project area has been divided into four zones along the length of the plot, each with distinct slopes, as described below:

- **Zone A (Primary cutting area):**

This is the initial stretch of the plot where major cutting is proposed to bring the terrain to the required grade. The slope considered in this zone is 1 in 130.

A 2 m rise is provided between zone A and Zone B to address the steep slope and avoid excessive cutting.

- **Zone B (Secondary and tertiary cutting / Storage area):**

Extending over a length of 150 m, this zone accommodates Winch area, cutting and storage areas. The slope applied here is 1 in 50, continuing from 2 m rise in phase 1 and 1 in 65 for phase 2 & 3.

- **Zone C (Admin and facility area):**

Covering a length of 40 m, this zone includes the administrative building, hazardous waste storage, and other allied facilities. The slope considered for this section is 1 in 65.

- **Zone D (Access road):**

Located behind the plots, this zone encompasses the main service road and has been considered with a slope appropriate to match the road gradient and adjoining plots.

To ensure accurate quantification, the finished surface levels used in calculations exclude the top 600 mm, which is reserved for pavement layers, concrete surfacing, and impermeable layers.

Table 6-2 Slope calculations

Zone/ plot	Phase	Length (m)	Proposed slope	Elevation raised (m)	Final elevation (m)	Avg elevation (m)
	1				8.9	
A		25	1 in 130	0.19	9.09	9.00
B		150	1 in 50	3.00	14.09	12.59
C		40	1 in 65	0.62	14.71	14.40
D		24	1 in 65	0.37	15.08	14.89
	2&3				8.9	
A		25	1 in 130	0.19	9.09	9.00
B, C & D		214	1 in 65	3.29	14.38	11.74

The material generated from the cutting zones is proposed to be reutilized in the filling areas to the extent possible, reducing the need for sourcing.

A summary of the calculated earthwork quantities for ship recycling plots across phases is provided below.

Table 6-3 Earthwork quantity summary table

Description	Phase 1	Phase 2 & 3
	Volume (m ³)	
Total Cutting Quantity	7,48,695.98	5,58,352.25
Total Filling Quantity	4,34,730.69	29,92,775.55

6.1.3 Different types of buildings & structures

The list of different types of buildings/ structures are as follows:

- i. Workshop
- ii. Machinery room
- iii. Godowns
- iv. Storage sheds
- v. Admin building
- vi. Restroom
- vii. Canteen and recreation room
- viii. Pump room
- ix. Shed for winches
- x. Retaining wall
- xi. Compound/ boundary wall
- xii. Storm water drains
- xiii. Storm water tanks and fire water tanks
- xiv. Cable pull pit or chambers
- xv. Oil water separators

6.1.4 Buildings

Buildings such as the admin building, canteen & recreation room, and restrooms shall be constructed using reinforced concrete (RC) frame structures. Facilities like workshops, machinery rooms, godowns, and sheds for winches shall be built using steel structures. An underground pump room constructed with reinforced cement concrete (RCC) is proposed to house all pumps required for firefighting and other utilities.

6.1.4.1 Foundation system

The type of foundation system shall be determined based on the structural loading configuration, load intensity, and the underlying soil strata. The foundation design at different locations will depend on the soil profile, which shall be finalised as per the recommendations provided in the detailed geotechnical investigation report.

All foundations will be designed in accordance with the relevant Indian Standards (IS codes), following the limit state method of design.

Depending on the allowable bearing pressure and settlement criteria, either open foundations or pile foundations may be adopted.

Based on preliminary geotechnical studies conducted by Ideal Geoservices Private Limited for BMT Consultants (India) Pvt. Ltd. (now Merizen), open foundations are considered technically feasible for most structures within the master plan area. However, this shall be revalidated during detailed design with confirmatory soil investigations.

The preliminary geotechnical findings are presented in the Geotechnical Investigation Report submitted separately to GMB.

6.1.4.2 Plinth and plinth protection

Unless specified otherwise, all buildings shall have 600 mm plinth height and 2 m wide footpath as plinth protection all around.

High Bay (Warehouse) building shall have 200 mm high plinth for easy truck access.

Workshop shall have 200 mm high plinth for easy entry for vehicles to be maintained.

6.1.4.3 Room heights

All habitable room shall have minimum clear height of 3.0 m. For all utility buildings, the clear room height shall be dependent on equipment requirements. However, it should not be less than 4.0m clear.

6.1.4.4 Other facilities

Buildings shall be installed with automatic fire detection system, CC TV surveillance. Lighting in the interiors of the building shall be 300 lux. All the buildings shall be installed with Ductable /Split air conditioning system.

6.1.5 Other structures

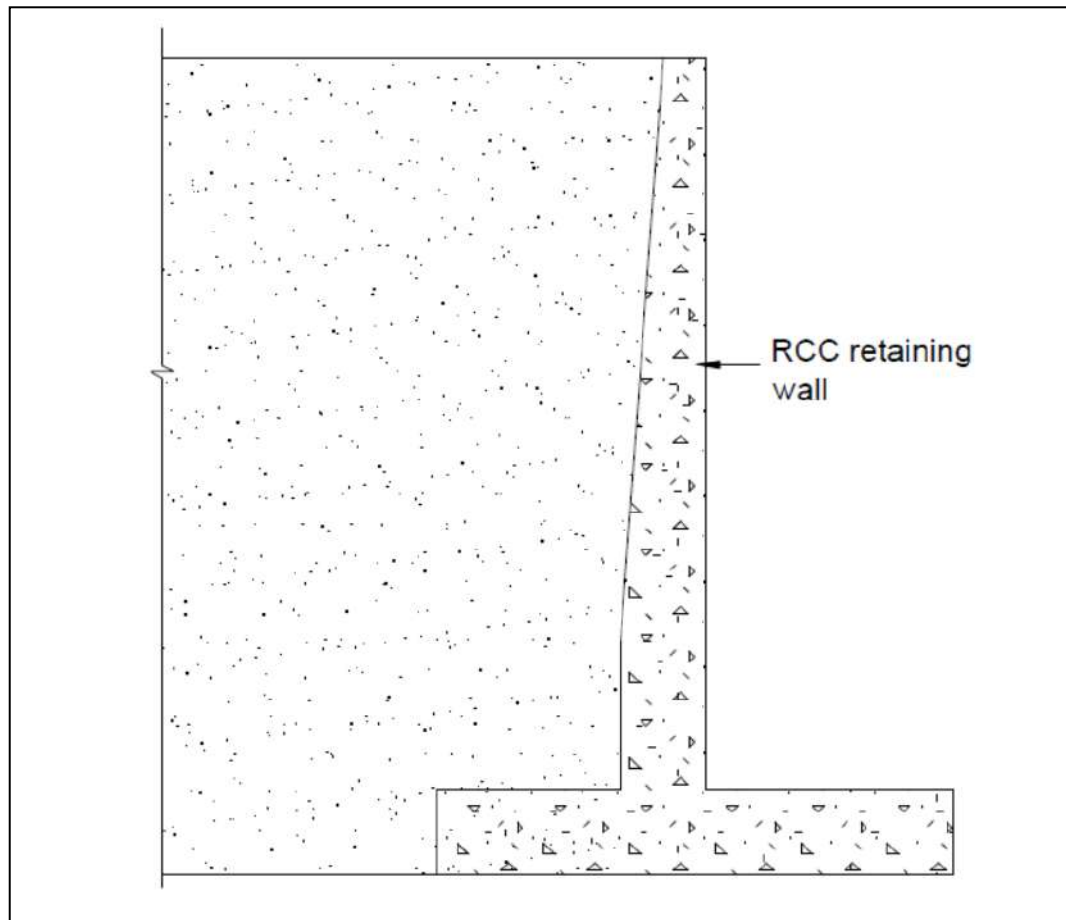
6.1.5.1 Retaining wall

Retaining walls are proposed at two locations of the recycling yard:

- i. Front of primary cutting zone along the shoreline.
- ii. At the junction between the primary cutting zone and the winch area.

These retaining walls shall be constructed using Reinforced Cement Concrete (RCC) to ensure structural stability and durability. At the beginning of the primary cutting zone, the retaining wall is intended to support the pavement of the recycling yard, maintaining it at the desired elevation.

At the interface between the primary cutting zone and the winch area, a retaining wall is proposed to accommodate a level difference of approximately 2.0 metres between these two zones. This design approach has been adopted to conform with the natural contours of the plot and to minimize earth-cutting volumes, thereby optimizing both cost and environmental impact.

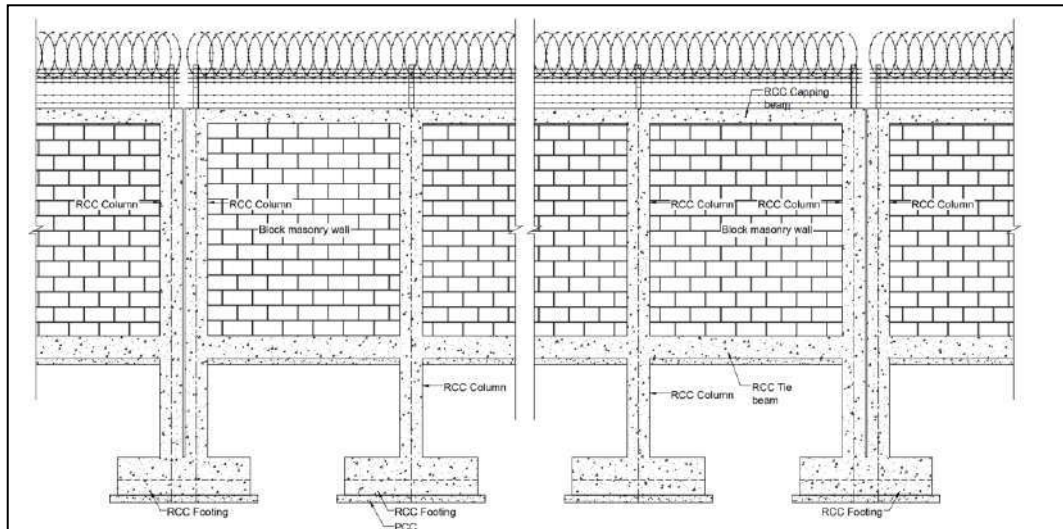
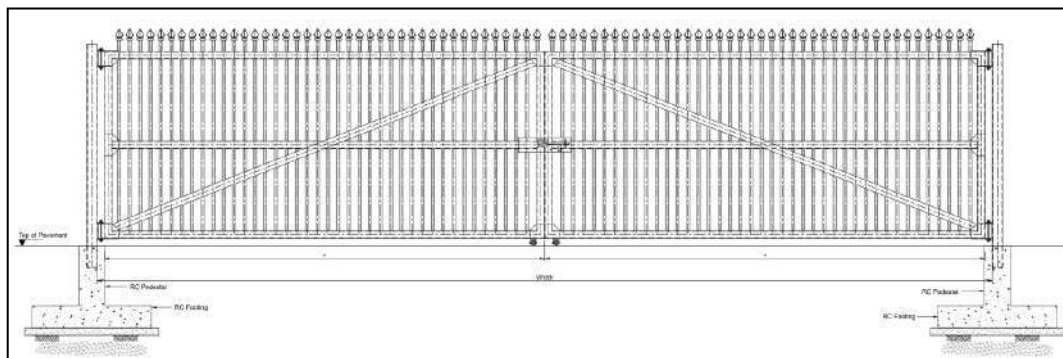
Figure 6-1: Indicative sketch of RCC retaining wall

6.1.5.2 Compound wall and Gates

RCC compound walls are proposed along the periphery of each recycling yard plot to ensure site security and controlled access. The compound wall system will consist of cast-in-situ RCC columns spaced at approximately 3.0 metres centre-to-centre (typical), with a continuous RCC plinth beam and precast RCC infill panels between the columns. The plinth beam shall provide structural support to the wall and enhance overall wall stability. expansion joints shall be provided at intervals of approximately 30 metres along the length of the wall. This configuration offers both structural stability and durability under varying environmental conditions.

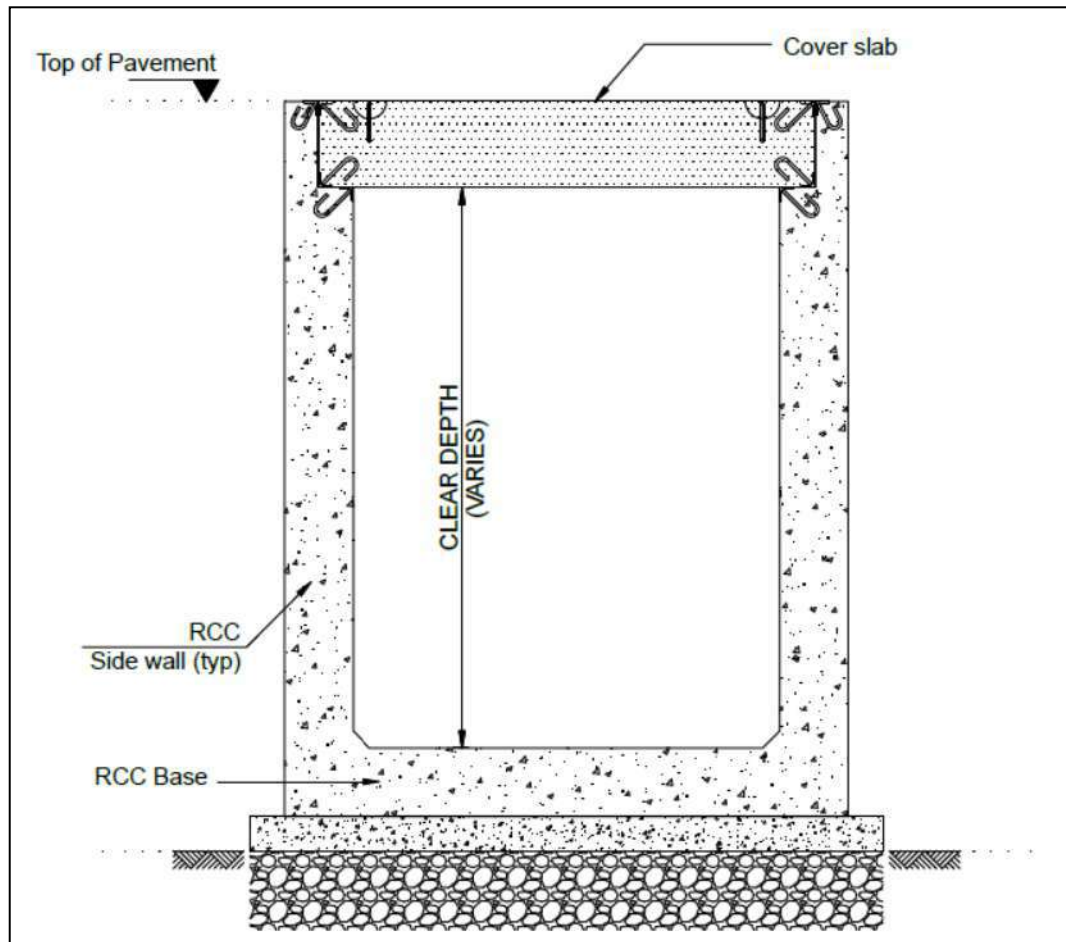
The height of the compound walls shall be finalized based on site-specific security requirements. Additionally, barbed wire fencing shall be installed along the top of the walls to enhance protection against unauthorized entry.

Steel gates shall be installed at designated entry points, including the main access gate and emergency exits, to ensure secure and controlled movement within the premises. These gates shall be designed for durability, ease of operation, and compliance with site safety and access requirements. Gate widths shall be determined based on functional and site-specific requirements, with the main access gate designed to be wider than the emergency exit gates to accommodate larger vehicular movement.

Figure 6-2: Indicative sketch of compound wall**Figure 6-3: Indicative sketch of steel gate****6.1.5.3****Storm water drains**

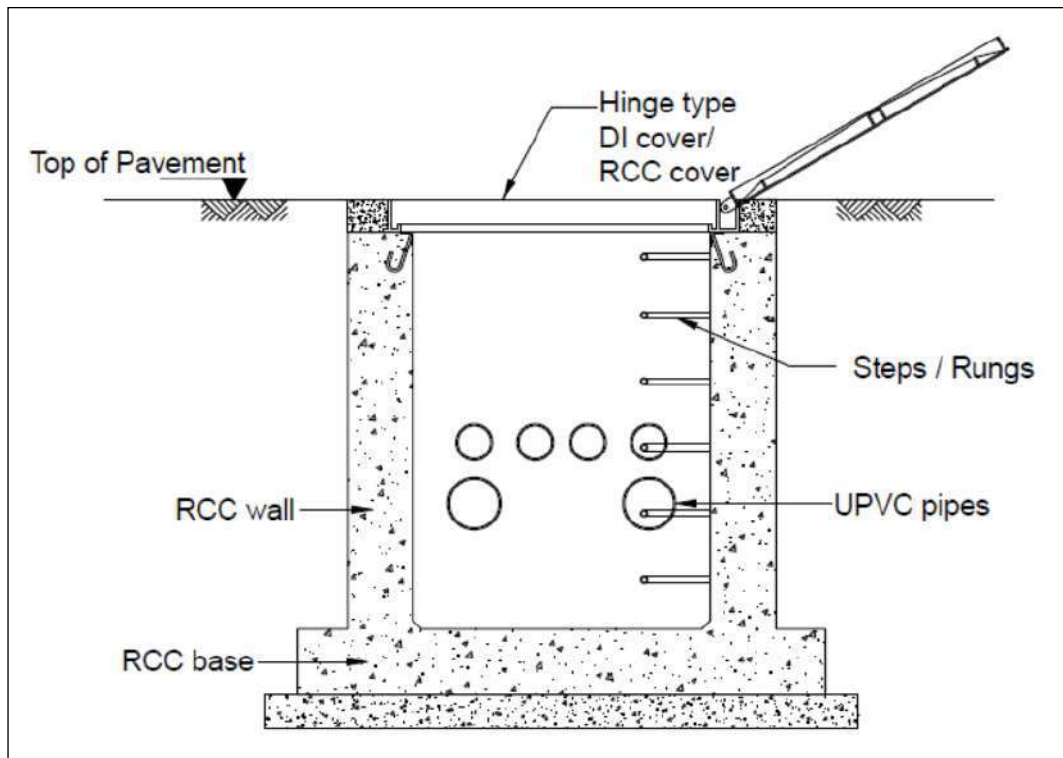
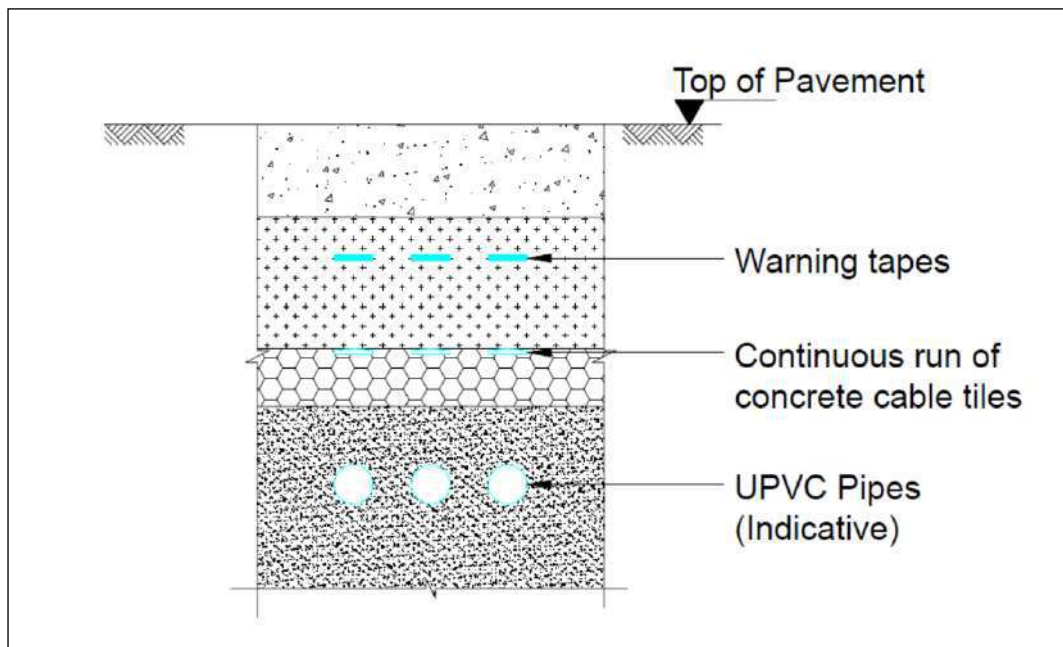
RCC storm water drains are proposed within the yard to efficiently collect and convey rainwater to the designated rainwater storage tank. The drains will be of U-shaped cross-section and constructed using RCC, ensuring durability and structural integrity. The dimensions of the storm water drains shall be determined based on hydraulic design calculations, considering anticipated rainfall intensity, surface runoff, and site topography to ensure adequate drainage capacity.

To enhance safety and accessibility, the drains shall be covered with top slabs made of either RCC or steel grating, depending on the location and loading requirements. This design will ensure proper surface drainage while preventing debris ingress and enabling periodic maintenance.

Figure 6-4: Indicative cross section of storm water drain**6.1.5.4 Cable distribution network**

Power supply to various buildings, the pump house, machinery, equipment, and lighting high masts shall be provided through underground cabling to ensure safety and reliability within the yard. The electrical cables will be laid in protective conduits buried below ground level. To facilitate easy cable laying, installation, and future maintenance, intermediate RCC cable pull pits shall be provided at regular intervals along the cable route.

This arrangement will help in minimizing exposure to environmental elements, reducing the risk of mechanical damage, and ensuring long-term serviceability of the electrical infrastructure.

Figure 6-5: Indicative cross section of cable pulling pit**Figure 6-6: Indicative cross section of buried cable arrangement****6.1.5.5 Foundations for lighting infrastructure**

For the installation of light poles and high-mast lighting within the yard, appropriate foundations shall be constructed using RCC. These foundations shall be designed to withstand wind loads, vibrations, and other structural stresses, ensuring the stability and longevity of the lighting infrastructure.

6.1.5.6 Water and oil storage tanks

The following storage tanks are proposed to be constructed as underground structures using RCC for durability, safety, and optimal land utilization:

- i. Fire water tank
- ii. Rainwater tank
- iii. Domestic water tank
- iv. Raw water tank
- v. Oil storage tank
- vi. Foam concentrate tank

These RCC tanks shall be designed to meet the respective capacity requirements and operational needs, ensuring structural integrity, water-tightness, and resistance to environmental factors. Proper access covers, ventilation, and maintenance provisions shall be incorporated into the design as per applicable standards.

6.1.5.7 Intertidal compacted area

The area beyond the primary cutting zone, extending approximately 30–40 m depending on the bathymetry of each plot, requires compaction and formation of a gentle, uniform slope to support proper vessel landing. This zone marks the transition where the vessel begins to lose tidal draught during high-tide approach, making a stable and well-graded surface essential for safe grounding. Accordingly, this stretch shall be compacted, and where required, filled with rubble, clay, or laterite soil and geo-membranes to achieve the desired slope and ensure a smooth landing surface.

6.1.6 Materials**6.1.6.1 Concrete**

Concrete shall comply with IS: 456 – 2000. Unless noted otherwise concrete is to be normal weight, with a typical dry density of 25 kN/m³. The following list shows the 28-day cube strength (minimum) to be achieved by the concrete for some main structural members.

Table 6-4 Grades of concrete

Sr No	Structure member/element	Minimum Concrete class	Cube strength at 28 days
1	RCC piles	M40	40 N/mm ²
2	Shallow Foundations	M30	30 N/mm ²
3	Super structure elements like column, wall, beam and slab	M30	30 N/mm ²
4	PCC	M15	15 N/mm ²

6.1.6.2 Reinforcement

Properties of steel reinforcement are to be adopted as per stipulations of the Indian standards. Only HYSD bars that are of standard sizes of 8, 10, 12, 16, 20, 25mm & 32mm diameter and with grade Fe 500D.

All other mechanical and chemical properties are to be in accordance with the code IS:1786- 2008.

Minimum cover to any reinforcement shall be considered as per Table 16 of IS: 456 – 2000, unless otherwise specified.

6.1.6.3 **Structural steel**

All Structural steel shall confirm to IS: 2062-2011 with minimum yield strength of 250 N/mm².

For Pre-Engineered Building (PEB), all steel tube/pipe sections shall be 310 Mpa grade and conforming to IS:1161. All rectangular hollow sections shall be 310 MPa grade and conforming to IS:4923.

6.1.7 **Design loads**

The buildings are analysed for the following basic load cases:

- i. Dead Load
- ii. Live Load
- iii. Seismic Load
- iv. Wind Load
- v. Temperature Load
- vi. Crane loads for workshop/ machinery building

6.1.7.1 **Dead load**

The dead load comprises of self-weight of the structure and loading due to finishes and flooring's etc. which are permanent in nature. The self-weight of partitions, ceiling, sunk load, elevation load, flooring, and facade etc. are applied as either area loads to slabs or line loads to beams.

The following parameters are considered as per IS 875 part – I 1987:

- | | |
|-------------------------------------|---|
| i. Finishes including services load | = 1.5 kN/m ² |
| ii. Facade load | = As per actual |
| iii. Density of concrete | = 25 kN/m ³ |
| iv. Density of red brick | = 20 kN/m ³ (Values should be check with local material) |
| v. Density of plain concrete | = 24 kN/m ³ |
| vi. Density of steel | = 78.5 kN/m ³ |
| vii. Density of aluminium | = 28 kN/m ³ |
| viii. Density of glass | = 25 kN/m ³ |
| ix. Earth fill | = 18 kN/m ³ |

6.1.7.2 **Live load**

Live loads shall include uniform loads that account for temporary and movable items such as people, portable tools, and equipment used during maintenance. These loads represent typical use and movement over floor areas. However, uniform live loads will not be considered for floor areas permanently occupied by fixed equipment.

Foundations and fixing arrangements for items of equipment, which generates vibration, shall be designed to prevent transfer of such vibrations to the adjoining structures.

Floors and supporting members, which are subject to heavy equipment loads shall be designed on the basis of the actual weight of the equipment.

Live Loads considered on floor slabs are as per IS 875 (Part 2) – 1987. In general, the following live loads are considered.

i.	Accessible roof	=	1.5 kN/m ²
ii.	Non-accessible roof	=	0.75 kN/m ²
iii.	Grating & Chequered plate	=	3.0 kN/m ² for grating & Chequered plates
iv.	Galleries	=	3.0 kN/m ² or a concentrated load of 2.0 kN at center whichever is critical. In addition to this, load due to cable trays, firefighting/ service water pipes shall also be considered
v.	Platform/Walkway	=	3.0 kN/m ²
vi.	For cover slabs of surface drainage	=	Load from vehicular movement such as trucks / forklifts / mobile cranes, etc. shall be considered in case the drain crosses or falls in these areas)
vii.	General rooms with storage	=	3.0 kN/m ²
viii.	Toilet	=	2.0 kN/m ²
ix.	Staircases	=	3.0 kN/m ²
x.	Corridors	=	4.0 kN/m ²
xi.	Server room, chiller & other	=	Minimum 10 kN/m ² or actual loading if it exceeds 10 kN/m ²
xii.	A.H.U, Lift Machine Room	=	10.0 kN/m ² or as per actual

All other loads which are acting on the structure but not mentioned above shall be taken and analysed as per the governing IS Codes.

Notes:

- No impact factor in the design of pile.
- Impact for IRC vehicular load shall be as per IRC 6:2010.
- For manual or electric monorail/hoist design, the impact factor to be considered as per relevant Indian standards.
- For design of R.C.C. beams supporting drive machinery like head end, trail end, drive pulley, gear boxes etc., the impact factor to be considered as per relevant Indian standards.

6.1.7.3 **Wind load**

Wind load shall be calculated as per IS 875(Part 3):2015. The factors used for calculating wind load are as follows:

Table 6-5 Wind Load Parameters as per IS 875 (part 3):2015

Wind parameters	Adopted values	Remarks
Basic Wind Speed, V_b	50 m/s	Refer the wind map for India
Probability Factor, K_1	1.0	General building
Terrain Factor, K_2	as Per Table 2 of IS 875 (part 3):2015	as Per Table 2
Terrain Category	2.0	clause 6.3.2.1
Topography factor, K_3	1.0	clause 6.3.3
Importance factor for cyclonic region, K_4	As per corresponding building	clause 6.3.4
Design wind speed, V_z	$V_b.K_1.K_2.K_3.K_4$	-
Design Wind Pressure, P_z	$0.6 V_z^2$	-
Wind Force, F	From code	As per IS requirements

6.1.7.4 Seismic load

IS 1893 (Part I): 2016 is used for calculating seismic load and as the basis for seismic load combinations.

Table 6-6 Seismic Load Parameters as per IS 1893 (part 1):2016 and Part 4

Seismic parameters (clauses 6.4.2)	Adopted values	Remarks
Seismic Zone	3	Figure 1
Zone factor, Z	0.16	Maximum Considered earthquake (MCE) for the service life of the structure. (Table 3)
Importance factor, I	From code	As per IS 1893 (part 1) Table 8 and IS 1893 (part 4) Table 3 & Table 6
Response reduction factor, R	As per corresponding building	As per IS 1893 (part 1) Clause 7.2.6 (Table 9)
Soil type	Medium filled soil	-
Structural damping	5%	Clause 7.2.4 for steel and concrete structures
Percentage of imposed load	25% (for LL up to 3kN/m ²) 50% (for LL > 3kN/m ²)	Clause 7.3.1 (Table 10)
Time period	From code	As per IS 1893 (part 1) Clause 7.6

6.1.7.5 Temperature load

Temperature load case shall be considered for temperature rise and fall relevant and site specific.

Shrinkage stress shall be considered in accordance with Cl.6.2.4.1 of IS:456:2000.

For shrinkage strain of $\epsilon = 0.00015$ & co-efficient of thermal expansion of $\alpha = 1.2E-05$, equivalent temperature fall shall be considered additionally.

6.1.7.6

Load combination

All the Structural elements will be designed for following load combinations and partial safety factors as per IS: 456 -2000 & IS 800:2007.

Table 6-7 Primary load cases

Primary Load Cases	
1	Dead Load (D. L.)
2	Live Load (L. L.)
3	Earthquake X-dir (Eq _x)
4	Earthquake Y-dir (Eq _y)
5	Wind X-dir. (WL _x)
6	Wind Y-dir. (WL _y)

Table 6-8 Load combinations for RC structures

Load combination	Limit state of collapse				Limit state of serviceability			
	DL	LL	WL	EL	DL	LL	WL	EL
DL + LL	1.5	1.5	-		1.0	1.0	-	-
DL ± WL	1.5	-	1.5		1.0	-	1.0	-
	0.9	-	1.5		1.0	-	1.0	-
DL ± EL	1.5	-	-	1.5	1.0	-	-	1.0
	0.9	-	-	1.5	1.0	-	-	1.0
DL + LL ± WL	1.2	1.2	1.2	-	1.0	1.0	1.0	-
DL + LL ± EL	1.2	1.2	-	1.2	1.0	1.0	-	1.0

Table 6-9 Load combinations for steel structures

Load combination	Limit state of collapse						Limit state of serviceability				
	DL	LL		WL	EL	AL	DL	LL		WL	EL
		Leading	Accompanying					Leading	Accompanying		
DL + LL	1.5	1.5	1.05	-	-	-	1.0	1.0	1.0	-	-
DL + LL ± WL	1.2	1.2	1.05	0.6	-	-	1.0	0.8	0.8	0.8	-
	1.2	1.2	0.53	1.2	-	-	-	-	-	-	-
DL + LL ± EL	1.2	1.2	1.05	-	0.6	-	1.0	0.8	0.8	-	0.8
	1.2	1.2	0.53	-	1.2	-	-	-	-	-	-
DL ± WL	1.5	-	-	1.5	-	-	1.0	-	-	1.0	-
	0.9	-	-	1.5	-	-	-	-	-	-	-

Load combination	Limit state of collapse						Limit state of serviceability				
	DL	LL		WL	EL	AL	DL	LL		WL	EL
		Leading	Accompanying					Leading	Accompanying		
DL ± EL	1.5	-	-	-	1.5	-	1.0	-	-	-	1.0
	0.9	-	-	-	1.5	-	-	-	-	-	-

6.1.8 Design methodology

The structural design shall be guided by parameters essential for ensuring adequate structural strength and rigidity, in accordance with relevant Indian and International codes. These parameters shall be selected based on the intended usage and functional requirements of the proposed structures.

Wherever required, a 3D model shall be prepared, and the structure shall be analysed using the STAAD Pro/ETABS software. Appropriate loads and its combinations, as described in above section shall be chosen for analysis and design.

The design of the structures shall be based on Limit State Method as specified in IS:456 – 2000 for reinforced concrete elements and IS 800:2007 for structural steel elements. Design calculations for various structural elements may be performed using licensed software packages, internally developed spreadsheets, or manual methods, as appropriate.

6.1.8.1 Design concepts

All RCC and steel structural members shall be designed in accordance with relevant Indian and international codes. All the stability criteria as envisaged in the clause 20 of IS 456 & IS 800 shall be taken care in the analysis.

In the method of design based on limit state concept, the structure shall be designed to withstand safely all loads liable to act on it throughout its life; it shall also satisfy the serviceability requirements, such as limitations on deflections and cracking.

The environmental exposure condition for the structure is to be taken as per IS 456. All the covers to the reinforcement bars are taken as to suit the mentioned parameters.

The retaining wall and any other sub-structure members shall be designed based on the soil parameters as per the geotechnical investigation.

6.1.8.2 Durability

The concrete durability is affected by the concrete mix and the exposure condition it is subjected to. It can be ensured by the proper design of the concrete mix as appropriate for the Environmental Exposure condition and by providing sufficient cover to the outermost face of any reinforcement. The Indian code IS:456-2000 lists out the different environmental exposure condition and based on it (Table 3).

Based on the requirements of the Fire rating and for the environmental exposure condition as listed above, the concrete covers are worked out as per Table 16 and 16A - IS: 456).

6.1.8.3 Limit state of serviceability

Deflection

For RCC structures

The following deflection criteria shall be considered for structures as per clause 23.2 of IS: 456:2000.

The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members, should not normally exceed $\text{span}/250$.

For Steel structures

The limiting permissible deflections for structural steel members shall be as specified in Cl:5.6.1 Table 6 of per IS 800 – 2007.

Crack control

As per Cl. 35.3.2 of IS: 456 – 2000, the surface width of the cracks should not, in general, exceed 0.3 mm in members where cracking is not harmful and does not have any serious adverse effects upon the preservation of reinforcing steel nor upon the durability of the structures.

In members where cracking in the tensile zone is harmful either because they are exposed to the effects of the weather or continuously exposed to moisture or in contact soil or ground water, an upper limit of 0.2 mm is suggested for the maximum width of cracks.

For particularly aggressive environment, such as the 'severe' category in Table 3, the assessed surface width of cracks should not in general, exceed 0.1 mm.

Corrosion protection

Nominal cover to reinforcement for all RCC members exposed to coastal environment shall be provided as specified in section 1.3.2 to meet durability requirement. No additional specific corrosion protection measures are envisaged for reinforcement.

For structural steel elements, suitable corrosion resistant paint shall be provided to all exposed surfaces. Areas and joints that are inaccessible for maintenance shall be suitably sealed by methods such as boxing with plates.

6.1.8.4 Fire resistance

The fire resistance of the buildings has been derived from the NBC 2016 Fire and Life Safety and local fire norms. Based on the usage of structure.

Taking as Type 2 construction in Fire zone 1, the required Fire rating for these structures are as follows.

Table 6-10 Fire Ratings of Members

Item of construction	Details	Fire ratings in Hrs.
External walls	Shear walls, columns and beams	2
Interior walls	Walls and columns supporting more than 1 floor	2
	Supports only one floor	2
	Supports roof only	2
Floor construction	-	2
Roof construction	-	2
Non-load bearing walls	-	0.5

6.1.8.5 Applicable standards

The design codes and standards to be used shall include, but not limited to, the following:

IS 456 – Code of practice for plain and reinforced concrete

IS 800 – Code of practice for general construction in steel

IS 875 – Code of practice for design loads for buildings and structures

IS 1343 – Code for practice for prestressed concrete

IS 4326 – Code of practice for earthquake resistant design and construction of buildings

IS 1786 – Specifications for high strength deformed steel bars and wires

IS 1893 – Criteria for earthquake resistant design of structures

IS 3370 – Code of Practice for concrete structures for the storage of liquids

IS 4651 – Code of practice for planning and design of port and harbours

IS 13920 – Ductile detailing of reinforced concrete structures subjected to seismic forces – code of practice

IS 808 – Dimensions for hot rolled steel beam, column channel and angle section

IS 1161 – Steel tubes for structural purposes

IS 1363 – Black hexagonal bolts, nuts and locknuts (dia 6 to 39 mm) and black hexagon screws (dia 6 to 24 mm) (All parts)

IS 1730 – Dimensions for steel plate, sheet and strip for structural and general engineering purpose

IS 2016 – Specifications for Plain Washers

IS 3502 – Specification for steel chequered plates

IS 4000 – High strength bolts in steel structures – Code of Practice

IS 4759 – Hot dip zinc coatings on structural steel and other allied products

IS 4923 – Hollow Steel sections for structural use

IS 1080 – Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell)

IS 1904 – Code of practice for design and construction of foundation in soils

SP 16 – Design aids for reinforced concrete to IS - 456.

SP 34 – Handbook on concrete reinforcement and Detailing.

SP 07 – National Building Code of India 2016.

SP 23 – Handbook on concrete mixes.

SP 24 – Explanatory handbook on Indian standard code of practice for plain and reinforced concrete (IS - 456).

IS 16700 – Criteria For Structural Safety of Tall Concrete Buildings

Latest edition of the above-mentioned codes and standards shall be followed unless specified otherwise. Wherever design criteria and codes / standards differ from each other, the order of priority shall be as follows:

Indian codes and standards

Other international codes and standards

The codes and standards mentioned above shall be the latest version applicable.

6.2 Design criteria – Pavement for recycling plot

This section applies to all proposed pavement works within the recycling plot. The whole recycling yard is to be constructed using rigid RCC pavement, designed as a hard impermeable platform to support all heavy-duty operations.

6.2.1 Site preparation and pavement level

To achieve the desired formation levels for the recycling yard plots, the existing ground will require cutting or filling as necessary.

The proposed pavement levels are designed to ensure that the recycling yard remains above the high tide level for the majority of the time, thereby reducing the risk of flooding and minimizing operational downtime. Additionally, the pavement level of the yard is considered in such a way to optimise the volume of cutting and filling required, ensuring cost-effectiveness and efficient use of resources during the earthwork process.

At the interface between the primary cutting zone and the winch area, a retaining wall is proposed to accommodate a level difference of approximately 2.0 metres between these two zones. This design approach has been adopted to conform with the natural contours of the plot and to optimise earth-cutting volumes, thereby optimizing both cost and environmental impact.

The finished pavement level of the recycling yard shall be set at +9.5m CD at the starting point of the **Primary Cutting Zone**. For smooth operation within the yard, the longitudinal gradient across various functional zones is proposed as follows:

- **Primary Cutting Zone (25 m):** Gradient of 1 in 130
- **Transition to winch area:** 2.0-meter vertical rise between the Primary Cutting Zone and the winch area
- **Winch and crane movement area to zone D (140 m):** Gradient of 1 in 50
- **Final 50 m near yard entrance:** Gradient of 1 in 65

6.2.2 Impermeable hard surface (RCC pavement)

The hard impermeable pavement is to provide a durable, structurally stable, and environmentally safe working platform for ship recycling operations. The pavement shall ensure containment of hazardous materials, facilitate surface runoff collection, and withstand the operational loads from heavy machinery and ship components.

6.2.2.1 Design life

Design life of the impermeable hard surface (RCC pavement) shall be 30 years.

6.2.2.2 Design loads

The pavement is required to withstand substantial loads from heavy-duty operations involving cranes, forklifts, transporters, and dismantled ship components. The following equipment or vehicles shall be considered for the design, but not limited to:

- Heavy-duty portal, crawler, or floating cranes with 150 to 300-ton lifting capacity
- Heavy duty mobile cranes with 25 to 100-ton lifting capacity
- Forklifts with 3 to 5-ton lifting capacity
- Excavators with shears of 20 to 40-ton lifting capacity
- Magnetic scrap handlers with 1.5 to 4-ton lifting capacity
- Plasma cutting machines, hydraulic/cold cutting saws, oxy-acetylene torches, etc.
- Fire truck
- Trucks and trailers
- Winches
- Both **static and dynamic loads**, including **impact and vibrations** resulting from dropped components, shall be considered in the structural design.

6.2.2.3 Pavement section

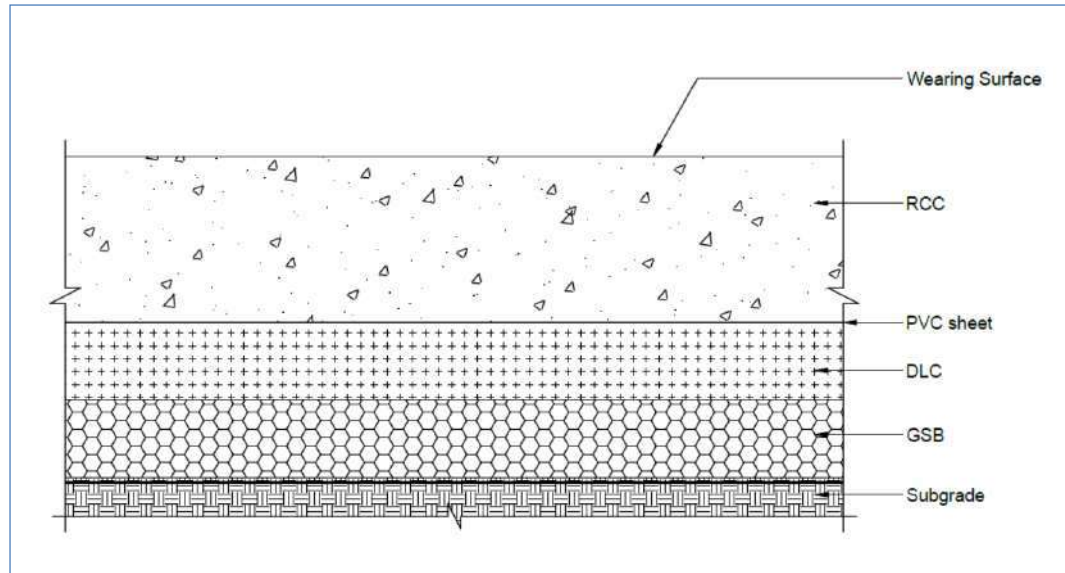
The thickness of different layers should be as per design. In general, different layers will be as follows:

Table 6-11 Material in different layers

Layer	Material
Wearing surface	Epoxy/PU coating for chemical resistance
	Chemically resistant joint sealants
	UHMW-PE coating for the primary cutting zone
Top layer	RCC/PQC of M40 grade
	Reinforcement to be provided as per IS 456 and IRC 58
Base course	M15 grade lean concrete
Sub-base course	Granular sub-base (GSB) of CBR 30% conforming to MORTH specifications

Layer	Material
Sub-grade	Improved soil/ Granular material with CBR $\geq$ 10%

An indicative cross section showing different layers of pavement is shown below.



6.2.2.4 Impermeability and chemical resistance

- Entire pavement shall be impermeable to oil, fuel, and other pollutants.
- Joints shall be filled with oil-resistant polysulphide sealant.
- Surface coating with epoxy resin or polyurethane-based waterproofing membrane.
- RCC to be designed for exposure condition – severe, as per IS 456:2000.

6.2.2.5 Design methodology

The design of rigid (RCC) pavement for ship recycling yards must account for heavy-duty industrial usage, chemical resistance, impermeability, and durability in harsh marine environments. The design should comply with IRC, IS codes, and applicable international standards (like ACI, ASTM, BS EN where necessary).

Applicable standards

The design codes and standards to be used shall include, but not limited to, the following:

Indian Standards

IRC:58 – Guidelines for the Design of Plain Jointed Rigid Pavement for Highways

IRC:118 – Guidelines for Design and Construction of Continuously Reinforced Concrete Pavement

IS 456 – Code of Practice for Plain and Reinforced Concrete

IS 800 – Code of Practice for General Construction in Steel

IS 10262 – Concrete Mix Proportioning – Guidelines

IS 3370 – Concrete for Liquid Retaining Structures (for impermeability practices)

IRC: SP-49:2014 – Guidelines

MoRTH Specifications for Road and Bridge works

International Standards

ACI 360R-10 – Guide to Design of Slabs-on-Ground

ACI 330R – Guide for Design and Construction of Concrete Parking Lots

BS EN 206 – Concrete specification, performance, and conformity

Design procedure

For design purpose, the equivalent single axle load and the anticipated number of load repetitions from all expected vehicle types shall be estimated. Based on this input, the structural design of the RCC pavement shall follow the guidelines of IRC:58-2015, which uses Westergaard's equations to calculate stresses induced in the pavement slab due to wheel or equivalent track loads at the interior, edge, and corner positions. The design flexural strength (modulus of rupture) of the RCC must exceed the maximum calculated stress, incorporating proper safety factor to account for dynamic load effects.

Alternatively, the pavement may be analysed using an analytical approach by developing a three-dimensional (3D) continuum model of the pavement section in STAAD or any other suitable structural analysis software. In this model, the material properties of each pavement layer shall be idealized accurately to reflect real-world behaviour. The model will then be subjected to various loading conditions, including all anticipated vehicle loads, as well as thermal effects due to temperature variations, to evaluate stress distribution and structural performance.

6.3 Design criteria – Water supply & drainage in recycling plot

6.3.1 Water supply

The main source of water to ship recycling plots shall be through GMB supply network proposed.

6.3.1.1 Domestic water requirements

The requirement of water shall be as per the NBC 2016.

Table 6-12: Water requirement in recycling plots

Description	Plot 240 x 215	Plot 300 x 215
Domestic water requirement		
Workers expected per plot	900	1100
shift	1	1
LPCD for industries	45	45
Total water demand required (LPCD)	40,500	49,500
2 days capacity for underwater tank	81,000	99,000
Total capacity considered (liters)	1,00,000	1,00,000
Fire water requirement		
Tank capacity as per IS 9668 - 1990 - 4.2.2-C	6,48,000	6,48,000
Total capacity considered (liters)	7,00,000.00	7,00,000.00

6.3.1.2 Water peak storage

- Capacity of underground tank for domestic water (for 2 days capacity): 1,00,000 liters
- Capacity of underground tank for domestic raw water: 50,000 liters
- Capacity of underground tank for fire water: 7,00,000 liters for both the plots
- Capacity of overhead tank of admin and training buildings shall be as per the requirement

6.3.1.3 External water distribution network

Domestic water for all buildings shall be supplied through a hydro-pneumatic system fed from underground water storage tanks. The same system configuration will also be applied for flushing water supply to ensure operational efficiency and pressure consistency.

The primary source of water shall be the GMB pipeline, with provisions made to receive water at the site through a dedicated GMB inlet. As borewells are not permitted within the ship recycling yard premises, an alternative emergency water source in the form of tanker-supplied water may be arranged in the event of supply disruption.

Water intake will be through the fire water storage tank, which is the only water source considered in the design. Overflow from the underground fire tank will be diverted to a designated domestic raw water compartment for further treatment.

Hydro pneumatic pump shall be used to pump domestic water from the underground tank. Domestic raw water will be pumped to a softening system using softener feed pumps. The pump room layout includes space allocation for the complete water treatment setup, including a softener unit, activated carbon filter, Multi-Grade Filter (MGF), and pressure sand filter. The detailed sizing and specifications of the filtration system will be finalised based on the results of a water quality test to be carried out during detailed engineering stage.

Water supply network distribution and operating pressures

The system shall be designed to maintain a consistent pressure of 1.5 bar $\pm$ 0.5 bar at the hydraulically most remote fixture, ensuring reliable performance across all outlets. The

maximum allowable pressure at any fixture will generally be limited to 3.5 bar to prevent equipment damage and ensure user comfort.

Pressure reduction, where required, shall be achieved through the use of Pressure Reducing Valves (PRVs) or calibrated orifice plates. All domestic and flushing water equipment—including pumps, control systems, and distribution piping—shall be engineered to minimise pressure fluctuations throughout the network, ensuring stable and efficient operation.

6.3.1.4 **Pump system and components**

Domestic water pump:

Fully Automatic hydro pneumatic booster system with cast iron housing Enclosure class IP44 minimum, with built in PTO motor protection and stainless-steel impeller pump, pump model GRUNDFOS CMB 5-46 series or equivalent one pump working and one standby for support with following specifications:

- i. Power: 2.25kw/3 HP, 3 Phase
- ii. Flow rate: -12cm²
- iii. working pressure: -4.5 to 5 kg
- iv. GI inlet & outlet header size 40/80 mm, outlet 50 mm with NRV,

6.3.2 **Contaminated water disposal**

6.3.2.1 **Contaminated water tank**

Rainwater trenches covered with grates, shall be provided at the end of primary cutting zone, secondary cutting zone and after the administration and storage area. All the 3-level trenches covered by grate shall be connected to the rainwater collection tank. The width of the trench shall be 600 mm across the path.

Table 6-13: Contaminated water storage capacity

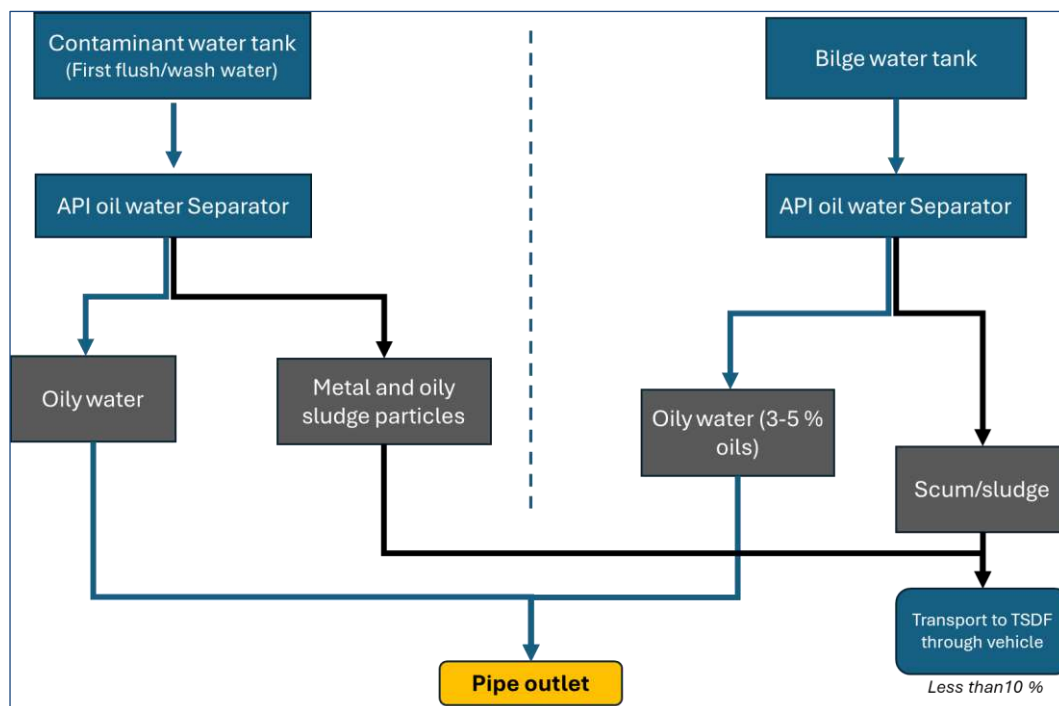
Description	Plot 240 x 215	Plot 300 x 215
Rainwater collection tank		
Area of plot	51600	64500
Coefficient of runoff	0.9	0.9
Intensity of rainfall in (m/hr)	0.05	0.05
Duration of peak storm in hr	0.33	0.33
capacity (cum)	766.26	957.825
Total capacity considered (liters)	7,70,000	9,60,000

The contaminated water storage tank capacity has been designed to accommodate maximum volumes, approximately 20 minutes of peak rainfall, which exceeds the minimum requirements specified by CPHEEO guidelines. During non-monsoon period, wash water from the plot will also be collected in this tank, this design ensures effective capture of the initial runoff, which typically contains the highest concentration of surface pollutants.

Contaminated rainwater or wash water collected in these tanks will be subjected to quality testing prior to being discharged into the central contaminated water transfer network outside the plot boundaries.

6.3.2.2 Effluent processing and discharge

Figure 6-7: Flow diagram for contaminated oily water transfer system



Each ship recycling plot is equipped with a contaminant water tank (for first flush/wash water) and a bilge water tank. Both tanks feed into an API Oil–Water Separator (OWS). The separated oily water (typically containing 3–5% oils) is collected into the central pipe network, while the heavier metal/oily sludge and scum (<10% by volume) are transported to the TSDF by road for safe disposal.

Contaminated water collected over first flush or wash water that contains discharge parameters beyond safe limits specified by CPCB guidelines are to be safely transferred to CETP to treat before safely discharging.

The ship recycling plots are not allowed to carry out any activities which involves galvanisation like metal processing which will additional treatment methods. API oil separator shall treat the bilge water or contaminated water in such a way that the output discharge shall have the parameter below specified values:

Table 6-14: Outlet parameter for oil water separator

Characteristics	Outlet from oil water separator
pH	6.0 – 8
TSS (mg/L)	< 30
Oil & Grease (mg/l)	< 15

Though these parameters are below safe discharge limits as per CPCB, oil water separators cannot remove fumes, fine airborne solid or liquid particles. And require separating it out in an ETP.

Recommendations:

- Regular monitoring and quality testing of contaminated water collected in discharging into transfer network is strongly recommended, especially during the initial rainfall events of the season.
- First-flush systems shall be incorporated as a critical component in hazardous areas to prevent entry of pollutants into the marine or groundwater recharge systems.
- Runoff exceeding the first 20 minutes of rainfall will be discharged directly to the sea as surface runoff, as most pollutants and debris are expected to be captured during the initial runoff period by design unless specified otherwise by any other guidelines defying CPCB guidelines.

This approach ensures both environmental compliance and operational efficiency in managing stormwater within the development area.

6.3.2.3 Pump system and components

Contaminated water pump:

Submersible single stage single entry pumps connected to submersible motor (The motor shall be watertight according to IEC class IP 68, and incorporate class F, insulation materials to withstand a continuous operating temperature of 155 deg C) for 415 + 10% volts, 3 phase, 50 cycles A.C. power supply with mechanical seal, pump connector unit with rubber diaphragm and bend, vertical discharge pipe, electrical panel within built level controller with operational mode as one pump working at low level, both pumps at high level with a hooter alarm and cut off at dry level as determined.

The pump shall be provided with a lifting devise of pull chain/guide rail & G.I. heavy class rising main of 5m length including interconnecting piping, valves (Ball Valve / Butterfly), Non return valves (GM/CI) 15 m cable etc. as per requirement complete in all respects. (Pumps shall be installed in a set of two pumps One working and One standby, with cascade operation). (Pumps suitable to handle solids upto 25 mm size with C.I. body, SS304 shaft, C.I. impeller with 15 m cable, double mechanical seal).

6.3.3 Reference codes & standards

National Building Code of India – 2005 (NBC)

Uniform Plumbing Codes – India – 2013.

IRC – SP042 – 2014

IS: 1172: Code of basic requirements for water supply and sanitation

IS: 1742: Code of practice for building drainage

IS: 2064: Selection, Installation and maintenance of sanitary appliances – Code of practice.

IS: 2065: Code of practice for water supply in buildings.

IS: 12251: Code of practice for drainage of building basements

IS: 5572: Code of practice for sanitary pipe work

IS: 8301: Code of practice for building drainage

IS: 10500: Code of Drinking water quality

Manual for water supply & treatment published by CPHEEO (Central Public Health & Environmental Engineering Organization).

Manual for sewage & sewage treatment published by CPHEEO (Central Public Health & Environmental Engineering Organization)

Other relevant BIS standards

6.4

6.4.1

Design criteria – Firefighting facilities in recycling plot

Fire protection system components

The fire protection infrastructure for ship recycling plots and associated facilities shall comprise the following systems and equipment:

- Underground fire water storage tanks
- Fire pumps with standby arrangements
- Hydrant network with landing valves
- Fire brigade inlet connections
- Hose reel systems
- Portable fire extinguishers
- Foam-based fire suppression systems for oil zones and cutting areas
- Mini fire tender

6.4.2

Design considerations and layout requirements

- A minimum 6.0-meter-wide access road shall be provided between plots to allow unimpeded movement of fire tenders.
- Foam concentrate units shall be strategically located near both the oil block zones and primary cutting areas to ensure rapid response to fuel-based fires.
- All electrical shafts and vertical ducts shall be constructed with a minimum 2-hour fire resistance rating. Other service shafts shall provide at least 1-hour fire resistance.
- Electrical and ELV shafts shall be sealed using certified passive fire protection systems to prevent fire and smoke propagation.

6.4.3

Material specifications

Table below provides the typical materials proposed for various firefighting system components:

Table 6-15: Material description for firefighting system

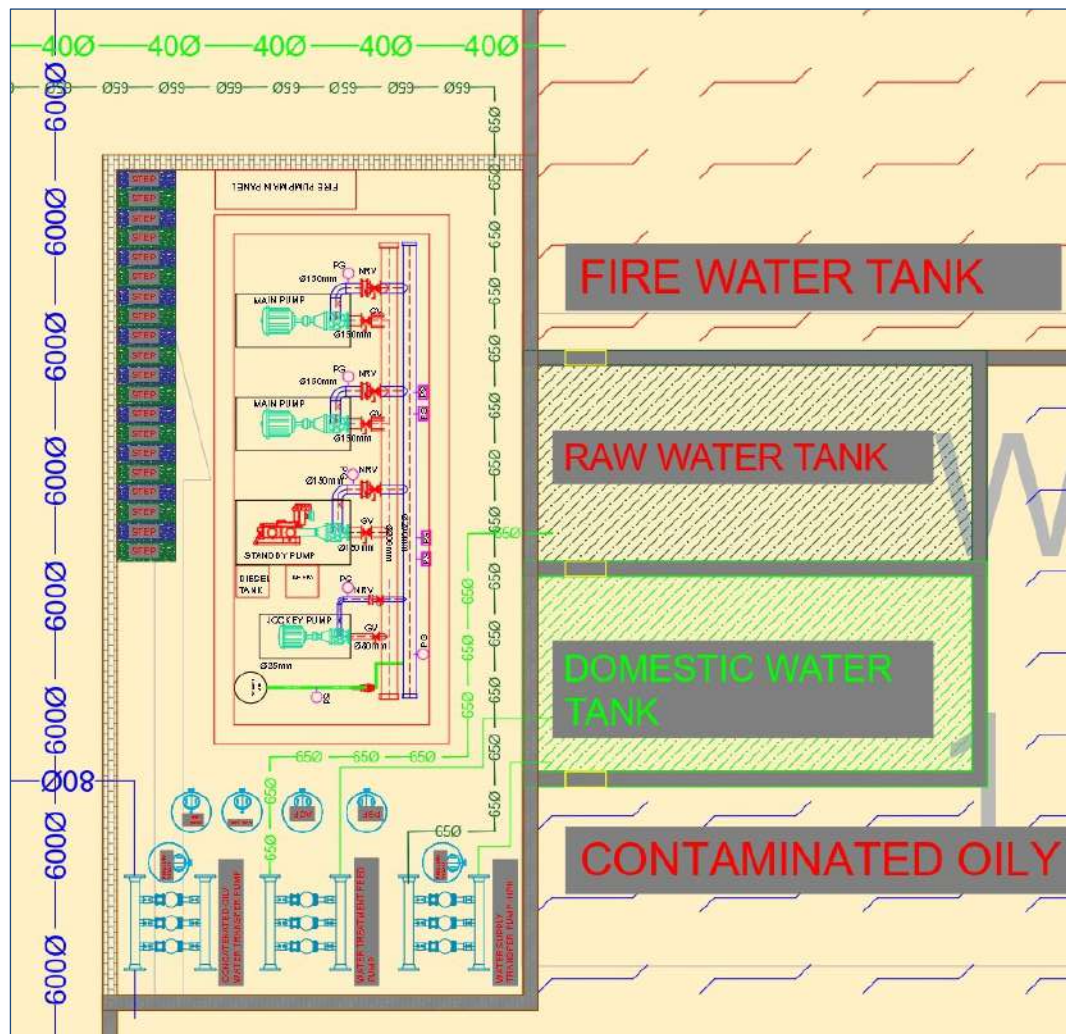
Sr.no	Item description	Material
1	M.S. Underground pipe	G.I./M.S. 'B' Class with wrapping coating
2	M.S. above ground pipe	G.I./M.S. 'B' Class with primer & paint
3	Centrifugal Pumps	Body: C.I. Impeller: Bronze Shaft: SS
4	Valves and Non return Valve	Body: C.I.
5	Hose Pipe	Reinforced Rubber Liner hose
6	Hose reel	Drum: M.S Hose: as per IS
7	Air Release Valve	Gun metal
8	Fire bridged inlet connection	Gun metal/Cast iron
9	Hose Box	FRP
10	Fire extinguishers	ISI Marked (SS304 or better)
11	Hydrant valves and accessories:	Stainless Steel
12	Isolation valves (Gate/Butterfly valves):	Cast Iron

6.4.4 Fire water storage requirements

Fire water tank capacities for ship recycling plots are as follows:

- Plot 240 x 215: Fire water requirement (litres) 6,48,000
- Plot 240 x 215: Total tank capacity considered (litres) 7,00,000
- Plot 300 x 215: Fire water requirement (litres) 6,48,000
- Plot 300 x 215: Total tank capacity considered (litres) 7,00,000

A common underground fire tank with a total capacity of 7,00,000 litres has been proposed for both plot types.

Figure 6-8: Fire pump room layout

6.4.5 Fire water distribution network

6.4.5.1 Distribution network

- The fire water system shall be pressurised and fed via fire pumps connected to the underground fire tank.
- Fire test line is connected to pressure sensor of the fire pump system.
- Distribution shall be through a network of fire hydrants and hose reels, with sufficient spacing to ensure coverage of all plot areas.
- Fire brigade inlets shall be provided for external firefighting support.
- Foam suppression systems shall be installed in high-risk areas such as oil blocks and primary cutting yards.
- System design shall comply with minimum residual pressure requirements and be equipped with pressure monitoring and control features to ensure system readiness.

6.4.5.2 Pump system and components

Based on the fire water storage tank capacity of 7 lakh liters, the fire pump capacity has been considered with 3 hours of operation, giving a total of $2.73 \times 3 = 8.19$ lakh liters.

Further, the pump capacities provided are worked out based on assumptions and shall be detailed out and modified accordingly in further staged.

Main fire water pump:

Electric driven Main Fire Pump suitable for automatic operation and consisting of following, complete in all respects, as required:

- i. Horizontal type, multistage, centrifugal, split casing pump of cast iron body & bronze impeller with stainless steel shaft, mechanical seal conforming to IS 1520.
- ii. Suitable HP Squirrel cage induction motor, TEFC, synchronous speed 1500 RPM, suitable for operation on 415 volts, 3 phase 50 Hz, AC supply with IP 55 protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS-325.
- iii. M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts etc. as required. (d) Suitable cement concrete foundation duly plastered - 2280 lpm at 56 m Head.

Diesel driven pump:

Horizontal type, multistage, centrifugal pump of cast of iron body and bronze impeller with stainless steel shaft, mechanical seal conforming to IS 1520. Suitable HP, 1500 RPM water cooled with radiator, diesel engine conforming to relevant IS standard complete with auto starting mechanism, 12 /24 volts electric starting equipment, diesel tank, exhaust pipe extended upto 10 m outside pump house duly insulated with 50 mm thick glass wool with 1.0 mm thick aluminium sheet cladding, residential silencer, instruments and protection as per standard specification. Battery capacity with 12 hours of charging duration to be considered.

Jockey Pump:

Horizontal type, multistage, centrifugal pump of cast iron body and bronze impeller with stainless steel shaft, mechanical seal conforming to IS: 1520. Suitable HP squirrel cage induction motor TEFC type suitable for operation on 415 volts, 3 phase 50 Hz AC supply with IP 55 class of protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS: 325. M.S. fabricated Common base plate, coupling, coupling guard, foundation bolts etc. as required.

All the pumps shall have suitable cement concrete foundation duly plastered and with anti-vibration pads.

6.4.6 Fire tender (mini truck)

- 2500-3000 liters water tank
- 150 liters foam tank
- High pressure pump (~150 LPM @ 100 kg/cm²)

6.4.7 Reference codes and standards

The work shall be carried out in accordance with the regulations of local bodies and the following codes which may govern the requirement of the system.

Indian Standards (IS)**IS 325:** Induction motors – 3-phase**IS 636:** Fabric reinforced rubber lined hose**IS 844:** First aid hose reel**IS 900:** Installation and maintenance of induction motors**IS 903:** Fire hose delivery couplings, branch pipes, nozzles and nozzle spanner**IS 908:** Fire hydrant stand post**IS 909:** Underground fire hydrant sluice valve type**IS 1239 (Part I & II):** M.S. tubes and fittings up to 150 mm**IS 2190:** Selection, installation, and maintenance of first aid fire extinguishers**IS 2871:** Specification for universal branch pipe for firefighting purposes**IS 3589:** M.S. tubes above 150 mm**IS 3844:** Installation and maintenance of internal fire hydrants and hose reels**IS 5132:** First aid fire hose**IS 12469:** Specification for pumps for firefighting system**IS 15301:** Installation and maintenance of firefighting pumps**IS 15683:** Portable fire extinguishers – Performance and construction**6.5 Design criteria – Electrical works in the plot**

The objective includes energy efficiency and centralised grouped location of services installation to ensure easy maintenance, state of the art technology, fast track installation and compliance to all statutory regulations.

6.5.1 Broad concept of services

The services system for the project has been designed with reference to existing ship recycling plot layouts and applicable design standards. Key considerations include:

- **Concealed services** with accessible provisions to allow future modifications
- **Equipment layout** prioritising ease of access for preventive maintenance
- **Manual isolation features** to enable maintenance or upgrades without service disruption to adjacent areas
- **Sustainability focus** through integration of **solar energy systems**, with dedicated space allocated for solar panels and metering on the administrative and training building terraces, promoting zero-emission, renewable energy use.

6.5.2 Source of power supply

The principal source of electrical power will be the PGVCL Power. HT side shall be supplied by PGVCL including its required specification.

Table 6-16: Electrical load sheet for recycling plots

Sr. No.	Description	Diversity	Load in KW	Diversified Load in KW	Load in KW	Diversified Load in KW
			240 x 215 m plot		300 x 215 m plot	
1	Flood light load	0.7	5	4	7	5
2	Winches	0.5	153	77	207	104
3	Plumbing load	0.4	30	21	30	21
4	Firefighting load	1	45	45	45	45
5	Other building load	0.7	15	11	15	11
	Total load in KW			157		185
	Overall diversity @ 80%		0.8	125	0.8	148
	Total load in KVA @ 0.90 P. F		0.9	139	0.9	164
	Transformer loading factor @90%		90%	155	90%	182
	Transformer size proposed in KVA	1 No. 200KVA Transformer				

The power requirement for each plot has been calculated based on the proposed equipment, and a 200 kVA dry-type transformer with an OLTC tap changer has been adequately sized and proposed for each plot.

6.5.3 Emergency power (Through DG Set)

Power supply shall be provided with full load back up for the DG setup.

- 1 No. 200 KVA/250 KVA 3 phase DG Set
- The DG sizing is done considering 70% overall diversity.

6.5.4 Distribution network

There are mainly following possible options for cable laying methodology.

Cable distribution is arranged in the following methods based on the location

- Wall mounted cable tray
- In cable trench

6.5.5 Brief of equipment and outline specification

6.5.5.1 Distribution boards

For all internal distribution networks for lighting PPI / ETPN / VTPN and SPN type distribution boards will be used depending upon the load having IP 42/43/54 protection and metal double door as required at site. For all indoor applications we recommend IP 43 type DB; and for all out-door application we recommend IP 54 type DB with additional covering

arrangement so that any unauthorized personnel cannot touch DB. The DB will have MCB / ELCB configuration as under.

- SP MCBs for individual lighting/power circuits
- DP ELCB/ELMCB for per phase earth fault protection.
- DP/FP MCBs for incomer of all single/three phase distribution board.

All electrical panels shall be provided Loto arrangements, including lockable incomer and feeder breakers, provision for padlocks, Loto hasps, danger/identification tags, and a Loto station for safe isolation during maintenance. The panel design shall enable secure locking of switching devices in off position in accordance with standard electrical safety practices.

All electrical equipment including HT panels, transformers, HT/LT power and control cables, cable trays, switchgear assemblies, metering units, protective devices, structural steel supports, DG sets, power and control panels, distribution boards (DBs), luminaires and associated fittings shall be from approved standard manufacturers as per project specifications.

Electrical panels shall be equipped with an internal fire-detection trace tube system. The trace tube shall provide automatic detection and localized extinguishing within the panel to ensure immediate suppression in case of overheating or electrical faults. The system shall cover all critical components inside the panel and comply with approved fire-safety standards.

6.5.5.2 **Wiring system**

Pipes: PVC pipes for internal wiring having 20/25/32/40 mm outer dia. are being considered medium gauge pipes for wiring in slab and heavy gauge pipes for below floor are being considered.

Wires: For power/lighting wiring for all internal purposes, FR copper flexible wire of 1.1 KV grade shall be considered. Colour coding is to be used for wiring such as red/yellow/blue for phase, black for neutral and green for earth.

6.5.5.3 **External lighting**

Flood lights of 8 no. of 150-watt HPSV / Metal halide lamp is provided on each pole. A total of 9 flood lights in a 240 m plot and 12 lights in a 300 m plots have been proposed for an illumination that will allow the yard operations even in night especially during times when beaching and other works needs to be carried out during night due to High tide timings.

All poles shall be heat resistant cast aluminium body. Alternate connections shall be made at circuit level at different loop to save energy. All lights mast considers motorized carriage with avitaion lamp & lighting protection and Automatic lighting control in 2nd stage.

As per IS 6665(1972): Code of practice for industrial lighting, an average of 100 lux shall be maintained during operations

6.5.5.4 **Earthing**

Entire system shall be earthed in accordance with the provisions of the relevant IEC recommendations/IS code of Practice IS 3043-1987 and Indian electricity rule. The principal requirements of the grounding are Low resistance and adequate current carrying capacity. The resistance of earthing network shall be less than 1.0 ohm

6.5.5.5 Cable tray

Considering the humid atmosphere, non-metallic (FRP) ladder type cable tray is suggested.

Cable tray is a safe and economical solution for supporting requirements of electric power, signal, control, instrumentation, and communication cables. Fabricated in numerous styles (ladder, ventilated trough, channel, and solid bottom) and sizes, cable tray provides the greatest versatility among cable support systems.

Ladder Type Cable Tray: Ladder cable tray is used for power cable & wiring system installations. It is the predominate cable tray type due to its heavy duty and robust construction.

A ladder cable tray without covers permits the maximum free flow of air across the cables. This allows the heat produced in the cable's conductors to effectively dissipate. So that cables will not prematurely age due to excessive operating temperatures. Cables may exit or enter the ladder cable trays through the top or the bottom of the cable tray.

ELV (Extra Low Voltage) services

The proposed plot shall be equipped with essential ELV services including CCTV surveillance, access control systems, structured data cabling, public-address and emergency communication, fire alarm and detection systems, and outdoor wireless connectivity. These systems shall be designed with adequate weatherproofing, redundancy and coverage for operational, safety and security requirements across the cutting zone, scrap handling area, entry/exit points and administrative buildings. Provision for integration with central monitoring and future expansion shall also be incorporated.

- ICT Infrastructure - Information & Communication Technology (Data & Telecom) Infrastructure
- Electronic Security – Video Surveillance/CCTV System
- Safety To Human Life and Assets - Fire Detection & Alarm System & Public Announcement System.

The proposed ELV services will be utilized by various service providers. It is proposed to provide underground cable space provision from external approach to entry up to ELV room/area.

6.6 Design criteria- soft dredging in the intertidal area

Bathymetry, geotechnical and geophysical investigations indicate the presence of shallow hard outcrops within the intertidal zone. Side Scan Sonar and Sub-Bottom Profiling show multiple zones of medium to high seabed reflectivity, interpreted as harder strata. Supplementary investigations further suggest that these features comprise a combination of hard clay layers and pockets of soft rock

These outcrops are located in the proposed vessel landing corridor, where ships will settle during landing activity. If left unaddressed, these hard projections pose a risk of hull damage, affecting both operational safety and environmental compliance.

To ensure a safe and obstruction-free beaching surface, localised land-based dredging is recommended. As the intent is to create a soft surface for the vessel to land on, dredging shall be carried out with depth ranging 1 - 2 m depending on the bathymetry at each

outcrop, sufficient to remove the exposed and near-surface hard strata and let it fill naturally back by soft clay/silt.

The objective of this dredging is to:

- Create a smooth and uniform seabed profile for safe beaching
- Eliminate localized hard points that could damage vessels
- Maintain the functional gradient of the intertidal approach zone

6.6.1

Basis of dredging quantity calculation:

For planning purposes, the dredging estimate has been derived considering:

1. Mapped rocky/hard surface considering an extent of around 200 m from the primary cutting zone into the intertidal area.

This zone is critical because during the landing operation the vessel gradually loses tidal draught and begins to settle onto the seabed. Beyond this 200 m reach, the natural seabed slope generally provides sufficient depth for the vessel to remain afloat while approaching, reducing the likelihood of hull contact. Therefore, the risk of hull damage from hard seabed features is primarily concentrated within the first 200 m.

2. Outcrops mapped beyond the 200 m extent that may pose obstacles to the vessel's movement during the landing operation.

Figure 6-9: Proposed dredging area



The dredging works shall be further refined during the detailed design stage, where precise footprints will be extracted from the integrated bathymetry & geotechnical data.

Table 6-17: Soft dredging quantities

Phase	Dredging quantity (m ³)
Phase 1	3,23,700
Phase 2	6,32,400
Phase 3	-
Total	9,56,100

6.7**Design criteria – Site preparation for master plan**

For the development of associated facilities, such as backup yards, scrap markets, physical infrastructure, and other ancillary components. The site requires substantial surface levelling to achieve the recommended finished levels. Similar to the earthworks undertaken for the ship recycling plots, Phase 1 involves higher cutting than filling, whereas Phases 2 and 3 require comparatively greater filling.

To minimize excessive filling requirements in Phases 2 and 3, the proposed ground slopes in these phases have been kept lower than those in Phase 1. The grading strategy has been aligned closely with the existing topography to reduce unnecessary cut-and-fill operations. Any elevation difference between Phase 1 and Phase 2 will be gradually adjusted along the length during the detailed design stage.

To estimating earthwork quantities, the overall site, excluding the ship recycling plots has been divided into two functional zones:

- Backup yard zone, extending 200 m in depth,
- Scrap market mone, comprising a total of 124 m (100 m market area with a 24 m wide road at the rear).

Table 6-18: Proposed elevations

Zone/ plot	Phase	Length (m)	Proposed slope	Elevation raised (m)	Final elevation (m)	Avg elevation (m)
	Phase 1				15.08	
Backup yard zone		200	1 in 65	3.08	18.15	16.62
Scrap yard zone		124	1 in 50	2.48	14.38	19.39
	Phase 2 & 3				14.38	
Backup yard zone		200	1 in 100	2.00	16.38	15.38
Scrap yard zone		124	1 in 100	1.24	17.62	17.00

The material generated from the cutting zones is proposed to be reutilized in the filling areas to the extent possible, reducing the need for sourcing. The areas marker under both zones have been provided in Annexure N.

A summary of the calculated earthwork quantities for ship recycling plots across phases is provided below, Detailed calculations are provided in Annexure L.

Table 6-19 Earthwork quantity summary table

Phase	Zone	Total Cutting Quantity (m ³)	Total Filling Quantity (m ³)
Phase 1	Backup yard zone	-11,69,917.12	1,27,419.28
	Scrap market zone	-4,99,209.06	92,029.16
Phase 2	Backup yard zone	-93,215.76	1,40,350.32
	Scrap market zone	-30,491.00	4,82,236.00
Phase 3	Backup yard zone	-70,733.60	38,39,539.32
	Scrap market zone	-	55,35,208.50

6.8 Design criteria – Utilities for master plan / infrastructure outside the plots

6.8.1 Water supply

6.8.1.1 Water storage reservoirs

Based on the water demand calculated and the existing water storage reservoirs, the storage requirements for underground and elevated water tanks at various locations have been determined. The proposed design includes both elevated tanks and underground reservoirs, each planned with a two-day storage capacity, phased across the master plan area. Of the total storage volume, approximately half is allocated to elevated tanks and half to underground reservoirs. Each water storage facility will be equipped with a dedicated pumping station

Table 6-20: Water storage proposals

Description	Phase 1	Phase 2	Phase 3	Units
Water supply demand	2.11	0.88	4.29	MLD
Storage required (2-day storage)	4.23	1.76	8.58	Million liters
Storage proposed	5	3	7	

Phase	Storage proposed (M liters)	Description	No. of tanks proposed	Capacity M Liters	Area required per tank (3 meters height)
Phase 1	5	Elevated	2	1.25	416
		UGWT	2	1.25	416
Phase 2	3	Elevated	1	1.5	500
		UGWT	1	1.5	500
Phase 3	7	Elevated	3	1	334
		UGWT	3	1 & 2	334 & 500

6.8.1.2 Quality of water supplied

The quality of water supplied by GWS&SB shall be as per IS 10500. No further treatment is deemed required.

6.8.1.3 Water distribution system

- Water for the expansion phases of Alang will be sourced from the Trapaj HGLR through the existing pipeline network currently connected to the Alang water storage tanks.
- Primary tapping point for the proposed phases shall be to the existing trunk pipeline (300 mm DI) running across the 10 km stretch at a suitable point.
- GMB pipeline will be utilised to fill the Underground Water Tanks (UGWTs) proposed across all phases of the development. In the event of a disruption or failure in the main GMB pipeline, backup borewell provisions have been planned at each UGWT location to ensure uninterrupted supply.
- Water stored in the UGWTs will be pumped to Elevated Water Tanks (EWTs) using dedicated pumping systems.
- From the elevated tanks, water will be distributed via gravity to the internal water supply network, ensuring a minimum pressure head of 7 metres at the consumer end.
- The internal network will supply water to individual plots, residential units, rolling mills, commercial establishments, and all other utility structures by feeding their respective UGWTs.
- All water supply operations will be regulated through a system of manually or automatically operated valves to ensure efficient control and distribution.
- Each individual connection shall be provided with a calibrated water meter, and water usage charges will be collected by GMB based on metered consumption.

6.8.1.4 Material

All distribution pipes shall be of DI class K9 pipe. Main Isolation valves shall be constructed from cast iron or ductile iron.

Other Important Considerations

- Kinetic air valves to be provided at suitable ridge points.
- Scour valves to be provided at suitable low points where natural drainage is available
- Minimum cover over the crown of pipes to be provided in traffic area.

6.8.2 Sewerage network

In order to comply, the disposal standards, provide pollution free environment at Alang, proper sewerage system must be opted. Decentralised STP's have been proposed over phases which will collect sewage generated from all the shipyards, residential and other facilities within Alang. No sewerage network is present at present in Alang.

Sewage network has been proposed in yard which will collect sewage from various locations. This sewage shall be pumped /carried to Sewage Treatment Plants proposed based on the estimated quantities.

Table 6-21: Sewerage demand estimation

	Water requirement (MLD)	Estimated sewage generation	Proposed STP (MLD)
Phase 1	2.1	1.7	2
Phase 2	0.9	0.7	1
Phase 3	4.3	3.4	3

6.8.2.1 Design criteria

The system shall be designed on the basis of standard criteria as stipulated in the “Manual for sewerage & Treatment “published by the Central Public Health & Environmental Engineering Organization (CPHEEO), NBC-2004, SP-35(S&T) -1987 and other proven National & International practices on the subject.

Design basis in brief shall be as follows:

- Estimated sewage Flow : 80 % of daily water demand.
- Peak flow : 3 times average flow
- Minimum pipe diameter : 150 mm to 230 mm
- Minimum velocity of flow : 0.6 m / sec
- Maximum velocity of flow : 3.0 m / sec
- Design flow conditions
- Pipes up to 400 mm diameter : Running half full
- Provision of drop manhole : At difference in Invert levels more than 600 mm

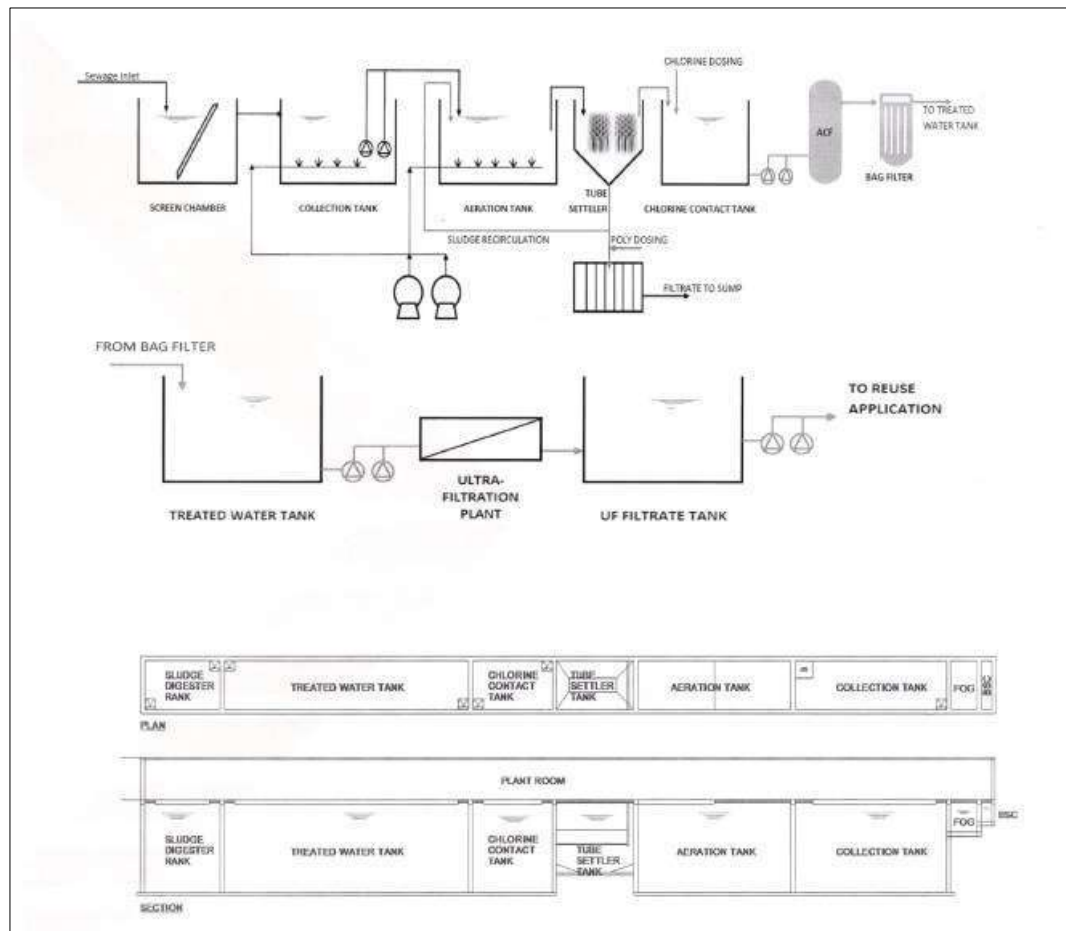
6.8.2.2 Drainage disposal network

All the main drain line shall be connected with manhole network. All the drainage lines should be connected to gully traps before connecting to manholes. Last manhole of ship recycling plots, housing units, hospital and other structure premises shall be sewer trap manhole to prevent foul smell and gasses from main network.

6.8.2.3 Sewerage treatment plant

The sewage, after screening will straight away enter the collection tank. After sufficient equalization, the sewage will enter the Moving bed biofilm reactor (MBBR) based Aeration tank, where the organics will be removed biologically. The entire effluent mixture will then pass through the secondary settling tank, and the supernatant from which, shall enter the filter feed tank. This treated effluent shall further pass through the tertiary treatment in the form of pressure sand filter and activated carbon filter and finally shall be disinfected by sodium hypochlorite dosing

The treated effluent shall be used for gardening purpose. Excess treated effluent shall be discharged into the proposed storm water drain.

Figure 6-10: Flow diagram of sewage treatment process**Table 6-22: Sewerage characteristics**

Characteristics	Inlet (Raw effluent)	Outlet (Treated sewage)
pH	6.5 – 7.5	6.0 – 8
BOD (mg/L)	< 300	< 10
TSS (mg/L)	< 100	< 20
COD (mg/L)	< 500	< 100
Oil & Grease (mg/l)	< 20	< 5

6.8.2.4 Material and Structural form**Sewer pipes**

Pipes installed in coastal areas where soil and groundwater contain high chloride content shall be constructed using low corrosive materials as double wall corrugated pipe.

Manholes

PE (Readymade- Prefabricated)/SFRC manholes are also available in market which can be a good alternative. These manholes prefabricated with complete benching enabling very fast installations even in waterlogged areas and a robust leak proof sewerage network with minimal maintenance could be possible.

Hydraulic design

Throughout the project, the Manning equation for closed conduits will be used to determine the velocity of the calculated flow and pipe sizes.

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where,

V - Velocity - m/s:

n – Roughness coefficient.

R – Hydraulic mean radius

S – Slope/ hydraulic gradient – invert slope of full pipe - 1m/200m

Pipe velocities

Minimum velocity is provided based on self-cleansing velocities/ and to prevent solids deposition in sewers and maximum velocity is provided to prevent the manhole corrosion, minimize sewer gases in sewer system and minimize the negative effects of abrasion on the drainage pipe and manholes. Normally minimum velocity in pipe should be 0.6 m/s for gravity flow.

Minimum cover to pipe top

In order to provide the protection from external loads, the minimum cover to the pipe top levels is to be adopted. Generally minimum cover to pipe top is 1 m from ground level

Maximum distance between manholes and chambers

The maximum distance between manholes/ chambers limited to allow jetting and video inspection of pipe network proposed at every junction, change of alignment/grade and change in diameter of the pipes. The spacing of manholes will be at 30 m intervals at straight stretches.

Manhole and inspection chambers

Suitable manholes / Inspection Chamber shall be provided to pipe sewage lines at every 30 m intervals, at junctions and at change of gradient, alignment and diameter of pipe and shall be of masonry or RCC construction. All manholes shall be designed considering maintenance, inspection and cleaning of pipes. Easy accessibility and safety shall also be given due consideration

- Details of manholes shall be as per IS: 4111(Part-I)
- MOC : CC Blocks / RCC
- Type : Rectangular for inspections chamber and circular for manholes

Pre-Cast concrete manhole covers & frames

- Pre-cast reinforced cement concrete manhole covers intended for use in sewerage and water works shall generally conform to IS 12592.
- The frames of manhole shall be firmly embedded to correct alignment and level in RCC slab or plain concrete on the top of masonry which shall be paid as extra unless specified otherwise.

6.8.3 Electricity

Electricity to Alang is supplied through substation located in Manar of capacity 66 kv operated by Gujarat Energy Transmission Corporation Limited (GETCO). This substation is connected to many transformers of capacity ranging from 10 KVA to 100 KVA across Alang of overhead cable network. The demand calculations mentioned in section 0.

6.8.3.1 Codes and standards

The system will be designed to the latest editions of the applicable codes and standards of the following institutions will be used as guidelines in the design of electrical systems and equipment.

1. Indian Electricity Rules (IE)
2. Bureau of Indian Standard (BIS)
3. NEC Regulations
4. Energy Conservation Building Codes (ECBC)
5. National Building Code (NBC) – 2016
6. Local Authority Regulations

6.8.3.2 Source of power supply

The principal source of electrical power will be the PGVCL Power. The incoming supply for the project shall be received at 11 kV HT Line. The HT supply shall be provided by PGVCL to all the CSS proposed through HT lines,

Nominal voltage	Phase	Configuration
HT Supply from Supply Company – 11kV	Three	Three Wire
LT Distribution – 433V or 415V	Three	Four Wire + Earth
Single Phase Distribution – 230V	Three	Two Wire + Earth

6.8.3.3 Distribution system

The 433V, 3-phase + Neutral, 50Hz LT power supply from the transformers shall be routed to the main distribution feeder pillars. From these feeder pillars, power will be distributed to the meter rooms of each block, with all necessary protection and control mechanisms in place.

LT power will be transmitted using XLPE-insulated underground cables to the LT feeder pillars, which will in turn feed the respective meter rooms. Each meter room shall be equipped with MCBs/MCCBs and individual energy meters for accurate monitoring.

Power from the meter rooms will be supplied to individual units via designated vertical electrical shafts. The main conduits serving each unit will be laid along cable trays at the

ground floor ceiling level, extending from the vertical shafts to the meter points located at beam bottom level.

Essential common services and amenities, such as the pump house, external lighting, borewells, elevators, and health centre—will be connected through separate LT metering arrangements to ensure independent control and billing.

6.8.3.4 Wiring and distribution system

The wiring system shall consist of PVC insulated FRLS copper conductor in PVC conduits. Colour code shall be maintained for the entire wiring installation i.e. Red, Yellow and Blue for three phases, Black for the Neutral and Green for earthing.

For all internal distribution networks for lighting PPI / ETPN / VTPN and SPN type distribution boards will be used depending upon the load having IP 42/43/54 protection and metal double door as required at site. For all indoor applications we recommend IP 43 type DB; and for all out-door application we recommend IP 54 type DB with additional covering arrangement so that any unauthorized personnel cannot touch DB. The DB will have MCB / ELCB configuration as under.

- SP MCBs for individual lighting/power circuits.
- SP/DP MCBs for AC/Geyser type heavy electrical appliances.
- DP ELCB/ELMCB for per phase earth fault protection.
- DP/FP MCBs for incomer of all single/three phase distribution board.

6.8.3.5 Earthing

• Substation & Meter room

Separate Earthing system shall be provided for substation equipment like HT Breaker, Transformer, DG sets, LT feeder pillars, Meter rooms etc. LT distribution system earthing through local earth stations with effectively bonding the equipment.

• ELV Services

The ELV services like data telephone & related equipment shall be connected to separate dedicated earth electrode by copper strip/conductor.

6.8.3.6 ELV (Extra Low Voltage) services

- Video Surveillance
- Telephone Connectivity
- TV connectivity.

The final configuration of system can be frozen in design development stage.

6.8.3.7 Tariff system

All the facilities and recycling plots will have separate metering, and the power supply authority will issue bill to individual plot owner.

6.8.4 Storm water drainage

Stormwater management is a critical component of sustainable infrastructure planning, particularly for industrial areas like the Alang Ship Recycling Park. Effective drainage is essential to prevent waterlogging, maintain operational safety, and protect both infrastructure and the environment. With the entire development spanning approximately **9.84 km²** (excluding ship recycling plots), stormwater design must consider existing land use, future land cover, rainfall patterns, and topography.

6.8.4.1 Existing sewerage system

Storm water drainage pipeline is provided along the main road of the Alang ship recycling yard with a length of 9660 meters. The main pipe is of dia. 450 mm, with cross drainage into the sea.

6.8.4.2 Terrain and natural drainage pattern

Alang being a coastal area, the steep incline towards ocean makes storm water entering the plot. Planning storm water network throughout the area along both side of the road network as well as recharge pits within all the building premises will help address this issue.

6.8.4.3 Stormwater runoff estimation

Methodology

The Rational Method is adopted for preliminary peak runoff estimation. This method is widely used for small to medium urban catchments

The equation is:

$$Q = \frac{C * I * A}{360}$$

Where,

Q = Peak discharge (m³/s)

C = Runoff coefficient

I = Rainfall intensity (mm/hr)

A = Drainage area (ha)

Only the area within the master plan area is considered as our drainage area in this calculation is assuming that the outer ring road parallel to master plan boundary proposed by AADA development plan will be designed to take care of the runoff collection beyond the master plan boundary.

Rainfall intensity

Design rainfall intensity for the storm water drains is considered as 50 mm/hr.

Runoff coefficients

Based on the proposed land use in the master plan, the runoff coefficients have been considered accordingly.

Table 6-23: Runoff coefficient as per the proposed land use

Land Use Category	Area (ha)	Runoff Coefficient (C) considered	Rationale
Industrial A / Recycling plots	334.12	0.9	Heavily paved, industrial nature
Mixed Industrial Use (IZ7)	42.73	0.6	Medium-density housing
Industrial B (IZ6)	367.62	0.7	Paved sheds, rest unpaved
Agriculture	66.1	0.3	Natural pervious surface
Green Buffer/Restricted	88.07	0.25	Vegetated or restricted use
Roads	85.38	0.9	Heavily paved

Runoff calculations**Table 6-24: Runoff calculations**

Land Use Category	Runoff Coefficient I	Rainfall intensity	Area (ha)	Runoff (m ³ /sec)
Industrial A / Recycling plots	0.9	50	334.12	41.77
Mixed Industrial Use (IZ7)	0.6	50	42.73	3.56
Industrial B (IZ6)	0.7	50	367.62	35.74
Agriculture	0.3	50	66.1	2.75
Green Buffer/Restricted	0.25	50	88.07	3.06
Roads	0.9	50	85.38	10.67

Total Runoff: 97.55 m³/sec

Multiple outlets have been proposed to decongest the stormwater network. And detailed pipe network design shall be carried out in detailed design stages based on detailed runoff calculations.

6.8.4.4 Stormwater management strategy

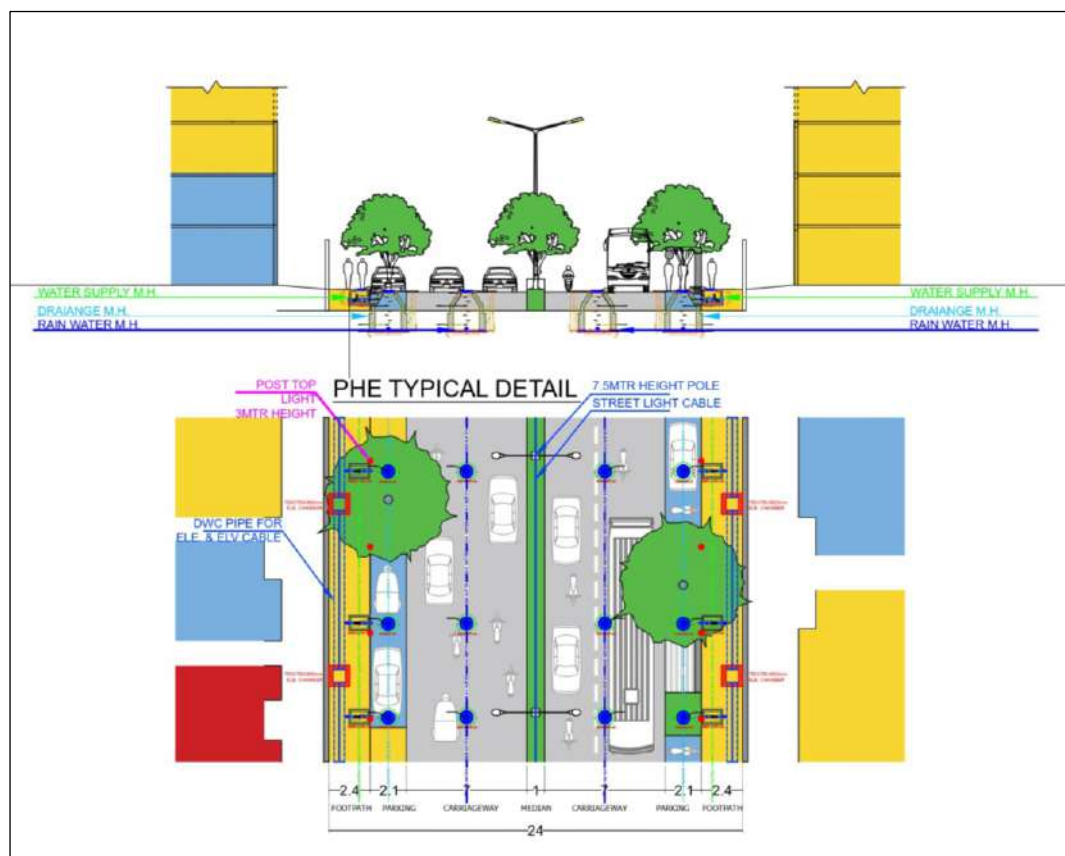
The stormwater disposal strategy for the project premises is designed to ensure efficient drainage, minimise flooding, and support sustainable practices.

Key components of the proposed approach include:

- **Zoning of catchments:** The site shall be divided into 5–6 sub-catchments based on natural ground slope, road alignment, and land use patterns to effectively route and manage stormwater runoff.
- **Drainage network layout:** Main trunk stormwater lines shall be aligned along major road corridors, with secondary drains provided along internal roads for efficient collection and conveyance.
- **Gravity flow design:** The stormwater network shall be designed to discharge at the lowest point of the site to enable gravity flow and eliminate the risk of waterlogging.

- **Terrace rainwater management:** Rainwater from terraces of buildings within the ship recycling plots, commercial buildings, residential units, and hospital structures shall be collected through down-take pipes and directed to ground-level drainage points.
- **Ground-level collection and filtration:** Rainwater from down-take pipes will be conveyed through the surface drainage network, routed towards rainwater tanks for preliminary filtration and collection.
- **Final disposal:** Treated rainwater from the entire premises shall be pumped to the main stormwater network along the adjoining main road for final disposal into the sea.
- **Pollution control in ship recycling plots:** Given the potential for toxic or hazardous runoff from ship recycling plots, adequate pre-treatment measures shall be implemented before stormwater is discharged to prevent marine pollution.
- **Maintenance measures:**
 - Desilting of drains shall be undertaken before and after each monsoon season.
 - Regular inspection and maintenance of all stormwater drainage structures is essential for long-term functionality.
- **Rainwater harvesting:** Provision of rainwater harvesting systems shall be mandatory for all public buildings and private plots with an area exceeding 500 m², in alignment with sustainability guidelines.

Figure 6-11: Road cross-section showing utility lines



6.8.5 Contaminated oily water transfer & SCADA system

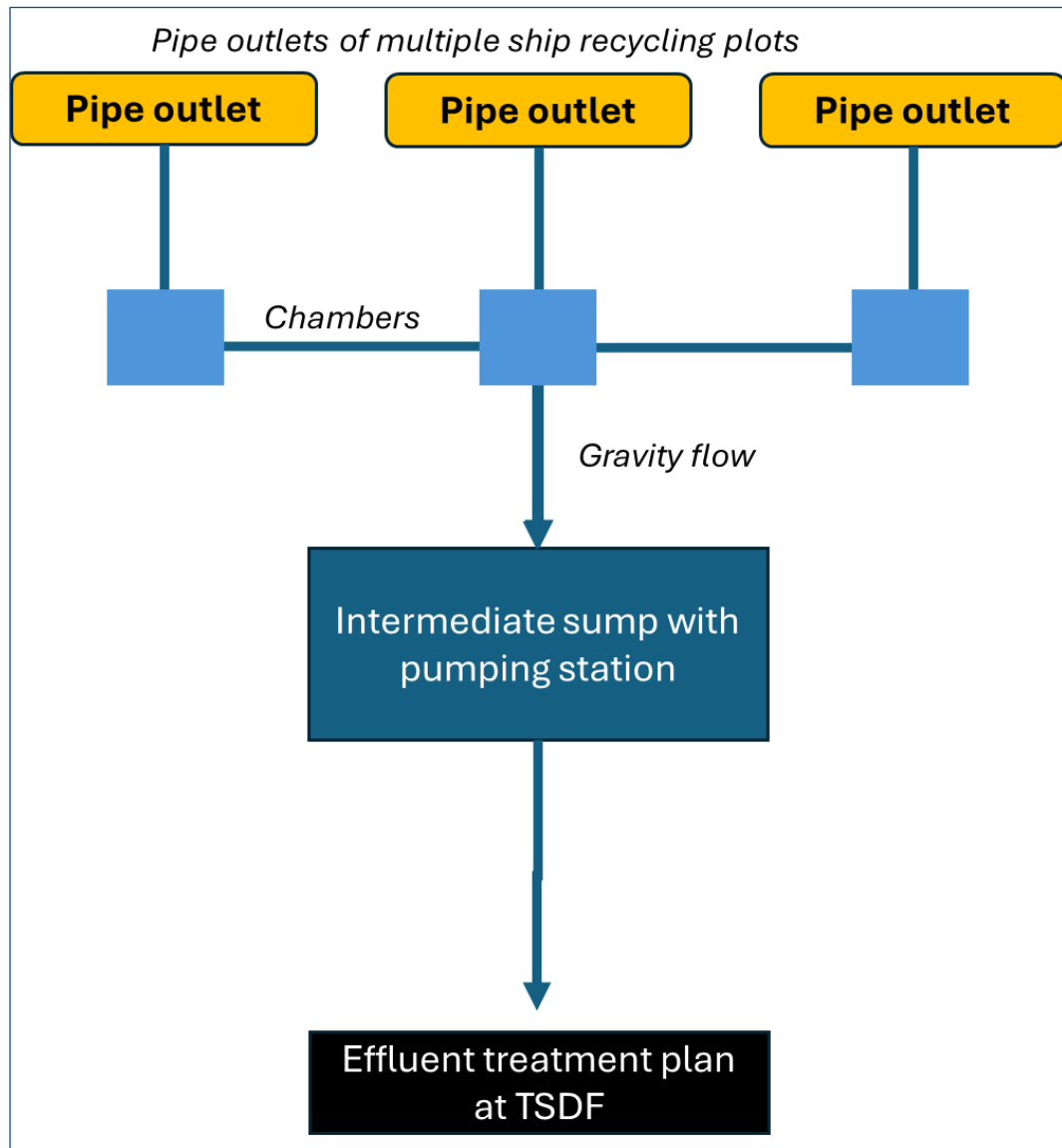
To avoid transfer of contaminated oily water to CETP through tankers as it is currently practised, an underground pipeline connecting all the plot contaminated oily water outlets have been proposed with intermediate sumps and pumping stations.

All plots are connected through a central buried HDPE network which conveys the oily/contaminated water to intermediate sumps using gravity flow. Each sump is equipped with pumping stations that discharge the fluid through rising mains to the Central Effluent Treatment Plant (CETP) located at the TSDF. This network will be developed in three phases, each with its own sump and dedicated rising main.

6.8.5.1 *Transfer network*

All the pipe outlet chambers are connected to a chamber outside the plot, and all the chambers are connected through pipe network transferring contaminated water to nearest intermediate sumps through gravity. Plot owners to send contaminated water sample discharge into the transfer network for record of outlet parameters. And each plot will have a meter to read the quantity discharged to help authority levy charges.

The contaminated water collected in the intermediate sumps are then pumped out into CETP through pumping stations.



6.8.5.2 Design basis and assumptions

The design basis reflects typical conditions for oily and contaminated water handling in marine recycling environments. Key design considerations include HDPE buried pipelines, gravity flow from plots to sumps, and pumped discharge to the CETP. The system assumes moderate hydrocarbon contamination levels with Zone 2 hazardous classification near sumps. Dedicated power and 4G/LTE connectivity will be available at all sump locations.

To determine the size of the intermediate sumps, a few key assumptions were considered. Each sump is planned to serve approximately 6–9 plots, depending on the phasing and operational requirements. The proposed sizing for the four intermediate sumps is based on the ability of each sump to accommodate and pump a volume equivalent to the total expected wash water, 30% of the total first-flush water, and 50% of the oily-water quantity generated from its connected plots. This design capacity is intentionally higher than 50% of the peak first-flush volume.

Given the large plot dimensions of 240 × 215 m and 300 × 215 m, the first-flush volumes are significantly high, and constructing sumps sized for peak monsoon flows would not be an efficient or practical solution. Instead, the intermediate sumps are designed to buffer

and store excess volumes when the CETP is operating at maximum load, and during non-monsoon periods they help maintain consistent hydraulic pressure and stable transfer to the treatment system.

To estimate the expected wash-water quantities, a rate of 2 L/m² has been considered for partial washing, which is assumed to take place twice a week. In addition, a thorough wash using 10 L/m² is expected once a week. These assumptions have been applied to the plot areas to derive the total weekly wash-water generation. A total of 120 m³ is expected from a plot per day during non-monsoon period. and for a 20 mins retention period, an average of 840 m³ is considered for first flush.

Average plot area (m ²)	Quantity of water for partial wash per week (m ³)	Quantity of water for thorough wash per week (m ³)	Average wash water per day (m ³)
60,000	240	540	111.43

Considering pumphouse works at least 10 hrs, the proposed sump capacities have been proposed accordingly.

Table 6-25: Total quantity to pump by each sump

Intermediate Sump / Phase	No. of Plots	Total Daily Wash quantity (m ³ /day)	30% First Flush Volume (m ³)	50 % of oily water volume	Total quantity to pump (m ³ /day)	Proposed tank size (m ³)
Sump-1 (Phase 1)	9	1008	2268	787.5	4063.5	1,200
Sump-2 (Phase 2)	6	672	1512	525	2709.0	800
Sump-3 (Phase 3)	8	896	2016	700	3612.0	1,00
Sump-4 (Phase 3)	9	1008	2268	787.5	4063.5	1,200

Reference codes and standards

The system shall be designed on the basis of standard criteria as stipulated in the Manual for sewerage & Treatment published by the Central Public Health & CPCB / GPCB discharge/handling guidelines, NBC-2004, SP-35 (S&T) -1987 and other proven National & International practices on the subject.

Parameter	Basis / Assumption
Pipe material	HDPE PE100 (buried)
Flow regime	Gravity from plots to intermediate sump; pumped to CETP
Fluid characteristics	Oily/contaminated water with hydrocarbons & suspended solids
Hazard classification	Likely Zone 2 (oil vapours near sumps), Ex-proof instrumentation
Power supply	Dedicated feed at each sump
Communication	4G/LTE private APN; FO backbone optional
Monitoring points	Each yard outlet, each sump, and CETP inlet
OiW analyser	At CETP inlet only

6.8.5.3 Effluent treatment plant

The effluent treatment plant shall use relevant technology to treat the incoming effluent to the standards of latest CPCB discharge guidelines. As it is expected that the effluent will have oil and grease content, ETP shall have oil and grease filters.

Table 6-26: Effluent characteristics

Characteristics	Inlet (Effluent at CETP)
pH	6.5 – 7.5
BOD (mg/L)	500 - 1500
TSS (mg/L)	< 200
COD (mg/L)	1000-3000
Oil & Grease (mg/l)	> 50

6.8.5.4 Material and structural form**Transfer pipes**

HDPE (PE-100) pipes shall be used for the contaminated-water transfer system because they provide a fully leak-proof, corrosion-free conveyance suitable for effluents containing oil, grease and suspended solids. HDPE's excellent chemical resistance ensures that the wastewater characteristics expected from ship-recycling plots do not degrade the pipeline over time. The pipes are joined by butt-fusion, creating a single continuous line without joints that could leak or fail underground movement. Their flexibility and high impact resistance make them ideal for underground installation in industrial yards with heavy vehicular activity. HDPE also offers a smooth internal surface, reducing headloss and helping maintain self-cleaning flow velocities.

Manholes

PE (Readymade- Prefabricated)/SFRC manholes are also available in market which can be a good alternative. These manholes prefabricated with complete benching enabling very fast installations even in waterlogged areas and a robust leak proof sewerage network with minimal maintenance could be possible.

Hydraulic design

Pipe network between plots and intermediate sumps, the Manning equation for closed conduits will be used to determine the velocity of the calculated flow and pipe sizes.

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where,

V - Velocity - m/s:

n – Roughness coefficient.

R – Hydraulic mean radius

S – Slope/ hydraulic gradient – invert slope of full pipe - 1m/200m

Pipe velocities

Minimum velocity is provided based on self-cleansing velocities/ and to prevent solids deposition in sewers and maximum velocity is provided to prevent the manhole corrosion, minimize sewer gases in sewer system and minimize the negative effects of abrasion on the drainage pipe and manholes. Normally minimum velocity in pipe should be 0.6 m/s for gravity flow.

Minimum cover to pipe top

In order to provide the protection from external loads, the minimum cover to the pipe top levels is to be adopted. Generally minimum cover to pipe top is 1 m from ground level.

6.8.5.5 SCADA system

The Leak Detection and SCADA system aims to create a centralized, automated, and intelligent monitoring framework capable of ensuring continuous surveillance and incident response.

Primary objectives

- Early detection and localization of leaks/overflows of contaminated and oily water along laterals, branch mains, and trunk lines.
- Continuous visibility of flows, levels, pump status, oil-in-water (OiW) alarms, and sump capacities across the network.
- Event/alarm handling, audit trail, and reporting to meet regulatory and ESG obligations (spill prevention, response time, data retention).

Success criteria

- Leak detection sensitivity aligned to pipe size and service (target detection of $\geq 1-2\%$ imbalance at DMA/branch level; point leaks via sensing cable on critical trunk stretches).
- Alarm to operator latency ≤ 2 minutes for SCADA events; ≤ 30 seconds for critical sump/pump trips.
- System availability $\geq 99\%$ (excluding utility power outages beyond design backup window).
- Compliance with hazardous area and cyber-security norms applicable to the installation.

Proposed system architecture

Each yard outlet and sump will be fitted with a full-bore electromagnetic flow meter and pressure transmitter. Level transmitters will monitor sump capacity with high-high and pump interlocks. Hydrocarbon sensing cables will be installed along critical trunk lines to detect leakage or pipe failure. Gas detectors (H_2S , LEL) will ensure safety in confined spaces.

The central SCADA located at the CETP will consolidate data from all field RTUs, providing real-time visualization, alarm handling, historical trending, and report generation. Communication between field RTUs and central SCADA will use private LTE/4G APN with VPN encryption.

Each sump station and yard monitoring node would have an RTU/PLC panel — effectively the “field brain” that connects the instruments to the central SCADA at CETP. An RTU is a field control and communication device that:

- Interfaces with sensors (flow, pressure, level, leak-detection cables, etc.) and actuators (valves, pumps).
- Collects analog and digital data, converts it into standard communication protocols (like Modbus, IEC-104, DNP3), and transmits it to the central SCADA server.
- Executes limited local control or logic (like pump start/stop, alarm interlocks) even if communication with SCADA is temporarily lost.

The instrumentation and control design philosophy aims for standardization, modularity, and maintainability across all three phases. Each node (yard outlet or sump) will house a standardized RTU/PLC panel serving as the local data acquisition and control interface.

- **Field Instruments:** Flow, level, and pressure sensors shall be of industrial grade, IP68-rated, with wetted parts in SS316 or compatible non-corrosive materials.
- **Control Logic:** Each sump RTU will autonomously manage pump start/stop and high-level shutdown interlocks to ensure continued safe operation even during temporary communication outages.
- **Redundancy:** Each sump RTU shall be equipped with dual SIM LTE modems, and optionally, a fiber optic link for redundancy to ensure 99% communication uptime.
- **Data Reporting:** Measurement data shall be time-stamped and archived at 15-second scan intervals, with 10-minute aggregation cycles for daily and monthly reports.
- **Integration:** All field RTUs will communicate via IEC 60870-5-104 or Modbus TCP/IP protocols to the central SCADA historian. The historian will generate automated compliance reports for GPCB/CPCB submission, covering alarms, pump run-hours, sump overflows, and leak incidents.

The control system will also maintain an event-driven alarm hierarchy to prioritize responses and ensure quick operator intervention for critical conditions such as pump trip, leak cable activation, or gas alarm events.

Leak detection strategy

A multi-layered approach is proposed. The leak detection philosophy combines flow mass-balance analysis with direct sensing technologies:

- Hydraulic & mass-balance monitoring (primary)
 - Create District Monitoring Areas (DMAs) at branch level (10–30 yards per DMA). Measure inlet branch flow and trunk outflow to compute imbalance.
 - Night/low-flow windows used to accentuate signal; generate alarms if sustained imbalance > threshold.
 - Instruments: Magnetic flow meters (full-bore for trunk/branch; insertion type where practical), pressure/level sensors at key high points/sumps.
- Point / line leak detection (secondary, risk-based)

- Hydrocarbon-sensing leak detection cable in a small monitoring conduit within double-contained pipe segments along critical trunk stretches (roads, waterbodies, near habitations). Provides addressable leak location (zone-based, typically ± 5 –25 m depending on controller & layout).
- Sump over-flow & bypass detection at yards (level high-high, pump run-dry, unauthorized bypass via event logging and seal-in alarms).
- CCTV at central sump & critical junction chambers for incident verification.
- Quality/contamination sentinel nodes
 - Online oil-in-water (OiW) at the centralized collection sump (mandatory) and select upstream branches (sentinel nodes) to detect carry-over from yards; supports compliance & incident back-tracing.

The leak detection framework integrates hydraulic imbalance monitoring and direct hydrocarbon contact detection to cover both gradual and instantaneous failures.

In addition to the sensing philosophy described, the following operational measures are recommended:

- **High-risk segments:** Continuous sensing cables shall be installed along all double-contained HDPE stretches, road crossings, and within 50 m of each sump or populated corridor.
- **Zoning & addressing:** The leak cable network will be divided into addressable zones (typically 250–500 m), allowing location pinpointing with ± 5 –25 m accuracy.
- **Alarm verification:** Leak detection alarms shall be automatically correlated with pressure transients and flow deviations to reduce false positives caused by transient flow conditions.
- **Verification & calibration:** The O&M team shall perform semi-annual leak simulation tests using calibrated hydrocarbon samples to verify sensor performance.
- **Integration with SCADA:** All leak events will be time-stamped, logged, and displayed on GIS-linked SCADA graphics, highlighting the affected zone and guiding maintenance crews to the probable leak location.

This multi-tiered strategy ensures early warning for both slow seeps and sudden ruptures, while maintaining operational practicality for field maintenance teams.

Safety & regulatory compliance

Safety, environmental compliance, and cyber integrity form the backbone of the SCADA and leak detection system design.

- **Hazardous area classification:** A formal study shall confirm Zone 2 classification around all sumps and OWS units. Equipment installed in these zones shall comply with IS/IEC 60079 (Ex-d / Ex-ia protection).
- **Alarm standardization:** Alarm colour coding, prioritization, and annunciation will follow IS 15325:2003 (Industrial Alarm Systems). Critical alarms (red) shall trigger audible-visual alerts and SMS/email notifications.

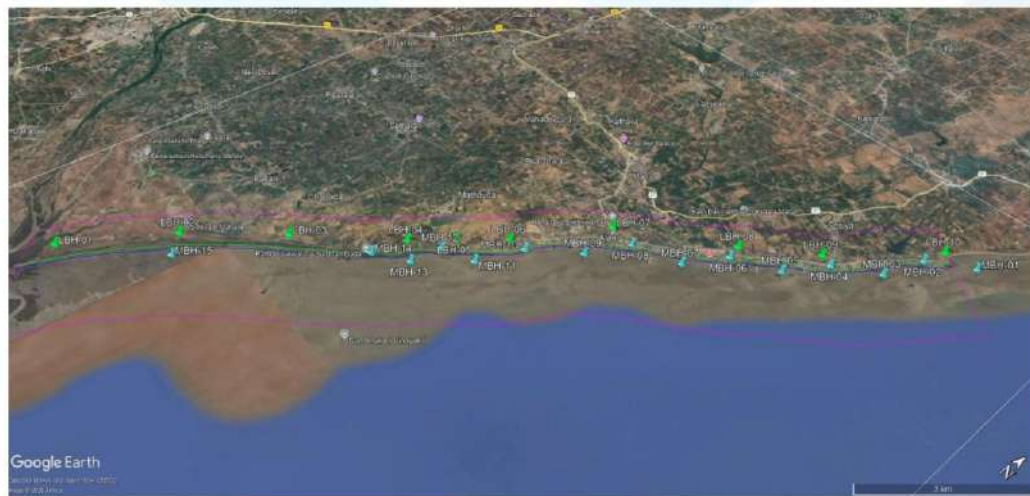
- **Cybersecurity:** The SCADA system shall include network segmentation, firewall protection, VPN encryption, and annual third-party cybersecurity audits as per ISO/IEC 27001 practices.
- **Material compatibility:** All wetted components (sensors, valves, fittings) shall use SS316 or FRP-coated materials suitable for hydrocarbon service.
- **Operational safety:** Gas detectors (LEL, H₂S) shall be provided at each sump, with automatic alarm and ventilation interlocks.
- **Regulatory reporting:** The historian will auto-generate daily and monthly discharge monitoring reports conforming to CPCB/GPCB templates, including flow volumes, OiW concentration trends, and incident logs.

6.9 Preliminary geotechnical investigation

The geotechnical investigation at various locations have been conducted and the following report is available, “Final Geotechnical Investigation Report for Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard, Gujarat, Document No. IDEAL-117-024 Geotechnical Report_GMB_BMT_Alang Rev.01 by Ideal Geoservices Pvt. Ltd., dated 28/4/2025.”

The locations of test bores are shown in figure below:

Figure 6-12: Google image showing locations of test points



The summary of various test bores considered is given in Table 6-27 and Table 6-28

Table 6-27 Land borehole details

Sr. No.	B.H. No	Borehole Location Coordinate (UTM WGS 84)		EGL wrt CD (m)	Termination Level of BH wrt CD (m)
		Easting (m)	Northing (m)		
1	LBH-01	200270	2359274	-12.50	-2.50
2	LBH-02	201605	2361451	-9.90	0.10
3	LBH-03	203150	2363238	-21.50	-11.50
4	LBH-04	204889	2365093	-17.10	-7.10
5	LBH-05	205526	2365900	-16.80	-6.80
6	LBH-06	206252	2366784	-20.00	-10.00
7	LBH-07	207347	2368732	-15.90	-5.90
8	LBH-08	209464	2370357	-12.50	-2.50
9	LBH-09	210733	2371519	-22.20	-12.20
10	LBH-10	212306	2373563	-16.50	-6.50

Table 6-28 Marine borehole details

Sr. No.	B.H. No	Borehole Location Coordinate (UTM WGS 84)		SBL wrt CD (m)	TD of BH wrt CD (m)
		Easting (m)	Northing (m)		
1	MBH-01	213004	2373652	-1.7	8.8
2	MBH-02	212173	2373015	-2.3	7.9
3	MBH-03	211872	2372030	-0.1	10.1
4	MBH-04	211038	2371410	-1.4	8.7
5	MBH-05	210500	2370499	-0.3	9.7
6	MBH-06	209555	2369990	-2.6	7.4
7	MBH-07	209050	2369078	-1.1	8.9
8	MBH-08	207994	2368677	-1.9	8.1
9	MBH-09	207560	2367722	-1.0	9.0
10	MBH-10	206673	2366846	-0.9	9.1
11	MBH-11	206295	2365825	-1.1	8.9
12	MBH-12	205538	2365522	-1.8	8.2
13	MBH-13	205456	2364798	-0.7	9.3
14	MBH-14	204711	2364307	-2.4	7.6
15	MBH-15	202132	2361048	-1.5	8.5

Based on the bore hole investigations, the design geotechnical parameters based on available data are given in Table 6-29 and Table 6-30.

Table 6-29 Geotechnical parameters for land boreholes

Layer No	Description	Extent of layer (m CD)		Thickness of layer (m)	Field Value N- (Blows)	Unit Weight (gms/cm ³)	Cu (kg/cm ²)	Φ (degree)	Coeff. of Volume Change -mv (cm ² /kg)	Modulus of Elasticity-E (kg/cm ²)	Poisson's Ratio m
		Top level	Bottom level								
1	Medium brown sand	+22.2 to +9.9	+20.7 to +5.0	0 to 10	18	1.8	0	32	-	180	0.35
2	Firm to stiff greyish clayey silt	+20.7 to +5.0	+20.0 to +2.5	0 to 4.5	7	1.8	0.3	0	0.016	74	0.5
3	Medium to dense silty sand	+20.0 to +2.5	+18.5 to +2.5	0 to 4.5	27	1.9	0	34	-	408	0.35
4	Very stiff to hard clayey silt	+18.5 to +2.5	+15.6 to -0.10	0 to 7.3	27	1.9	1.1	0	0.0041	270	0.5
5	Highly weathered to completely weathered rock/ Conglomerate, cemented layer	+15.6 to -0.10	+10 to -0.10	0 to 8.5	100	2.1	7.0	0	-	1500	0.3

Notes:

- The existing ground level is highly variable and along with highly variable strata. The recommended geotechnical parameters are based on generalised sub soil profile. While designing the foundations/pavements the design geotechnical parameters should be correlated with nearest test bore.
- The shear test results and consolidation test data is not available in the report. The recommended design geotechnical parameters are based on empirical correlation with Standard Penetration Test SPT N-values as per IS 6403, IS 2911 P1/S2 and CIRIA 143.

Table 6-30 Geotechnical parameters for marine boreholes

Layer No	Description	Extent of layer (m CD)		Thickness of layer (m)	Field N-Value (Blows)	Unit Weight (gms/cm ³)	Cu (kg/cm ²)	φ (degree)	Coeff. of Volume Change -mv (cm ² /kg)	Modulus of Elasticity-E (kg/cm ²)	Poisson's Ratio μ
		Top level	Bottom level								
1	Stiff to very stiff greyish clayey silt with lenses of cemented layer/ completely weathered rock	+2.6 to +0.1	+0.8 to -4.4	1.5 to 4.5	16	1.8	0.7	0	0.0070	158	0.5
2	Medium to dense sand	+0.8 to -4.4	-1.9 to -9.3	0 to 8.5	25	1.9	0	33	-	369	0.35
3	Stiff to hard clayey silt	-1.9 to -9.3	-2.7 to -9.3	0 to 4.6	17	1.9	0.7	0	0.0064	173	0.5
4	Highly weathered to completely weathered rock/ Conglomerate, cemented layer	-2.7 to -9.3	-7.4 to -9.7	0.9 to 5.7	100	2.1	7.0	0	-	1500	0.3
5	Very stiff to hard clayey silt	-7.4 to -9.7	-7.9 to -8.8	0 to 0.5	18	1.9	0.8	0	-	180	0.5

Notes:

- The existing ground level is highly variable and along with highly variable strata. The recommended geotechnical parameters are based on generalised sub soil profile. While designing the foundations/pavements the design geotechnical parameters should be correlated with nearest test bore.
- The shear test results and consolidation test data is not available in the report. The recommended design geotechnical parameters are based on empirical correlation with Standard Penetration Test SPT N-values as per IS 6403, IS 2911 P1/S2 and CIRIA 143.

6.9.1

Geotechnical design

Open foundations or pile foundations can be provided based on foundation pressures and permissible settlements. The recommended geotechnical parameters given in Table 6-29 and Table 6-30 are for guideline. The foundations and pavements should be design considering extent of various layers as per nearest test bores. Refer Annexure M also for the geotechnical parameters.

7

7.1

Phasing and Development Strategies

Yard capacity planning and phased transition

To enable the Alang Ship Recycling yard to achieve its target capacity and productivity levels, a range of critical enablers must be in place. These factors collectively support sustained operations, high throughput, regulatory compliance, and long-term viability of the yard. The key conditions are outlined below:

- **Steady supply of ships**
 - Consistent inflow of end-of-life ships, particularly large tankers, bulk carriers, and container vessels.
 - Global regulations and market trends that encourage ship scrapping, such as high steel prices and stricter environmental norms.
- **Favourable steel market**
 - Strong global and domestic demand for scrap steel.
 - Healthy demand in the Indian market for recycled steel derived from shipbreaking activities.
 - Limited competition from cheaper imported steel that could undercut domestic demand.
- **Efficient labour and workforce management**
 - Availability of a trained workforce skilled in cutting, dismantling, segregation, and safety procedures.
 - Maintenance of safe and productive working conditions to minimize incidents and ensure operational continuity.
 - Introduction of mechanization and automation, such as cranes for heavy lifting and digital systems for tracking.
- **Regulatory and environmental compliance**
 - Full adherence to international conventions such as the Hong Kong Convention (HKC) and EU Ship Recycling Regulation (EU SRR) to attract business from global ship owners.
 - Supportive government policies that facilitate recycling operations rather than over-regulate them.
 - Efficient systems for hazardous waste management to avoid compliance delays and penalties.
- **Infrastructure and technology upgrades**
 - Modern and well-maintained working platforms, cranes, and cutting equipment.
 - Facility upgrades to meet international safety and environmental standards.
 - Use of safer, modern technologies to reduce risk (e.g., explosion-proof tools, fire suppression systems).
- **Favourable weather conditions**
 - Predominantly dry and stable weather for uninterrupted outdoor operations.

- Predictable tidal and coastal conditions to facilitate smooth ship beaching and recycling processes.
- **Efficient logistics and material handling**
 - Reliable systems for quick transport of scrap steel to rolling mills and foundries.
 - Effective segregation and recycling of non-ferrous metals, machinery, and electronic components.
 - Robust market access for reusable materials, including furniture, spares, and electronics.
- **Competitive acquisition of scrap ships**
 - The ability to secure vessels competitively, ahead of other global recycling hubs such as Bangladesh, Pakistan, and Turkey.
 - Favourable currency exchange rates to support cost-effective ship imports.
- **Supportive government policies**
 - Low import duties and simplified taxation on incoming scrap vessels.
 - Streamlined procedures for ship acquisition and clearances.
 - Provision of financial incentives for environmentally friendly and compliant ship recycling practices.

If these conditions are aligned, Alang yard can operate at maximum productivity, achieving high throughput, profitability, and environmental sustainability.

7.2

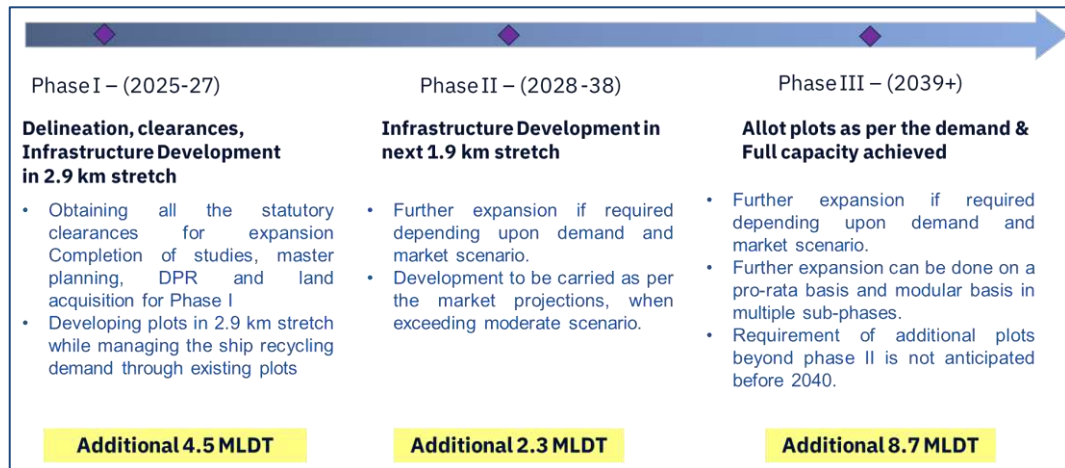
Phased development and implementation strategy

The successful implementation of the land use and zoning plan for the Alang ship recycling and expansion area requires a comprehensive and phased strategy. This includes:

- Alignment with national and international regulatory frameworks
- Investment in infrastructure development
- Active stakeholder engagement, including local authorities, yard owners, and labour representatives
- Monitoring mechanisms for environmental compliance, land use efficiency, and social development indicators

The implementation strategy aims to ensure that the proposed development is sustainable, aligns with the community's long-term goals, and effectively addresses key challenges such as environmental protection, optimal land utilization, and quality of life for workers and nearby communities.

An overview of the proposed implementation phasing strategy is illustrated in the figure below.

Figure 7-1: Expansion plan**Initial stakeholder discussion feedback**

Phasing strategy: Over discussions on the phasing strategy, GMB has advised to take care of accelerated scenario. To develop infrastructure in a timely phasing, phase 1 takes care of GMB's vision to double the capacity (9 MLDT). And the next phase fulfils the capacity of the yard in hand with the projected accelerated scenario (11.3 MLDT), Which can be implemented once the market exceeds the max capacity of the yard. And Phase 3 can be implemented only after accessing the global and regional recycling market as per the requirement.

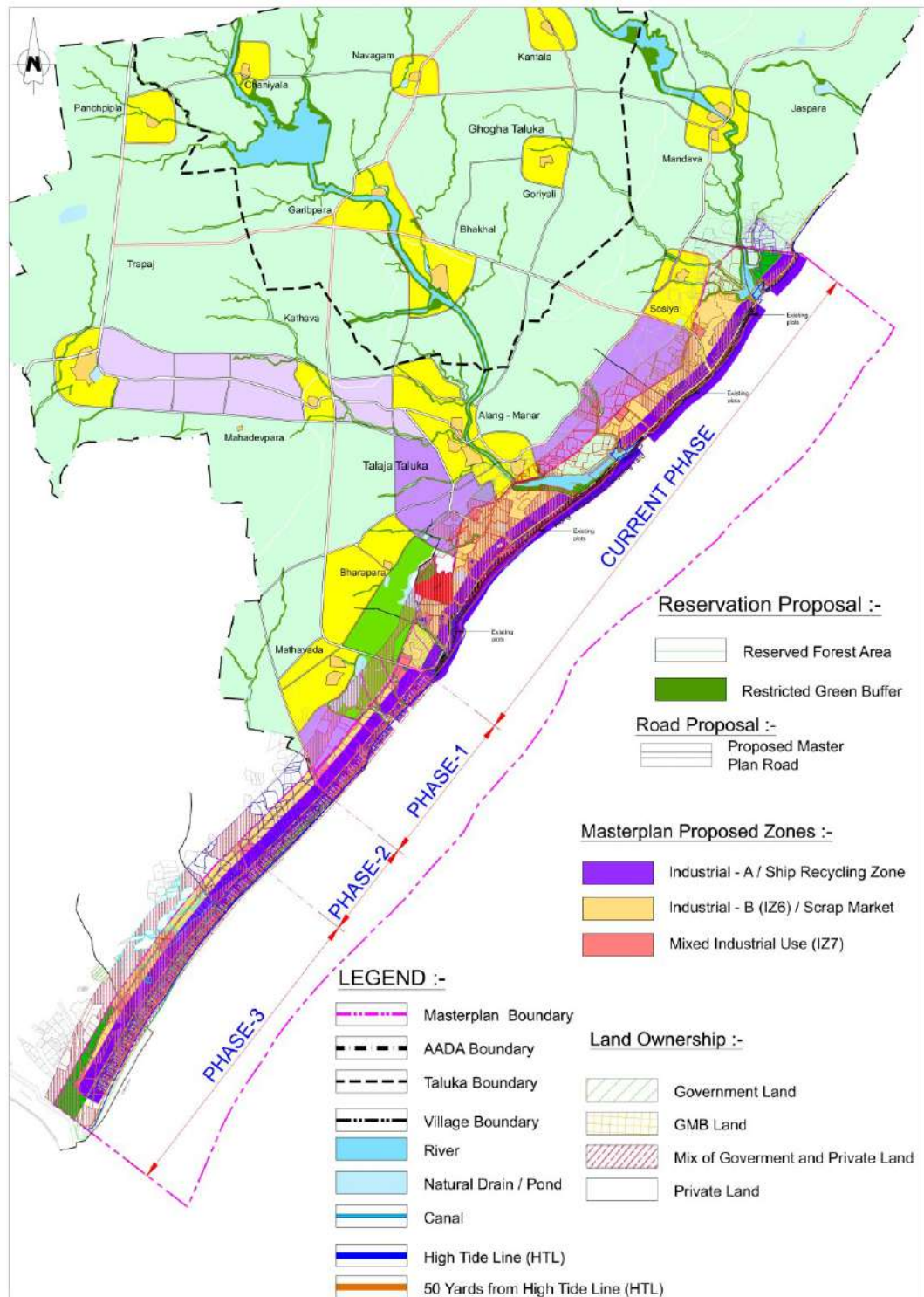
Along with the above expansion plan, the upgradation of the existing facility also to be developed in parallel.

7.2.1 Proposed phase wise capacity expansion plan (2025-2040)

Phase wise expansion of Alang Soshiya yard aligned with “moderate scenario as per market study in phase 1” with built-in flexibility to adjust to dynamic market changes and ability to align with accelerated scenario (if required) is considered based on the following rationale:

- Planning for moderate scenario will ensure that while the expansion strategy is neither too conservative as per BAU Scenario and nor too ambitious to create overcapacity which may go underutilized in case of unexpected hindrances.
- The moderate scenario also aligns with GMB's vision of doubling the capacity from 4.5 M LDT to 9.0 M LDT
- It will enable early approvals for land use, environmental clearances and infrastructure expansion to prevent bottlenecks at a later stage if it was planned for BAU scenario.
- The market conditions may be assessed during **Phase 1 (2025–2027)** or **Phase 2 (2028–2038)** to determine if scaling down is required.
- The master plan aligning with moderate scenario is expected to provide a balanced long-term vision, while execution of the plan remains adaptable to changing market dynamics.
- Phase 1: Development & optimization (2025–2027)
 - Planning & approvals
 - Completion of detailed studies

- Finalization of the master plan
- Securing statutory approvals and stakeholder alignment
- Establishing core Infrastructure
- Land delineation and acquisition
- Environmental and statutory clearances
- Development of centralized infrastructure
- Initial expansion towards Mathavada
- Modernization of existing yard parallelly (compliance with HKC & EU SRR)
- Technology upgrades
- Establishment of a model plot for training, research, and demonstration
- Market reassessment and realignment based on trends
- Phase 2: Expansion & scaling (2028–2038)
 - Growth and adaptation
 - Continued optimization of operational efficiency
 - Adapting to evolving international compliance standards
 - Advanced technology integration
 - Further expansion in towards Mathavada
 - Scaling operations in line with market demand (Accelerated scenario)
- Phase 3: Full-scale operations (2039+)
 - Further scaling in case of market requirement
 - Modular development in sub phases aligning the requirement
 - Fully utilisation of planned capacity of previous phases
 - Achieving long-term operational and environmental sustainability
 - Integration with regional and global recycling networks

Figure 7-2: Implementation plan**7.2.2****Phase 1: 2025-2027**

The current stated peak capacity of Alang-Sosiya yard as per GMB's estimate is 4.5 M LDT/year. Many of the existing plots are progressing in terms of effort, investment and resources to comply with EU SRR and most with HKC regulations that will be kicking in in 2025. These ship recycling plots shall continue to operate to meet the yearly demand as it arises with a potential to reach of 4.5 M LDT /year with 8993 m waterfront (i.e. approx. 503

LDT/waterfront width). The projected target as per Accelerate scenario is 3.2 M LDT by 2027, this target is well within GMB's estimated capacity of 4.5 M LDT.

Addition to the existing capacity, additional 4.5 MLDT capacity will also be developed by the end of Phase 1 and will be ready for operations. These larger plots will improve the productivity and standards of Alang ship recycling yard. The operations of the proposed plots will be based on the leasing of the plots to private players.

7.2.2.1 **Baseline capacity of existing plots**

Further to the analysis provided in section 4.2.2.4, Statistical and base line productivity assessment estimates align with the GMB's current capacity of the yard as 4.5 M LDT. Further assessment for considering 4.5 M LDT capacity is provided:

- Realistic representation of full functionality
 - The 4.5 M LDT/year capacity assumes that all 153¹³ plots are functional, which is realistic as:
 - The expansion plan expects these plots to be operational and compliant by 2029.
 - Operational inefficiencies (e.g., 22 non-functional and 7 zero-production plots¹⁴) have been factored out in scenario planning but presumed resolved under baseline capacity assumptions.
- Regression and correlation analysis support
 - 5.74 LDT/m²/year (which is conservative compared with median 5.78 LDT/m² is a balanced yard-wide average, capturing a range of plot sizes, technologies, and practices.
 - This reinforces that 4.5 M LDT is not aspirational but a central tendency across diverse plot conditions.
- Case studies support the threshold
 - Case studies of small (Plot 30), medium (Plot 11), and large (Plot V-1) plots indicate:
 - Realized and extrapolated productivity in line with or exceeding the 5.74 LDT/m²/year benchmark.
 - Even during market downturns, high-performing plots achieved 6.3–9.96 LDT/m²/year, indicating headroom beyond the baseline.
 - When extrapolated to peak market conditions (as projected in 2025 and beyond), these plots collectively support the yard's capacity reaching or exceeding 4.5 M LDT/year.
- Baseline capacity used for scenario modelling
 - The entire phased expansion plan (2025–2040) uses 4.5 M LDT as the foundational anchor for:
 - Moderate scenario growth to 7.0 and 8.8 M LDT
 - Accelerated scenario growth to 9.0 and 11.3 M LDT

¹³ Plot numbers cited are based on the 2024 configuration used for data analysis

¹⁴ Plot numbers cited are based on the 2024 configuration used for data analysis

- This standardization of baseline ensures that future capacity additions are quantified relative to a consistent, empirically validated base.
- Conservative yet reliable benchmark
 - The value of 4.5 M LDT/year is conservative, as:
 - It assumes 100% utilization of all plots at average productivity.
 - It excludes capacity unlocked through optimization measures like extending plot lengths to 215 m or upgrading technology.
 - Hence, it serves as a stable, policy-friendly reference while allowing upward flexibility through Phase 1 optimization or land expansion.

Conclusion

Taking 4.5 M LDT/year which is the most conservative estimate as the baseline capacity of the Alang-Sosiya yard is both data-backed and logically sound. It reflects:

- The average output possible with full plot utilization,
- Conservative productivity assumptions validated by historical and statistical evidence,
- A rational foundation for scalable expansion under both moderate and accelerated scenarios.

7.2.2.2 Optimization of existing plots

To accelerate this, a pilot project may also be initiated by GMB during this phase by establishing a model ship recycling facility fully optimized and compliant with HKC and EU SRR in one of the unutilized plots preferably over 60 m waterfront width which can be later mimicked by existing and newer plots. This pilot project may either be utilized for training, study/research and demonstration etc at GMB's discretion.

7.2.2.3 Expansion towards Mathvada

The south of Alang in Mathvada is under CRZ-II zone shall be acquired by GMB and is available for allotment of additional plots after necessary area reclamation and required minor dredging and preparation of seabed to ensure gently sloping seabed ensuring smooth operation during landing of vessels as per master plan.

- 04 plots of 300 m waterfront producing $04 \times 4,94,100 = 1.97$ M LDT/year (conservative estimate)
- and
- 05 plots of 240 m Waterfront Producing $05 \times 4,09,860 = 2.049$ M LDT/Year (conservative estimate)
- Although conservative production estimates have been used—further reduced to 90% of the individual plot capacity—the actual performance of ship recycling plots may exceed these estimates especially since these plots will have advanced equipment's which can improve the capacity to optimise by at least 30 %. In Phase 1, a total of 2,400 meters is practically usable due to the presence of a water channel and the required buffer zone.
- Additionally, the reserve forest area beyond Mathvada can only be considered for development after it is officially de-notified. Taking these constraints into account,

Phase 1 has been planned with four plots of 300 meters and five plots of 240 meters each.

- Despite these limitations, considering at least 15 % optimised capacity of these plots, the combined total capacity of the proposed plots is estimated at 9.09 million LDT, which exceeds the projected ship recycling volume under the moderate growth scenario.

7.2.2.4 **Worker safety and environmental compliance**

Recognizing the cyclical nature of the ship recycling industry, the master plan identifies a critical need to ensure compliance with the Hong Kong Convention (HKC) and Ship Recycling Act provisions especially concerning worker safety and environmental safeguards.

The following proposals are expected to mitigate the risks associated with rapid scaling of operations in the existing ship recycling plots during such phases:

1. **Development of public housing units and support Infrastructure:**

The provision of labour housing facilities close to the plot premises is proposed to ensure continuity of the workforce. This will reduce high turnover and limit the inflow of untrained or inexperienced labour during demand spikes. The stability in the workforce will not only enhance operational efficiency but also allow workers to undergo advanced training programs offered at Training Institutes. Over time, this shall contribute to building a skilled, safety-conscious workforce.

2. **Institutional strengthening and monitoring:**

Acknowledging the risks of environmental non-compliance during peak operational cycles, it is recommended that the Gujarat Maritime Board (GMB) establish a framework for stringent compliance audits, including:

- Regular monitoring and **third-party environmental audits**.
- Worker safety especially around critical operations like tank entries/working at heights, dealing with Hazardous waste and Hot work inside confined spaces needs to be properly managed
- **Integration of PPE usage enforcement** into regular yard audits conducted by GMB.
- **Routine sampling and testing** of air, soil, and water for pollutants and HAZMAT residue.
- **Tracking and verification** of hazardous material removal procedures as per the **Inventory of Hazardous Materials (IHM)** protocols.

These measures will collectively reinforce the global credibility of the Indian ship recycling sector and safeguard its alignment with evolving international norms.

7.2.2.5 **Road and Infrastructure phasing**

Road network

In phase 1, 6.57 km of new road network is to be laid in the expansion towards Mathavada. Two series of 4 lane roads, one connecting proposed ship recycling plots and the other for the scrap market and few connection roads. The proposed roads connecting ship recycling plots will be connected to existing arterial road.

Along the Phase 1 road network, there are few minor streams with widths ranging from approximately 50 m to 100 m. To ensure uninterrupted natural flow and avoid any obstruction, minor bridges and culverts are proposed at these stream crossings.

Figure 7-3: Proposed road network (Phase 1)

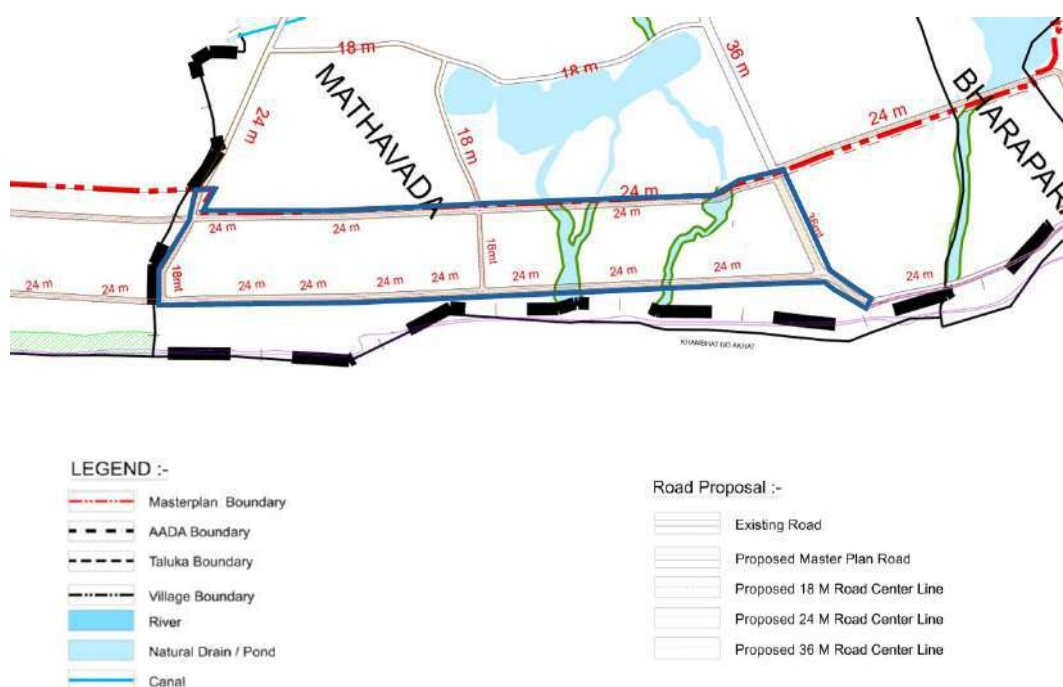
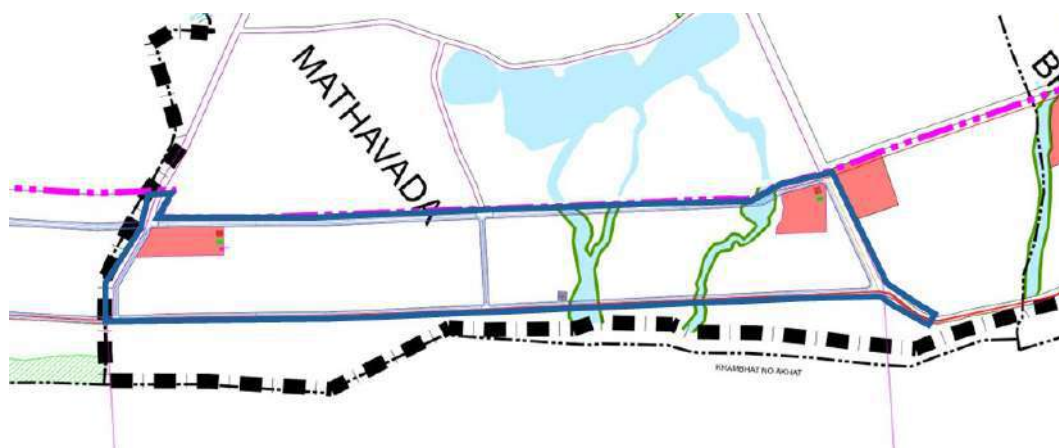


Table 7-1: Proposed road network length (Phase 1)

Sr.no	RoW (m)	Length (km)
1	18 m	0.81
2	24 m	5.12
3	36 m	0.44
	Bridges (minor)	0.2
	Total	6.57

Physical infrastructure

Figure 7-4: Proposed utility network (Phase 1)

Proposed Infrastructure :-

**Table 7-2: Infrastructure proposal (Phase 1)**

Sr.no	Description	Capacity
1	Water supply (Domestic)	5 M liters
2	Sewerage	2 MLD
3	Stormwater network	Across 6.57 km road network
4	Gas and contaminated water network	Connection to 9 proposed plots
5	Electricity	1 Nos. 2000kVA
6	GMB housing & amenities cluster	2 units

7.2.2.6 Key outcome

- The proposed facility once operationalise will enhance the capacity and streamlines recycling of larger vessels efficiently.
- **Optimizing plot lengths to 215 m**, improving procedures, and enhancing technology will **unlock greater capacity**, leading to **overcapacity** during phase 1.
- **Proposed larger and efficient plots ready for operations.**

Note: Considering administrative, legal and socio-economic issues that may pose challenges in allocating additional plot areas by extending length, it may not be possible to assign a timeline for implementation of optimization of existing Alang Sosiya yard. Accordingly, for further estimates of capacity planning during phase 2 and 3, **the baseline peak capacity of Alang yard i.e. 4.5 M LDT would be considered which is also the Baseline scenario.**

A suggestive action plan for the administrative, legal and socio-economic issues with reasonable assumptions and stakeholder consultation can enable early groundwork and parallel preparatory actions.

Around 30 plots have applied for EU Ship Recycling Regulation (EU SRR) certification under current phase, out of which 3 plots have successfully undergone audits. It is anticipated that additional plots from the existing inventory will pursue EU approval and transition towards environmentally sound recycling practices in Phase 1.

Action plan & assumptions for phase 1 (2025–2027)

Assumption: Legal, regulatory and land allocation issues may delay expansion

- As the government land in expansion of phase 1 in Mathavada is mostly falling under private land, the Land acquisition process might delay expansion process

Action plan:

- Initiate preparatory administrative actions: Begin legal due diligence, CRZ-II compliance checks, and community engagement for land consolidation/extension now.
- Form a joint stakeholder taskforce (GMB, local bodies, plot owners, legal advisors) to address land reallocation hurdles.

Assumption: Optimization of processes and layout can proceed without physical expansion

- Assume internal plot optimization and workflow upgrades can improve capacity even within current dimensions.

Action plan:

- Launch model plot pilot project as proposed, using an unutilized plot over 60 m wide to demonstrate:
 - HKC and EU SRR compliant workflow
 - Cutting-edge layout (segregation, block flow)
 - Upgraded crane and cutting tech
- Share learnings via workshops and capacity-building programs for plot owners.

Assumption: Technological upgrades and process efficiency will enhance productivity

- Assume productivity uplift through modern equipment, optimized manpower, and digitized tracking without new land.

Action plan:

- Provide financial incentives or soft loans for:
 - Crane upgrades
 - Faster cutting tools (plasma/oxy-acetylene)
 - Digital tracking (e.g. RFID for material movement)
- Mandate productivity benchmarking based on best-performing plots' metrics (e.g., target > 6.0 LDT/m²/year for optimized medium plots).

Assumption: Not all 153 plots¹⁵ are fully functional initially

- Assume 124 functional plots operate at improved median productivity with current lengths.

Action plan:

- Create a phased consolidation plan for underperforming plots.
 - Merge or lease 22 non-functional plots for interim use
 - Use them for training, logistics storage, or model facility development
- Provide compliance support (HKC, safety training) for lower-tier operators.

Assumption: Stakeholder collaboration is essential for phase 1 optimization

- Assume that without full stakeholder buy-in, reforms (especially on layout and compliance) will be inconsistent.

Action plan:

- Conduct bi-annual stakeholder consultations: Plot owners, recyclers, NGOs, labour unions, regulators.
- Promulgate Phase 1 optimization guidelines/recommendations.
- Deploy a monitoring and advisory cell under GMB to support rollout.

7.2.3

Phase 2: 2028-2038

7.2.3.1

Assumptions

- At this stage it would be imperative to assume that GMB has taken necessary clearances for expansion of yard in the remaining stretch (across Tarasara, Padri, Chopda villages) further south as per master plan.
- The 2027 target was 3.2 M LDT/year which could be met by the baseline peak capacity of 4.5 M LDT/year as per GMB's estimates.
- It is also assumed all the existing plots would have complied with HKC requirements and some of the plots would pursue EU SRR approval through audit and would be performing at least at their conservative median performance capacity to produce at least 4.5 M LDT.
- **It is further assumed that:**
 - Phase 1 stretch under CRZ-II zone has been acquired by GMB and is available for allotment of additional plots after necessary area reclamation and required rock dredging and preparation of seabed to ensure gently sloping seabed ensuring smooth operation during landing of vessels as per master plan.
 - The centralized infrastructure has been developed by GMB as per recommendations of master plan including administrative, environmental, road network infrastructure that is essential for further development.
 - All approvals and administrative actions have been completed, and new plots have been marked and are ready for allotment in phase 1.

¹⁵ Plot numbers cited are based on the 2024 configuration used for data analysis

- GMB has also initiated necessary procedure for seeking clearance for development of remaining stretch further south of Mathwada as per Master plan.

7.2.3.2 Accelerated scenario: Target 11.3 M LDT/year

In case of dynamic market changes that lead to higher demand capacity as per accelerated scenario, the requirement could go up to 11.3 M LDT/year as per market projections. Accordingly, the additional requirement of 2.3 M LDT/year could be met as follows

- 03 plots of 300 m waterfront producing 03 x 4,94,100 = 1.48 M LDT/year (conservative estimate)
- 03 plots of 240 m Waterfront Producing 03 x 4,09,860 = 1.23 M LDT/Year (conservative estimate)
- A total of additional capacity added to the facility in phase 2 is 2.71 MLDT.

Note: It is important to note that this additional expansion would likely require to meet market requirements if accelerated scenario type market conditions prevail. In this case, it will be imperative to move further into Phases 2 & 3 stretch that is under CRZ IA zone as of now. Accordingly, necessary clearances for expansion into this stretch should be in place prior to commencement of this phased expansion.

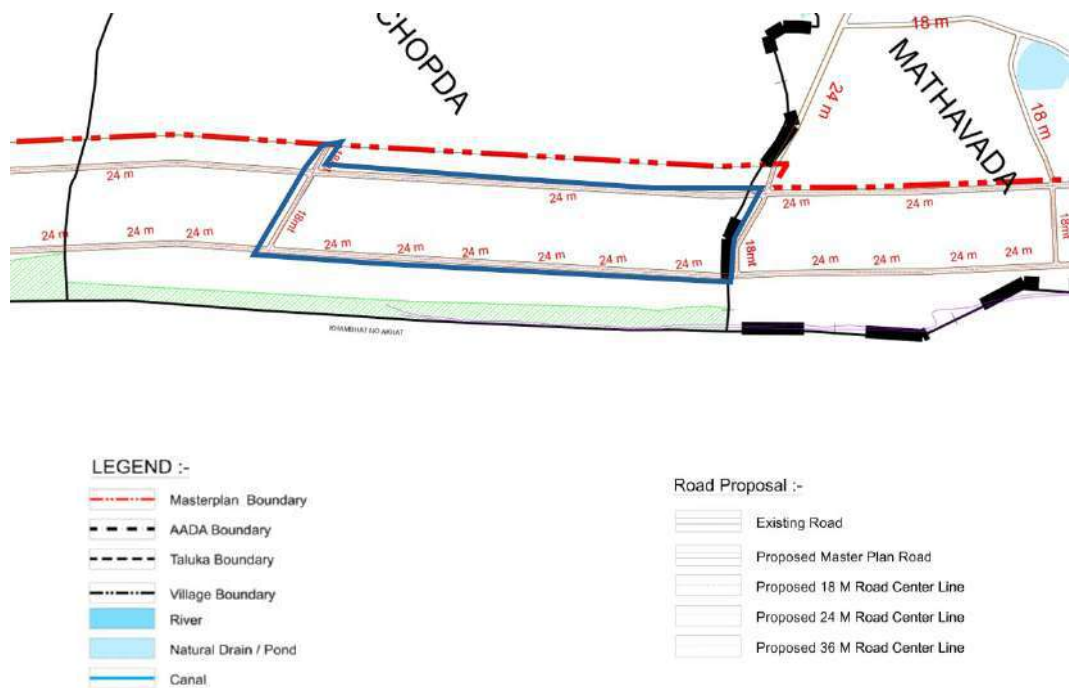
It is also opined that all the plots would opt for higher productivity through improvement in technology, training, better layouts and would be at the peak of the learning curve which would result in productivity towards the optimistic side of estimates and well performing plots can unlock at least 20-30% potential to take care of uncertainties in less performing plots.

Table 7-3: Summary table for Phase 2

Aspect	Accelerated scenario (11.3 M LDT/year)
Base year capacity (2027)	9.0 M LDT/year
Additional capacity required	2.3 M LDT/year
Plot development (South of Alang towards Mathwada)	- 03 plots × 240 m (409,860 LDT/year each) - 03 plots × 300 m (494,100 LDT/year each)
Additional capacity added by 2038	2.7 M LDT/year
Total estimated capacity by 2038	11.7 M LDT/year
Total waterfront occupied	1,672 m
Key assumptions	Accelerated scenario with additional dynamic market-driven demand
Purpose	Meet high demand growth to 11.3 M LDT/year by 2040

7.2.3.3 Road & Infrastructure phasing

Road network

Figure 7-5: Proposed road network (Phase 2)**Table 7-4: Proposed road network length (Phase 2)**

Sr.no	RoW (m)	Length (km)
1	18 m	0.49
2	24 m	3.7
	Total	4.2

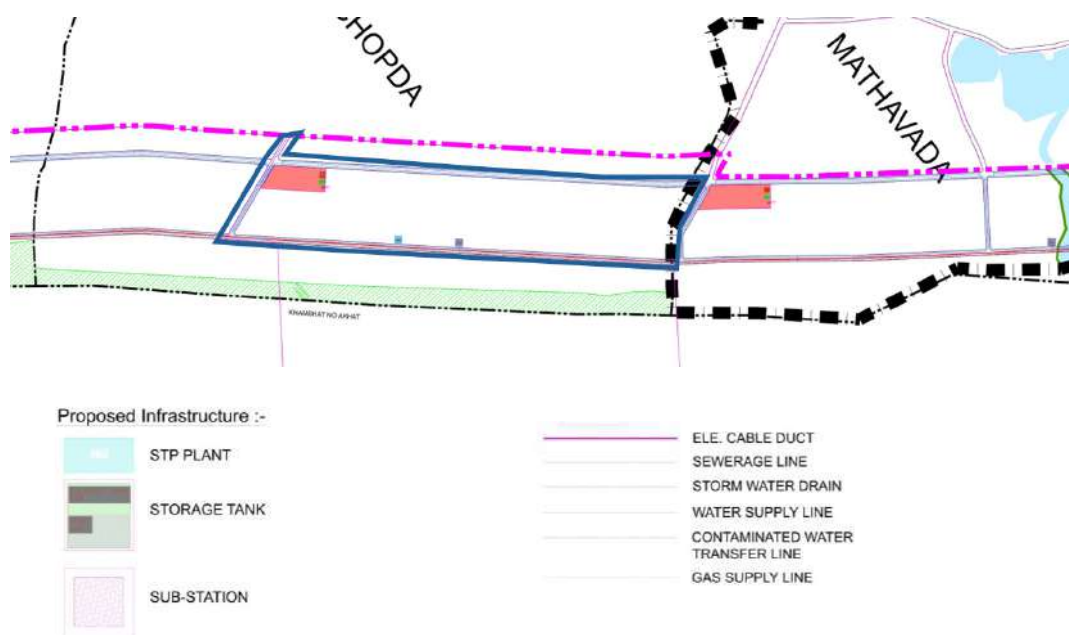
Physical infrastructure**Figure 7-6: Proposed utility network (Phase 2)**

Table 7-5: Physical infrastructure proposal (Phase 2)

Sr.no	Description	Capacity
1	Water supply (Domestic)	3 M liters
2	Sewerage	1 MLD
3	Stormwater network	Across 4.2 km road network
4	Gas & contaminated water network	Connection to proposed 6 plots
5	Electricity	1 Nos. 2000kVA

Social infrastructure**Table 7-6: Social infrastructure proposal (Phase 2)**

Sr.no	Facility	No of units
1	GMB housing & amenities cluster	1
2	50-Bedded Mult speciality hospital	1
3	Upgradation of training institute	1

Developed of **advanced training institute for ship recycling** in both capacity and curriculum upgradation to be undertaken.

7.2.3.4 Key outcomes

- **Accelerated scenario:** Target can be achieved by adding 6 new plots, reaching 11.3 M LDT/year.
- This phase requires significant land expansion, infrastructure, and administrative readiness, along with full functionality of existing plots

7.2.4 Phase 3: 2039+**7.2.4.1 Assumptions**

- The capacity of the yard facility will suffice the expected demand till 2040.
- Based on the market evaluation, the market is expected to rise beyond the capacity of the yard beyond 2040.

7.2.4.2 Capacity: 11.3 M LDT+**Table 7-7: Summary of phase 3 (2039+) of capacity expansion**

Aspect	
Base capacity (End of Phase 2)	11.3 M LDT/year
New plot development	- 09 plots × 300 m (494,100 LDT/year each) - 08 plots × 240 m (409,860 LDT/year each)
Total additional capacity created	8.7 M LDT/year
Total estimated capacity by 2040	11.319 M LDT/year

Aspect	
Additional waterfront occupied in Phase 3	5,385 m
Key assumptions	- It is assumed that this phase is to be developed only in case if the market goes beyond expected 11.3 M LDT - this phase is implemented in sub phases as and when required. - Expansion into remaining CRZ-IA zone as per Master Plan - Necessary clearances obtained
Productivity considerations	- Full productivity optimization expected through technology, training, and layouts
Purpose	Meet high market demand beyond 11.3 M LDT/year by 2040

7.2.4.3 Road & Infrastructure phasing

Road network

Figure 7-7: Proposed road network (Phase 3)

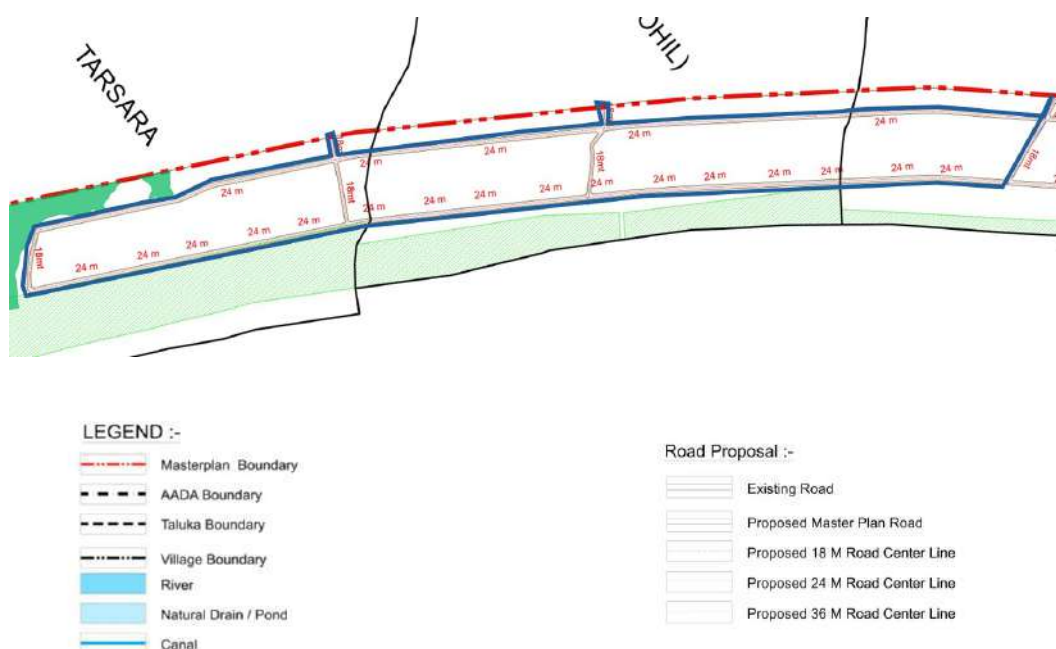


Table 7-8: Proposed road network length (Phase 3)

Sr.no	RoW (m)	Length (km)
1	18	1.26
2	24	10.68
Total		11.94

Infrastructure

Figure 7-8: Proposed utility network (Phase 3)**Table 7-9: infrastructure proposal (Phase 3)**

Sr.no	Description	Capacity
1	Water supply (Domestic)	7 M liters
2	Sewerage	3 MLD
3	Stormwater network	Across 11.94 km road network
4	Gas & Contaminated water network	Connection to proposed 17 plots
5	Electricity	2 Nos. 2000kVA
6	GMB housing & amenities cluster	3 units

7.2.5 Summary of capacity expansion / Phasing

Table 7-10: Capacity planning/optimization summary

Phase	Years	Target capacity (M LDT/year)	Actions/Assumptions	Capacity achievements
Phase 1	2025-2027	4.5 (Existing) + Additional 4.5 MLDT	Baseline peak capacity of 4.5 M LDT/year in the existing stretch. Add new plots in CRZ-II zone in Mathwada: • 04 x 300 m plots • 05 x 240 m plots • Centralized infrastructure complete	Optimization Scenarios: • Baseline: 4.5 M LDT/year • Optimized total capacity: 9 M LDT/year
Phase 2	2028-2038	Additional 2.3 MLDT	Extend further into CRZ-II zone: • 03 x 300 m plots • 03 x 240 m plot	Added capacity: 2.37 M LDT/year
Phase 3	2039+	Additional 8.7 MLDT (in case of	Full expansion in sub phases as required.	Added capacity: 8.7 M LDT/year

Phase	Years	Target capacity (M LDT/year)	Actions/Assumptions	Capacity achievements
		market requirement)		

Table 7-11: Road network phasing

Sr.no	RoW (m)	Phase 1	Phase 2	Phase 3	Total length (km)
1	18	0.81	0.49	0.126	2.26
2	24	5.32	3.72	10.68	19.72
3	36	0.44			0.44
Total length (km)		6.57	4.94	11.94	

Table 7-12: Physical infrastructure phasing

Sr. No	Description	Phase 1	Phase 2	Phase 3
1	Water supply (Domestic)	5 M liters	3 M liters	7 M liters
2	Sewerage	2 MLD	1 MLD	3 MLD
3	Stormwater network	Across 6.57 km road network	Across 4.94 km road network	Across 11.94 km road network
4	Electricity	1 Nos. 2000kVA	1 Nos. 2000kVA	2 Nos. 2000kVA
5	GMB housing & amenities cluster	2	1	3

7.2.5.1 Key takeaways from phase wise capacity expansion & planning exercise**Table 7-13: Strengths of suggested phase wise expansion**

Aspect	Strengths
Phased approach	It sensibly divides growth into realistic, manageable phases tied to demand, allowing time to assess market conditions before each expansion.
Capacity buffer	The existing baseline (4.5 M LDT) already meets the moderate targets until 2029, giving breathing room for regulatory and operational improvements.
Optimization potential	Unlocking capacity through better plot layouts (215 m plots) and productivity boosts before physical expansion makes good use of existing assets.
Master plan alignment	Aligns with long-term infrastructure upgrades (like centralized facilities) and controlled CRZ zone development.
Scalability	Provides an accelerated pathway in case of unexpected high market demand, allowing growth to 11.3 M LDT/year till phase II and furthermore if expansion is necessary.
Risk awareness	It acknowledges administrative, legal and environmental challenges and factors them into the timeline.

Table 7-14: Potential concerns/weaknesses of suggested phase wise expansion

Aspect	Concerns
CRZ and Environmental Clearances	Expansion into CRZ-II and CRZ-IA zones may face significant legal hurdles and opposition from environmental authorities, which can cause delays or restrictions.
Market dependency	The moderate and accelerated scenarios assume high global demand, which is sensitive and subject to economic downturns, policy changes (like IMO regulations) and alternative recycling hubs.
Implementation risks	Optimizing plot lengths and productivity relies heavily on operator cooperation, investment in technology and workforce training, which may not be uniform across all plots.
Overcapacity risk	If the global market doesn't grow as forecasted, overbuilding could lead to underutilized plots and financial strain on operators.
Social impact	Expansion displaces local communities and ecosystems and while it's mentioned, the socio-economic balancing act may be more complex than accounted for.

While all efforts have been made to bring out a **well-structured and adaptable plan** encompassing: -

- Phase wise growth.
- Built-in flexibility (moderate to accelerated scenarios).
- Practical and optimized use of existing infrastructure.

However, its success will **depend upon**:

- Early resolution of CRZ clearances.
- Strong governance to ensure all plot owners upgrade their technology and training.
- Close monitoring of global ship recycling demand to prevent overbuilding.
- Robust implementation, project monitoring and sustainability.

Table 7-15: Suggested mitigation strategies for potential concerns

Potential concern	Mitigation strategy	Responsible stakeholders	Timeline
CRZ and Environmental Clearances	Engage early with regulatory authorities (MoEFCC, state bodies) to understand clearance requirements. Implement sustainable practices (waste management, biodiversity buffers). Include local environmental NGOs in consultations to minimize pushback.	GMB, Environmental Authorities, Legal Teams	Before Phase 2 (2027)
Market dependency & demand fluctuation	Periodic market analysis (every 2 years) to assess global LDT supply and demand. Adopt flexible expansion models that can scale up/down.	GMB, Trade associations, Recyclers	Continuous (starting 2025)

Potential concern	Mitigation strategy	Responsible stakeholders	Timeline
Implementation risks (Technology & Training)	Introduce mandatory productivity standards with incentives. Provide free or subsidized training programs for workers and management. Establish a "model plot" pilot project to showcase optimal practices. Facilitate access to financing for technology upgrades.	GMB, training institutes, plot owners	Start in Phase 1 (2026)
Overcapacity risk	Stagger expansion based on real demand growth (trigger thresholds). Build in the option to pause plot allocations if utilization rates fall below defined benchmarks. Develop temporary alternative uses for underutilized plots (storage, logistics).	GMB, market analysts	Monitoring from Phase 2 (2030)
Social impact (Community & workforce)	Early community engagement with clear communication of benefits. Ensure resettlement and compensation plans align with national and international best practices. Invest in local infrastructure (schools, hospitals) as part of CSR obligations. Prioritize local hiring and skill development programs.	GMB, local government, NGOs, social experts	Planning starts in Phase 1 (2026), active through all phases
Legal delays (Administrative approvals)	Form a dedicated task force to coordinate inter-departmental clearances. Set milestone-based action plans with government oversight. Utilize legal advisory teams to pre-emptively address policy gaps.	GMB, legal teams, state authorities	Pre-Phase 2 (2027)

7.2.5.2 General strategy highlights

- **Phased and adaptive growth** is key: do not overcommit without clear market signals.
- **Transparency and stakeholder involvement** (especially local communities and environmental groups) can reduce resistance.
- **Pilot programs and technology demonstrators** can help create confidence and set performance standards.
- **Flexible plot use** prevents stranded assets if demand slows.

7.3 Implementation mechanism for the proposed master plan

The successful implementation of the proposed master plan for the Alang region requires a robust institutional and legal framework. Two primary mechanisms are suggested for operationalizing the plan, both aligned with the Gujarat Town Planning and Urban Development Act (GTPUDA), 1976:

Option 1: Implementation through the Alang Area Development Authority (AADA)

Under this approach, the existing Alang Area Development Authority (AADA) would be the primary planning and implementation agency. The steps involved are as follows:

1. **Extension of jurisdiction:**
AADA would formally extend its planning jurisdiction to incorporate the full area covered under the proposed master plan.
2. **Revision of development plan:**
Upon jurisdictional extension, AADA would initiate a revision of the sanctioned Development Plan under Section 19 of the GTPUDA Act, which allows for modifications to be made in the existing plan.
3. **Publication and notification:**
The revised master plan would be published and notified as per the statutory procedure, inviting suggestions and objections from the public and relevant stakeholders.
4. **Implementation through Town Planning Schemes (TPS):**
Once notified, the area can be developed in a phased manner using Town Planning Schemes for infrastructure provisioning, land pooling, and reconstitution, ensuring equitable distribution of benefits and costs.

This mechanism relies on leveraging the existing statutory authority and administrative setup, ensuring continuity, transparency, and alignment with state policies.

Option 2: Formation of a Special Purpose Vehicle (SPV)

An alternate approach involves the formation of a Special Purpose Vehicle (SPV) dedicated solely to the implementation of the proposed master plan. The SPV would function as an autonomous agency with financial and administrative powers and may include representatives from key stakeholders, including state government departments, the Gujarat Maritime Board (GMB), Alang stakeholders, and urban development authorities. GMB can be the nodal agency for the same.

Key responsibilities and powers of the SPV could include:

- Planning and execution of physical and social infrastructure as per the master plan.
- Mobilization and management of funds from government grants, loans, or private partnerships.
- Acquisition of land either through direct purchase, transfer of government land, or implementation of TPS.
- Coordination with existing statutory bodies and utility providers.
- Ensuring regulatory compliance and environmental sustainability.

This model allows for focused governance, integrated planning, financial flexibility, and faster decision-making, especially for large-scale or complex urban regeneration projects.

Case Study: Sabarmati Riverfront Development Corporation Ltd. (SRFDCL)

A relevant and successful precedent for SPV-led implementation in Gujarat is the Sabarmati Riverfront Development Project in Ahmedabad. The project was executed through the Sabarmati Riverfront Development Corporation Ltd. (SRFDCL) an SPV established by the Ahmedabad Municipal Corporation (AMC) in 1997.

Key Features of SRFDCL's Functioning:

Ownership & structure:

SRFDCL was wholly owned by AMC but operated independently with a dedicated team of experts in planning, engineering, and finance.

Land acquisition strategy:

The SPV was empowered to acquire land through a combination of government transfers, Town Planning Schemes, and negotiated settlements.

Revenue generation:

The SPV financed its infrastructure development by selling a small portion of reclaimed land for commercial use, creating a self-sustaining funding model.

Inter-agency coordination:

SRFDCL coordinated with multiple stakeholders like AMC, AUDA, Gujarat Government, and environmental bodies for project approvals, infrastructure alignment, and sustainable design.

Efficient implementation:

With single-point accountability, clear objectives, and operational autonomy, the project achieved significant physical transformation, infrastructure upgrades, and socio-economic revitalization.

Both models leveraging the existing development authority (AADA) or creating a new SPV offer viable paths to implement the proposed master plan for Alang. The choice of mechanism can be determined based on the urgency, complexity, resource mobilization strategy, and institutional capacity required for the project. Drawing lessons from successful models like the SRFDCL can help in designing an adaptive, transparent, and outcome-driven governance structure.

7.3.1 Development mechanism

As part of the implementation framework for the Alang-Soshiya Ship Recycling Yard Master Plan, two strategic options have been developed to facilitate the effective execution of proposed land use, infrastructure, and environmental enhancements. These options are rooted in the regional context, stakeholder realities, and statutory mechanisms available to the planning authority.

7.3.1.1 Option 1: Land acquisition approach

This option proposes direct acquisition of land by the planning authority for the implementation of the master plan. It allows for full control over land reconstitution, placement of infrastructure, and the creation of public utilities such as TSDFs, buffer zones, and worker housing. This approach is more suitable for critical or time-sensitive development areas. However, it requires higher financial outlay for compensation and involves administrative challenges in acquiring privately owned land.

7.3.1.2 Option 2: Town Planning (TP) scheme approach

This option leverages Gujarat's statutory TP Scheme mechanism, where landowners contribute a portion of their land for infrastructure development and receive reconstituted plots. It ensures equitable participation of stakeholders while enabling planned development without full acquisition. The TP Scheme is more time-intensive due to statutory processes but offers a sustainable and inclusive path for implementation, especially in areas with fragmented ownership.

Both options are mapped and integrated within the master layout, offering flexibility in choosing context-appropriate strategies for different phases and zones of the development. The decision between the two or a hybrid approach can be guided by urgency, stakeholder cooperation, funding availability, and legal readiness.

GMB has shown interest in development through Land Acquisition approach for expansion of the project in phases considering time sensitivity.

7.3.2 Land acquisition

Based on the cadastral data collected, it is observed that almost the entire land parcel in Phase 1 within the master plan boundary falls mostly under private ownership. To achieve the planned capacity and ensure seamless implementation of the proposed development across Phases 1, 2, and 3, GMB may consider initiating land acquisition for the entire area within the master plan area in phases.

Basis of land acquisition

The land requirement for acquisition has been derived based on the master plan proposals. As the Authority intends to undertake the expansion in a phased manner, the land requirement has also been assessed phase-wise based on the master plan proposals. However, wherever the phase boundaries do not coincide with village or cadastral boundaries, land acquisition has been considered up to the nearest village or survey boundary to facilitate smoother and administratively efficient acquisition.

This approach avoids fragmentation of survey parcels, minimizes legal and procedural complexities, and eliminates the need for multiple acquisition processes for the same land parcels in subsequent phases. The additional land thus acquired is proposed to be utilized for development in future phases, ensuring continuity and flexibility in long-term planning.

The actual extent and timing of land acquisition shall be subject to statutory approvals, land ownership patterns, availability of land, and prevailing government policies, and may vary during implementation.

Detailed distribution of land ownership in terms of government land (Public), GMB land, public & private land, and private land have been provided below.

Table 7-16: Land ownership details

Phase	Land ownership/type	Total area (Ha)
Phase 1	GMB land	0.07
	Government land	3.00
	Private land	138.01

Phase	Land ownership/type	Total area (Ha)
Phase 2	GMB land	0.00
	Government land	44.8
	Forest Land	20.45
	Private land	123.6
Phase 3	GMB land	0.00
	Government land	126.1
	Forest Land	82.96
	Private land	100.5
Total (Ha)		639.59

For the purpose of estimating land distribution and tentative land acquisition costs, all land parcels falling in between the master plan boundary have been treated as private land, in case they include a mix of government and private ownership and spatially cannot identify the mix. This assumption has been adopted solely for preliminary costing, and the actual ownership distribution may vary upon detailed verification.

7.4 Strategies for integration

For the implementation of the proposed plan, the following steps need to be undertaken:

- **Jurisdiction realignment** - The areas currently under the jurisdiction of the Alang Area Development Authority should be integrated into the Ship Recycling Park to streamline governance and ensure unified planning and development.
- **Approval for plan variation** - To implement the new proposal, the Authority must approve modifications to the existing development plan.
- This variation must be sanctioned under Section 19 of the Gujarat Town Planning and Urban Development Act (GTPUDA) to legally incorporate the proposed changes into the planning framework.
- **Phased land acquisition strategy** - The land acquisition process shall be carried out in a structured manner, prioritizing different types of land in the following sequence:
 - **Step 1: Acquisition of available government wastelands**
 - Government wastelands to be identified and acquired first, as they are publicly owned and require minimal legal formalities.
 - These lands are usually non-arable and can be easily repurposed for industrial and infrastructural development.
 - **Step 2: Acquisition of available Gauchar (Grazing) land**
 - If additional land is required, available Gauchar (grazing) land to be acquired.
 - The process will involve compensatory arrangements, such as developing alternate grazing areas for livestock-dependent communities.
 - **Step 3: Denotification and acquisition of available forest land**
 - If required, forest land within the proposed area to be de-notified and converted for industrial use.

- This process involves obtaining necessary environmental and governmental approvals, including clearance from the Ministry of Environment, Forest and Climate Change (MoEFCC) and compliance with the Forest Conservation Act.
- **Step 4: Acquisition of private land**
- Private lands within the designated area to be acquired.
- The acquisition will be carried out as per the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation, and Resettlement Act (LARR), 2013.

Strategies for integration with local businesses

Most of the ancillary industries, such as scrap traders and other business that are spread across the road connecting Alang and Trapaj needs to be taken into consideration in the master plan to integrate local economy.

By integrating **ship recycling-related activities** within the scrap market zone, the region is poised for **sustained economic expansion**. The synergy between core and supporting industries will not only **increase industrial output** but also contribute to the overall **socio-economic development** of the area. This strategic move will **transform the region into a dynamic business hub**, attracting investors and further strengthening economic resilience.

7.5

Impact on surrounding areas & communities

The proposed Industrial Use Zones are strategically designed to incorporate activities such as allied industries supporting ship recycling, which will serve as a catalyst for local economic growth. By integrating these industries within the zone, the plan ensures a synergistic business environment where local enterprises can flourish while contributing to the broader industrial ecosystem.

Economic benefits and business growth

1. Support for local enterprises

- The inclusion of allied industries, such as metal processing, reconditioning of machinery, logistics, and waste management, will create numerous business opportunities for small and medium-sized enterprises (SMEs).
- Local workshops, repair services, and supply chain businesses will thrive as they cater to the demands of ship recycling operations.

2. Job creation and workforce development

- The establishment of these industries will generate a significant number of direct and indirect employment opportunities, helping to improve livelihoods in the area.
- Skilled and semi-skilled labour will be in high demand, encouraging vocational training programs and skill development initiatives to ensure a steady workforce.

3. Boost to economic activities

- The recycling and reusability aspect of ship recycling contributes to cost-effective production for various industries, reducing the need for importing raw materials.
- Increased business transactions in the region will lead to higher revenue generation, improving the overall economic landscape.

4. Infrastructure and commercial expansion

- The growth of allied industries will lead to investments in better infrastructure, including roads, utilities, and commercial spaces.
- Ancillary businesses such as retail, hospitality, and real estate will experience growth due to the increasing workforce and business influx.

In addition to the integration of allied industries supporting ship recycling, the proposed housing and physical infrastructure within the area, will play a vital role in improving the overall living standards of the people while benefiting the surrounding areas. A well-planned infrastructure framework will create a sustainable, well-connected, and thriving environment for residents, workers, and businesses.

7.6 Mitigation strategies

The proposed zoning has been carefully planned in alignment with the existing ship recycling activity, ensuring its continued support and expansion. In addition to facilitating the growth of ship recycling, the zoning framework provides opportunities for allied industrial activities, complemented by enhanced infrastructure that improves the quality of life for local residents.

To minimize potential challenges, the proposed zones have been strategically positioned to ensure that disturbances caused by heavy industrial activities do not interfere with other zones or negatively impact surrounding communities. The zoning plan also includes designated buffer areas to mitigate environmental and operational nuisances.

Furthermore, the permitted land uses within the proposed zone are designed to encourage the growth of allied industries and commercial enterprises, fostering a self-sustaining economic ecosystem. This approach not only enhances regional economic development but also ensures long-term sustainability by creating a balanced mix of industries, infrastructure, and community spaces.

7.7 Recommended actions for stakeholders

A detailed phase-wise action plan outlining the specific actions to be undertaken by GMB (Gujarat Maritime Board) and other primary stakeholders during the expansion of Alang Sosiya yard is presented in the tables below:

Table 7-17: Phase 1 (2025 - 2027): Infrastructure upgrade - actions by GMB

Focus area	Actions by GMB
Land acquisition & preparation	Complete delineation and acquisition of phase 1 stretch (CRZ-II zone) towards Mathwada Conduct rock dredging, seabed grading, land reclamation for future plot allotment
Master planning & strategy	Finalize comprehensive Master Plan as base. Detailed project report

Focus area	Actions by GMB
	Integrate flexibility for dynamic scaling Define clear milestones and monitoring framework
Regulatory buffering	Pre-emptively secure clearances for next 7.1 km CRZ-IA stretch to prevent future expansion delays
Infrastructure development	Develop centralized infrastructure: internal roads, drainage, green buffer zones, power supply, water management systems, waste processing units, weighbridges, surveillance systems
Compliance & upgradation	Ensure all 150 existing plots meet HKC compliance and encourage EU SRR audit readiness Promote environmental and safety standard upgrades
Set up pilot model recycling plot	Set up a Pilot Model plot for testing, training, demonstration, research, etc related to ship recycling process complying with EU SRR and piloting of new technologies or layouts with evolving needs.
New plot allotment	Allot additional plots (240 m and 300 m width) in mathvada CRZ-II stretch based on demand Implement progressive plot activation (phased handovers)
Infrastructure extension	Extend centralized facilities and port connectivity (approach roads, waste treatment, fire safety) to new plots
Market demand monitoring	Monitor industry trends, scrapping rates, international regulations (IMO, EU) for responsiveness
Technology & compliance tracking	Mandate continual upgrades to meet evolving global standards (automation, data logging, emissions)
Plot performance audits	Institutionalize performance and compliance audits for all plot holder Incentivize high performers
Centralised online market space	Establishing a centralised online market for furniture, fixture and machinery to provide a global reach.
Regulatory buffering	Secure next 7.1 km CRZ-IA stretch to for future expansion as required.
Sustainability measures	Enforce green norms: solar adoption, rainwater harvesting, waste reduction, biodiversity protection
Long-term compliance & sustainability	Drive EU SRR certification across majority plots Establish internal Sustainability & Compliance Cell to monitor adherence
Technology leadership	Encourage adoption of AI/data-driven plot management, remote monitoring, predictive maintenance
Industry & academic partnerships	Foster industry-academia collaboration for innovation in green recycling, hazardous waste management, material recovery
Global positioning & promotion	Promote and branding Alang internationally as a global model hub for sustainable ship recycling.
Risk & contingency planning	Implement robust disaster management plans (cyclone, fire, oil spill response), insurance frameworks, and crisis response mechanisms

Table 7-18: Phase 1 (2025-2027): Infrastructure upgrade - actions by other stakeholders

Agency	Actions
Plot owners	Begin operations in newly allotted plots Comply with GMB's allotment, safety, and green norms Maintain records for capacity & compliance audits Innovate for better performance (automation, layout efficiency)
AADA	Extend supporting civic infrastructure to new plot zones Facilitate logistics and workforce mobility Coordinate land use, buffer zones, and sustainable integration with nearby communities
Forest department	Evaluate and clear activities on reclaimed land Oversee Forest/environmental compensations Support biodiversity preservation near expansion zones

Table 7-19: Phase 2 & 3 (2028 – 2040+): Foundation and planning - actions by GMB

Focus Area	Actions by GMB
Final plot expansion	Allot new plots (as required) towards south of Alang (Tarasara, Padri, Chopda) CRZ-IA stretch (post-clearance) to meet 11.3 M LDT/year accelerated target and above if required
Completion of infrastructure grid	Complete all infrastructure linking of old and new plots seamlessly (logistics, monitoring, transport)
Continuous monitoring of market	Development of plots and backend development to align with the global and regional market trends.
Long-term compliance & sustainability	Drive EU SRR certification across all plots Ensure Sustainability & Compliance
Adaptive framework	Maintain flexibility to scale down or introduce performance-based deallocation or re-allotment policies in case of underperformance

Table 7-20: Phase 2 & 3 (2028-2040+): Foundation and planning - actions by other stakeholders

Agency	Actions
Plot owners	Expand operations to newly allotted CRZ-IA plots Achieve peak productivity through best practices Upgrade systems (data analytics, predictive maintenance) Engage in industry-academia innovation programs
AADA	Oversee full integration of industrial zone with district development plans Ensure emergency infrastructure, social amenities, public transport Lead smart-township development for workforce housing & services
Forest department	Review long-term ecological impact of full expansion Enforce mitigation strategies for CRZ-IA activities Regularly monitor green belts, coastal eco-zones, and compliance with forest laws

8

8.1

Cost Estimates

Summary

This represents a comprehensive block-level assessment of projected capital expenditures for the proposed master plan at Alang, Gujarat. The estimates cover the development of ship recycling plots, road infrastructure, physical and social infrastructure, and public housing facilities, across three implementation phases. The estimates have been derived using current market rates and SOR references wherever relevant, and serve as a strategic planning tool for budgeting, investment prioritisation, and phasing decisions. The total block cost across all components and across all implementation stages for GMB is approximately INR ₹ 1,41,780.35 Lakhs (INR 1,417.80 Cr), exclusive of taxes, escalation, and statutory charges and the breakups include:

- **Land development for ship recycling plots:** Land development cost for recycling plots is estimated at ~INR 26,016 lakhs.
- **Road Infrastructure:** Total cost across three phases is ~INR 24,312 lakhs.
- **Physical Infrastructure (water, sewerage, drainage, electricity):** Total cost ~INR 38,555 lakhs.
- **Social Infrastructure (Hospital and training institute):** Total cost ~INR 1960 lakhs.
- **GMB housing & amenities cluster:** Estimated cost of housing clusters is ~INR 19,888 lakhs.
- **Land development for scrap market:** Total cost is ~INR 7,974 lakhs
- **Dredging:** ~INR 3,650 lakhs

Cost responsibilities are allocated between Gujarat Maritime Board (GMB), private plot owners, and other development agencies such as GIDC. These estimates are not tender-ready and are subject to +/- 30% variation based on final design and DPR stage detailing including detailed quantity assessments, updated rate analysis for each infrastructure element, etc.

8.2

Preamble to cost estimates

The estimates are derived from concept engineering layouts and standard planning guidelines. These figures are indicative and must be validated through detailed design, detailed geotechnical assessments, and updated market rates during the DPR (Detailed Project Report) and subsequent execution stages.

8.2.1

Scope of estimates

The following components have been covered in the block cost estimates:

- **Development of ship recycling plots** including RCC pavement, drainage, buildings, tanks, and compound walls, etc. The estimates for plots are limited strictly to engineering works such as earthworks, foundations, structural concrete, drainage, and associated built infrastructure. Rates do not include cost of mechanical, supply items such as cranes, winches, etc. and any compaction/filling in the inter tidal area which will need to be considered by the yard operator and any statutory charges.

- **Road infrastructure** (18 m, 24 m, and 36 m ROW) with bituminous surfaces, footpaths, and bridge structures.
- **Physical infrastructure:** water supply, sewerage, stormwater drainage, electrical distribution, and TSDF. Cost associated with HT Cables has not been considered and will be provided by PGVCL
- **Social Infrastructure:** Multi-speciality hospital, upgradation of training institute
- **GMB housing & amenities cluster:** Modular RCC housing units with internal services, Shopping centre, dispensaries, Internal roads and parks.

8.2.2 Key assumptions

- Base year for costing is 2024; rates referenced from GMB SOR (2023–24) and supplemented by CPWD and NH SORs
- Quantities derived from conceptual master plan drawings and URDPFI norms
- High water table, corrosive marine environment, and ground improvement requirements considered for unit rates
- Engineering design is at a conceptual stage; no BOQs or construction-level drawings are available yet

8.2.3 Methodologies adopted

The cost estimates have been developed using a structured, component-wise approach tailored to each infrastructure category. Standard engineering practices, prevailing Schedule of Rates (SoRs), and region-specific site conditions at Alang were used as the basis for the methodologies adopted. The following outlines the methodology used for major components which is consistent, scalable and suitable for use in budgeting and prioritisation at the master planning stage.

- Ship recycling plots
 - Standardised layouts were considered for plot development based on typical functional zoning that can be used as templates.
 - Pavement layers (RCC with base preparation) were designed for heavy-duty vehicle loading.
 - Costing includes RCC retaining walls, compound walls, gates, drainage lines, administrative and support buildings.
 - Unit rates were developed per square metre, cubic metre, or running metre depending on the activity.
- Road Infrastructure
 - Road estimates were structured around ROW-based cross sections (18 m, 24 m, 36 m) with carriageway, footpaths, and medians.
 - Pavement structure includes layers of GSB, WMM, DBM, and BC as per MoRTH guidelines.
 - Footpath and bridge components estimated separately.
- Physical infrastructure (Water, Sewerage, Stormwater, Electricity):

- Gravity-based and pumped networks for water and sewer systems were assumed.
- RCC underground tanks, trenching, manholes, valve chambers, and cabling ducts costed using civil SoRs.
- Firefighting and water treatment components estimated with typical component rates based on IS/NBC norms.
- Public housing
 - G+2 RCC framed construction model with internal MEP, sanitation, and common circulation areas.
 - Labour housing unit counts were calculated using population projections and URDPFI norms (1 unit per 3 persons).
 - Estimated on a per square metre basis inclusive of structural, architectural, plumbing, and electrical works.
- Social infrastructure
 - Schools, health centres, and parks sized as per URDPFI norms.
 - Block cost estimates were developed using standard unit rates for RCC structures with basic finishes and services.
- Utilities and MEP components
 - Electrical infrastructure includes HT/LT panel boards, transformers, DG sets, AMF panels, and cabling.
 - Plumbing items include booster pumps, water supply pipelines, and rainwater harvesting.
 - All costs for utility-related civil works exclude supply and laying of pipes, cables, and mechanical fittings unless explicitly mentioned.
- Escalation and overheads
 - A flat escalation of 12% for two years has been added to account for inflation to cover the current market assessment and SORs use of 2024. Beyond 2025, during further studies and execution, no escalation has been considered and to be considered in subsequent stages.
 - Suitable assumptions for contingencies have been made and accounted for includes provision for 05% for physical contingencies and administrative overheads and additional soft costs.

8.2.4 Key exclusions

- GST and other statutory taxes
- Price escalation beyond 2025
- Statutory clearances, CRZ zone changes

8.2.5 Caveats

- Estimates are not suitable for tendering or contractual purposes without DPR-stage revision
- A cost variance of $\pm 30\%$ may be expected due to changes in scope, design, or market rates

- These figures serve as a budgeting tool for infrastructure sequencing and investment discussions. The cost estimation framework is intended to bring financial clarity at the planning stage and should be revisited as more detailed data becomes available through site investigations, final design development, and procurement inputs

Users are advised to revise and validate these estimates during the DPR stage or during pre-tender documentation based on approved engineering drawings, geotechnical inputs, and updated GMB/CPWD/NH SoR references.

8.3 Unit rates

Refer Annexure H for explanation on unit rates considered for cost estimation

8.4 Recycling yard - cost estimates

The recycling yard cost estimates have been structured in two distinct parts as part of the Phase 2 implementation strategy:

- **Part A: Earthwork and preliminary land development** – This includes all bulk cutting, filling, levelling, compaction activities, development of compound wall and gate to prepare the base for yard plots. These costs are expected to be borne by Gujarat Maritime Board (GMB) as part of enabling infrastructure.
- **Part B: Plot-level development** – This includes actual construction works within each plot such as pavements, buildings, utilities, storm water, drainage, electrical and plumbing infrastructure. These costs are envisaged to be borne directly by the plot owners at the time of individual plot allotment and development. Additionally, any cost for compaction/filling in the intertidal area if required shall be worked out separately by the plot owner as it will be different per each plot.

The unit rates applied are as per concept engineering and standard reference schedules, with explanatory breakdowns provided in Annexure H – Unit Rate Explanations.

8.4.1 Earthwork and land preparation – GMB Scope

Earthworks include excavation of existing ground, re-use of cut material, engineered filling with compaction, and platform preparation for nine new ship recycling plots in phase 1 and more in phase 2 & 3. These activities are necessary to achieve finished levels compatible with road and drainage infrastructure.

Table below details out cost estimate for ground preparation for recycling plots in phases

Table 8-1: Cost estimate per ground preparation for recycling plots in phase 1

Description	Unit			
		Quantity	Unit Rate	Total Amount
Earth cutting works	m ³	7,10,895.97	₹ 353.00	₹ 25,09,46,277
Filling work				
Filling + compaction	m ³	4,59,861.80	₹ 292.00	₹ 13,42,79,646
Filling of excess cut soil	m ³	2,51,034.17	₹ 175.00	₹ 4,39,30,980
			Total	₹ 42,91,56,903

Description	Unit			
		Quantity	Unit Rate	Total Amount
		Total cost in lakhs		₹ 4,291.57
		Add: 12% flat escalation		₹ 514.99
		Add: 05% Contingencies costs		₹ 214.58
		TOTAL		₹ 5021.14

Table 8-2: Cost estimate per ground preparation for recycling plots in phase 2 & 3

Description	Unit			
		Quantity	Unit Rate	Total Amount
Earth cutting works	m ³	10,38,644.18	₹ 353.00	₹ 36,66,41,396
Filling Works				
Additional soil + ramming (murrum)	m ³	19,36,674.30	₹ 292.00	₹ 56,55,08,896
			Total	₹ 93,21,50,291
			Total cost in lakhs	₹ 9,321.50
		Add: 12% flat escalation		₹ 1,118.58
		Add: 05% Contingencies costs		₹ 466.08
			TOTAL	₹ 10,906.16

Table 8-3: Cost estimate for land development for ship recycling plot in phase 1

	Project components	Phase 1	Phase 2	Phase 3
		Cost in lakhs		
1	Land development cost			
1.1	(Cutting & filling, earthwork, levelling of the entire area)	₹ 5,021.14	₹ 3,091.90	₹ 7,814
1.2	Retaining walls, compound wall & gates	₹ 2,848.01	₹ 1,882.76	₹ 5,358
	Total cost	₹ 7,869.15	₹ 4,974.66	₹ 13,172.63

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.4.2 Plot level development – Private developer scope

Upon completion of the land development by GMB, individual plot holders will undertake development of infrastructure within their allocated plots. These costs have been estimated for two representative plot sizes: 240 m x 215 m and 300 m x 215 m.

Table 8-4: Cost estimate per each plot

Sl. No	Description	Plot - 240*215	Plot - 300*215
		Total Amount	Total Amount
1	Hard impermeable pavement RCC pavement)	₹ 21,86,55,000.00	₹ 27,44,10,000.00
2	Storm water drains network (RCC)	₹ 2,34,40,000.00	₹ 2,85,28,000.00
3	Utility tanks (RCC)	₹ 2,60,60,000.00	₹ 2,83,40,000.00
4	Buildings	₹ 18,44,40,000.00	₹ 21,63,20,000.00
5	Civil works related with utility	₹ 74,02,000.00	₹ 86,95,000.00
6	Plumbing	₹ 2,30,83,545.00	₹ 2,65,66,309.00
7	Electrical works	₹ 55,68,564.00	₹ 57,81,208.00
	Cost	₹ 48,86,49,109.00	₹ 58,86,40,517.00
		₹ 4,886.49	₹ 5,886.41
	Add: 12% flat escalation	₹ 586.38	₹ 706.37
	Add: 05% contingencies costs	₹ 244.32	₹ 294.32
	Total plot cost	₹ 5,717.19	₹ 6,887.09

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.4.3 Backup yard development

The backup yard that the ship recycling yard will develop behind the yard for scrap storage and other facilities will have 2 major components, one being land development that involve cutting, filling compound wall and gate and the other being plot development and this part includes all the facilities inside the backup yard that the recycling management wants to develop. Both the Land and the plot development will be part of private plot owner, GMB will only provide them the land. The cost of the land development phase wise has been included here:

Table 8-5: Cost estimate for backup yard development- phase wise

	Project components	Phase 1	Phase 2	Phase 3
		Cost in lakhs		
1	Land development (Cutting & filling, earthwork, levelling of the entire area)	₹ 7,401.70	₹ 1,592.85	₹ 16,582.30
2	Compound wall & gates	₹ 1,225.45	₹ 811.35	₹ 2,307.25
	Total cost	₹ 8,627.15	₹ 2,404.20	₹ 18,889.55

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.5 Road infrastructure - Cost estimates

The cost estimates for road infrastructure have been developed in a phased manner in line with the overall implementation plan., including carriageways and footpaths. Costing has

been carried out separately for each implementation phase using standard unit rates for bituminous pavement and footpath. The proposed road hierarchy comprises 18 m, 24 m, and 36 m wide roads works as detailed in Annexure H. Additional provisions have been made for contingencies, escalation, and administrative overheads.

Minor bridges have been considered for stretches around 80-100m wide streams lengths and cost of it is included separately. Stream width around 50m is assumed to be aligned by culvert and the cost of the culvert is similar to roads, so the cost of culvert and roads have been included as same for the costing.

Minor bridges have been considered at locations where stream widths are in the range of approximately 80-100 m. The costs associated with these minor bridges have been estimated separately and included accordingly in the overall cost assessment.

For stream crossings with widths of around 50 m, culverts have been assumed as the appropriate crossing structure. Since the unit cost of culvert construction is comparable to that of road construction, the costs for culverts have been included under road infrastructure costs for the purpose of estimation.

8.5.1 Phase 1 – Primary road development

Phase 1 includes major arterial road development forming the core road network across the site in phase 1. Roads of 18 m, 24 m, and 36 m width are considered with a four-lane or six-lane configuration, as applicable. Costing includes both bituminous carriageway and footpath development.

Table 8-6: Cost estimation of phase 1 road infrastructure

Road width in meters	Length of roads in meters	Width of BT section	Total road area	Type of lane	Estimated cost in Rs. /m ²	Amount
						Rs. In lacs
18	810	12	9000	4 Lanes	3000	₹ 291.60
24	5,120	18	86508	4 Lanes	3000	₹ 2,764.80
36	440	26	11440	6 lanes	3000	₹ 343.20
Total						₹ 3,399.60
Road width in meters	Length of roads in meters	Width of footpath	Total footpath area	Type of lane	Estimated cost in Rs. /m2	Amount
						Rs. In lacs
18	810	5	3750	4 Lanes	1400	₹ 56.70
24	5,120	5	24030	4 Lanes	1400	₹ 358.40
36	440	8	3520	6 lanes	1400	₹ 49.28
Total						₹ 469.7
Bridges						
24	200	24	4800	4 Lanes	1,00,000	₹ 4,800.00
Upgradation of existing road						
24	3,000	24	66000	4 Lanes	800	₹ 576.00
				Total cost of road section		₹ 9,239.98
Add: 12% flat escalation						₹ 1,108.80
Add: 05% contingencies costs						₹ 462.00

	Total cost	₹ 10,810.78
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A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.5.2

Phase 2 –Roads

Phase 2 involves road development of the 4.1 km stretch in chopada after phase 1. The plan includes the construction of four-lane roads with widths of 18 meters and 24 meters, while no road construction is proposed under the 36-meter width category in this phase.

Table 8-7: Cost estimation of phase 2 road infrastructure

Road width in meters	Length of roads in meters	Width of BT section	Total road area	Type of lane	Estimated cost in Rs. /m ²	Amount Rs. In lacs
18	485	12	4560	4 Lanes	3000	₹ 174.60
24	3,720	18	66960	4 Lanes	3000	₹ 2,008.80
Total						₹ 2,183.40
Road width in meters	Length of roads in meters	Width of footpath	Total footpath area	Type of lane	Estimated cost in Rs. /m ²	Amount Rs. In lacs
18	485	5	1900	4 Lanes	1400	₹ 33.95
24	3,720	5	18600	4 Lanes	1400	₹ 260.40
Total						₹ 287.00
Total cost of road section						₹ 2,477.75
Add: 12% flat escalation						₹ 297.33
Add: 05% contingencies costs						₹ 123.89
Total cost						₹ 2,898.97

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.5.3

Phase 3 –Road network expansion

Phase 3 continues development of the road network to connect remaining areas and provide secondary access. Similar to Phase 2 it includes the construction of four-lane roads with widths of 18 meters and 24 meters, while no road construction is proposed under the 36-meter width category in this phase.

Table 8-8: Cost estimation of phase 3 road infrastructure

Road width in meters	Length of roads in meters	B.T. area in	Total road area	Type of lane	Estimate d cost in Rs. /m ²	Amount
		m ²				Rs. In lacs
18	1,255	12	13368	4 Lanes	3000	₹ 451.80
24	10,680	18	174960	4 Lanes	3000	₹ 5,767.20
Total						₹ 6,219.00
Road width in meters	Length of roads in meters	Footpat h area in	Total footpath area	Type of lane	Estimate d cost in Rs. /m2	Amount
		m ²				Rs. In lacs
18	1,255	5	5570	4 Lanes	1400	₹ 87.85
24	10,680	5	48600	4 Lanes	1400	₹ 747.60
Total						₹ 758.38
				Total cost of road section		₹ 7,054.45
Add: 12% flat escalation						₹ 846.53
Add: 05% Contingencies costs						₹ 352.72
						₹ 8,253.71

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.5.4 Hard impermeable pavement between proposed plots

For the access to the emergency exits of plots, hard impermeable pavement has been proposed of min width of 6 m to provide access to fire tender in case of emergencies till the end of crane and winch operations.

Cost of these hard impermeable pavement phase wise is as:

Phase	Pavement area	Unit Rate	Amount	Added contingencies	Total cost In lakhs
Phase 1	15,750	4,500	₹ 7,07,94,000	₹ 1,20,34,980.00	₹ 828.29
Phase 2	7,870	4,500	₹ 3,53,97,000	₹ 60,17,490.00	₹ 414.14
Phase 3	20,980	4,500	₹ 9,43,92,000	₹ 1,60,46,640.00	₹ 1,104.39

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.5.5 Summary – Total road infrastructure cost

The total cost of road infrastructure across all three phases is ₹ 24,312 lakhs. These estimates comprehensively account for carriageway construction, footpaths, RCC Pavement between plots, bridges, contingencies, and escalation, provisions based on current market rates and development phasing.

Table 8-9: Total cost estimation of road infrastructure

Phases	Total Cost (in lakhs)
Phase 1	₹ 11,640
Phase 2	₹ 3,313
Phase 3	₹ 9,358
Total Cost	₹ 24,312

8.6**Physical infrastructure - Cost estimates**

The physical infrastructure cost estimates presented below have been developed as block cost assessments aligned with the overall phasing of development. These estimates cover essential backbone facilities including water supply, sewerage, stormwater drainage, contaminated oily water transfer, electricity, TSDF (Treatment, Storage, and Disposal Facility), and other utilities. The costs are indicative in nature and based on broad conceptual planning; detailed project reports (DPRs) for each component will be required to finalise designs and arrive at definitive cost estimates.

8.6.1**Phase 1 – Trunk infrastructure development**

Phase 1 includes the core physical infrastructure required to support the initial phase of site activation and operational areas.

Table 8-10: Cost estimation of physical infrastructure facilities in phase 1

	Infrastructure	Cost in lakhs
1	Water supply	₹ 1,271.84
2	Sewerage	₹ 513.60
3	Stormwater drainage	₹ 360.24
4	Electricity	917.27
5	Contaminated oily water transfer	₹ 1,173.93
5	TSDF	₹ 5,954.40
6	Gas and other utilities	₹ 1,500.00
	Total	₹ 11,691.28
	Add: 12% flat escalation	₹ 1,402.95
	Add: 05% Contingencies costs	₹ 584.56
	Total cost	₹ 13,678.79

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.6.2**Phase 2 – Infrastructure expansion**

Phase 2 supports infrastructure expansion into new zones and includes enhancements to utility capacities and connectivity.

Table 8-11: Cost estimation of physical infrastructure facilities in phase 2

	Infrastructure	Cost in lakhs
1	Water supply	₹ 728.70

	Infrastructure	Cost in lakhs
2	Sewerage	₹ 381.57
3	Stormwater drainage	₹ 303.91
4	Electricity	560.41
5	Contaminated oily water transfer	₹ 811.93
5	TSDF	₹ 3,127.20
6	Gas and other utilities	₹ 600.00
	Total	₹ 6,513.71
	Add: 12% flat escalation	₹ 781.65
	Add: 05% Contingencies costs	₹ 325.69
	Total cost	₹ 7,621.04

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.6.3

Phase 3 – Final build-out

Phase 3 represents the full build-out of physical infrastructure across the remaining project area, including final capacities for trunk services.

Table 8-12: Cost estimation of physical infrastructure facilities in phase 3

	Infrastructure	Cost in lakhs
1	Water supply	₹ 1,833.92
2	Sewerage	₹ 1,054.57
3	Stormwater drainage	₹ 823.55
4	Electricity	1,458.81
5	Contaminated oily water transfer	₹ 2,158.13
5	TSDF	₹ 5,994.00
6	Gas and other utilities	₹ 1,425.00
	Total	₹ 14,747.98
	Add: 12% flat escalation	₹ 1,769.76
	Add: 05% Contingencies costs	₹ 737.40
	Total cost	₹ 17,255.14

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.6.4

Summary - Total physical infrastructure costs

The total estimated cost for physical infrastructure across all three phases is approximately ₹ 38,554.97 lakhs. This includes the core utilities necessary for the functioning of industrial, commercial, and ancillary facilities, and will be progressively implemented as per the development phasing. Final investment requirements may be refined further during DPR preparation and detailed design stage.

Table 8-13: Total cost of physical infrastructure facilities

Phases	Total Cost (in lakhs)
Phase 1	₹ 13,678.79
Phase 2	₹ 7,621.04
Phase 3	₹ 17,255.14
Total Cost	₹ 38,427.97

8.7**GMB housing & amenities cluster - Cost estimates**

This section outlines the block cost estimates for GMB housing to be developed in the designated cluster across the three implementation phases. Cost of each cluster development is around 29.11 cr. Excluding land development.

Table 8-14: GMB housing & amenities cluster cost

Item description	Estimated Qty	Unit (mt/Nos.)	Rate per unit	Estimated amount
Housing unit 600 persons per cluster	280	Units	600000	₹ 16,80,00,000
Convenient shopping 4 m ² per person	2400	sq.mt	25000	₹ 6,00,00,000
Neighbourhood parks & open spaces 9 m ² per person	5400	sq.mt	960	₹ 51,84,000
Internal Roads 15% of the housing cluster area	1260	sq.mt	1930	₹ 24,31,800
Dispensary	400	sq.mt	25000	₹ 1,00,00,000
Total				₹ 24,56,15,800
				₹ 2,456
Add: 12% flat escalation				₹ 294.74
Add: 05% Contingencies costs				₹ 122.81
TOTAL				₹ 2,874

Phase wise cost estimates of GMB housing & amenities cluster are provided in the table below with land development cost.

	Project components	Phase 1	Phase 2	Phase 3
		Cost in lakhs		
1	Land development (Cutting & Filling, Earthwork, levelling of the entire area)	₹ 577.78	₹ 177.34	₹ 1,891.05
2	Cluster development	₹ 5,747.41	₹ 2,873.70	₹ 8,621.11
	Total cost	₹ 6,325.19	₹ 3,051.05	₹ 10,512.16

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

The development of public housing is critical to support the workforce engaged in recycling yards. This cost estimate has been developed at a block level and will be refined during detailed project planning and design stages.

The total cost of constructing labour housing in all three phases is approximately ₹ 19,888.40 Lakhs (198.88 Cr).

8.8 Multi-speciality hospital and training institute - Cost estimates

This section outlines the block cost estimates for social infrastructure facilities planned across the three implementation phases focusing on ship recycling activities. These are indicative costs based on standard land-use norms and unit costs for institutional facilities and shall be refined during the DPR stage based on final designs, locations, and integration with physical infrastructure.

Table 8-15: Cost estimation of social infrastructure facilities in phase 2

Facility	Phase	Cost (in lakhs)
Training institute (upgradation)	Phase - 2	100
Mult speciality hospital	Phase - 2	1575
	Total	1675
	Add: 12% flat escalation	201
	Add: 05% contingencies	83.75
	Total cost	₹ 1959.75

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.9 Scrap market – cost estimates

Cost of scrap market that are envisaged behind the backup yard includes land development and plot development. Development of land including cutting, filling, compound wall and gate development will be taken over by GMB and the developed land with compound wall will be given on lease to interested players. Development of plot including any shed, building will be carried out by private players as per their requirement.

Table 8-16: Land development cost for scrap market

		Phase 1	Phase 2
	Project components	Cost in lakhs	
1.1	Land development (Cutting & Filling, Earthwork, levelling of the entire area)	₹ 2,632.11	₹ 1,596.10
1.2	Compound wall & gates	₹ 1,380.02	₹ 2,365.74
	Total cost	₹ 4,012.13	₹ 3,961.84

Cost of land development in phase 3 will be carried out by the respected private player as the leasing of shops in phase 3 will be as and when basis.

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.10

Soft dredging – cost estimates

The soft dredging shall be carried out by GMB to chisel out the hard strata for the ship to navigate smoothly to the shore. Cost of dredging has been worked out in phases as below:

Table 8-17: Dredging cost

	Phase 1	Phase 2
Dredging area (in m²)	2,16,000	4,22,000
Average dredging depth (m)	1.5	1.5
Total dredging volumes	3,24,000	6,33,000
Rate per m²	₹ 326	₹ 326
Total cost (in lakhs)	1056.24	2063.58
<i>Add: 12% flat escalation</i>	126.7488	247.6296
<i>Add: 05% Contingencies costs</i>	52.812	103.179
Total cost	1235.80	2414.39

Total cost of dredging across phases is around 3650.19 Lakhs (36.50 Cr).

A flat escalation of 12%, 5% for physical contingencies and administrative overhead and additional soft costs towards further studies like DPR, EIZ, etc, PMC services, further detailed investigations, etc. have been assumed.

8.11

Land acquisition and forest conversion cost

8.11.1

Land acquisition

As GMB is intending to follow land acquisition approach for implementation mechanism, tentative land acquisition cost has been worked out for three phases.

The cost of government land has been considered Based on agricultural jantri rate (2011), which is in the range of ₹ 50 to ₹ 100 per m² based on village and survey number. For the cost estimation purpose, maximum of irrigatable and non-irrigatable rates have been considered.

For private land, the same jantri rate has been doubled as per The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (LARR Act) and additional 100% as solatium has been considered and the total to be 4 times the Jantri rate. The tentative land acquisition rate has been derived as per the current Agriculture Jantri rate. The final rate may vary as per the rates decided by the Competent authority.

Table 8-18: Land acquisition cost

Phase	Type of land	Total area (Ha)	Acquisition cost in Lakhs	Total Acquisition cost in Lakhs
Phase 1	Government land	3.0	₹ 84	₹ 4,908.12
	Private land	138.01	₹ 4,824	

Phase	Type of land	Total area (Ha)	Acquisition cost in Lakhs	Total Acquisition cost in Lakhs
Phase 2	Government land	44.8	₹ 269	₹ 3,242.68
	Private land	123.6	₹ 2,974	
Phase 3	Government land	126.1	₹ 779	₹ 3,209.19
	Private land	100.5	₹ 2,431	
	Total	536.12		
		Total LA Cost (Cr.)		₹ 11,359.99

8.11.2 Forest conversion

As per the revised Net Present Value (NPV) for Eco Class-I, a rate of ₹16 lakh per hectare has been considered. Additionally, a cost of ₹50 lakh per hectare has been assumed for compensatory afforestation land and ₹12 lakh per hectare for compensatory afforestation activities to arrive at the tentative total cost of forest conversion.

Table 8-19: Forest conversion cost

Phase	Type of land	Total area (Ha)	Forest conversion cost (in Lakhs)	Total cost (in Lakhs)
Phase 2	Reserve Forest	20.45	₹ 1,595	₹ 8,065
Phase 3	Reserve Forest	82.96	₹ 6,470	

The cost provided are indicative and subject to change based on the availability of compensatory land for afforestation, the scale of afforestation activities required, and other statutory compliance costs. These estimates will be refined during subsequent stages of the approval and conversion process.

8.12 Cost breakup for GMB

The total project cost has been categorized across two primary stakeholder groups based on roles and responsibilities in the development process. These are:

- Ship recycling plot owners
- Gujarat Maritime Board (GMB)

Each category's contribution has been determined based on their respective scope of development during each implementation phase.

8.12.1 Ship recycling plot

Plot owners will be solely responsible for the development within individual ship recycling plots, including internal pavements, plot-specific buildings, machinery foundations, and services. GMB's role is limited to land grading and bulk earthworks to provide a levelled site for handover.

This approach promotes private investment while enabling efficient public resource deployment. Plot development costs can be recovered by plot holders over the lease period, especially if longer-term leases are granted.

All subsequent infrastructure within the plot boundaries will be privately developed by the ship recyclers. Cost to develop each plot after preliminary earthwork considering escalations and contingencies is provided below.

Table 8-20: Cost estimate for plot development - each

Plot	Cost (Lakhs)
240 m Plot	₹ 5,717.19
300 m Plot	₹ 6,887.09

8.12.2 Gujarat Maritime Board

GMB will be responsible for core infrastructure across the entire master plan.

- **Basic infrastructure (Core yard and physical infrastructure)** - This component covers the following essential infrastructure:
 - Earthwork and levelling for recycling plots
 - Internal and regional road network
 - Core physical infrastructure (water supply, sewerage, stormwater, and power)
 - GMB housing & Amenity blocks
- **Land acquisition and forest conversion** - This component covers tentative land acquisition cost and forest conversion cost:

Table 8-21: Phase wise cost estimates for basic infrastructure

	Project components	Phase 1	Phase 2	Phase 3
A	Infrastructure	Cost in Lakhs		
1	Roads (Roads, bridges and pavements in between)	₹ 11,640.01	₹ 3,313.32	₹ 9,358.30
2	Water supply (Water reservoirs, pumping stations, water supply network)	₹ 1,488.06	₹ 852.58	₹ 2,145.68
3	Sewerage system (Sewerage network, STP's)	₹ 600.91	₹ 446.44	₹ 1,233.85
4	Stormwater network	₹ 421.48	₹ 355.57	₹ 963.56
5	Electricity & Utilities duct (Electricity, ELV and facility for optic fibre etc..)	₹ 1,073.20	₹ 655.68	₹ 1,706.81
6	Contaminated oily water network (Pipeline, intermediate sumps, pumping stations & SCADA System)	₹ 1,373.50	₹ 949.96	₹ 2,525.01
7	Gas network	₹ 1,755.00	₹ 702.00	₹ 1,667.25
8	TSDF	₹ 6,966.65	₹ 3,658.82	₹ 7,012.98
9	Multi-speciality hospital & upgradation of training institute	-	₹ 1,959.75	-
10	Land development cost for ship recycling plots (Cutting & filling, Retaining walls, Compound wall & gates)	₹ 7,869.15	₹ 4,974.66	₹ 13,172.63

	Project components	Phase 1	Phase 2	Phase 3
11	Public utility cluster development cost (Cutting & filling, housing units, shopping centre and parks)	₹ 6,325.19	₹ 3,051.05	₹ 10,512.16
12	Land development of secondary market shops (cutting & filling and compound wall & gate)	₹ 4,012.13	₹ 3,961.84	₹ 0.00
13	Soft dredging (Land based excavation of hard strata)	₹ 1,235.80	₹ 2,414.39	
	Total	₹ 44,761.08	₹ 27,296.05	₹ 50,298.23
B	Land acquisition cost	₹ 4,908.12	₹ 3242.68	₹ 3209.19
C	Forest conversion	-	₹ 1,595	₹ 6,470
	Grand Total (A+B+C)	₹ 49,669.20	₹ 32,133.73	₹ 59,977.42

8.12.3 Summary

- Infrastructure (core yard, roads, and utilities) requires ₹ 1,22,355.36 lakhs (₹ 1,223.55 Cr) across all three phases.
- Tentative cost of forest conversion and land acquisition is around ₹ 19,424.99 (₹ 194.25 Cr)
- Total cost for GMB for the proposed development in three phases is ₹ 1,41,780.35 (₹ 1,417.80 Cr)

These figures are based on preliminary block estimates and will be revised during DPR preparation. Final project costs may vary by up to ±30%, based on site-specific design finalisation, procurement mode, and construction methodology.

This phased and stakeholder-based allocation allows for flexibility in financing, while ensuring that critical infrastructure is prioritised in line with long-term yard operational requirements.

9

9.1

Conclusions and Recommendations

Conclusions

- **Capacity potential** - Alang has the capability to surpass its current estimated annual capacity of 4.5 million LDT and scale up to 11.3 million LDT by 2038 and above, driven by planned infrastructure and operational improvements.
- **Plot performance insights** - While smaller, high-density plots demonstrate higher productivity per unit area, larger plots provide opportunities for greater scalability and more efficient layout planning.
- **Strategic development planning** - Achieving long-term capacity goals will require careful plot allocation, along with a phased transition strategy aligned with demand, infrastructure availability, and compliance requirements.
- **Preferred dismantling method** - The controlled landing method has emerged as the most practical, scalable, and cost-effective approach for Alang's operational and environmental context.
- **Infrastructure and worker safety upgrades** - Investing in modern infrastructure, developing a pilot model plot, and enhancing worker safety protocols will enable Alang to:
 - Attract more international ship recycling business
 - Minimize environmental risks
 - Sustain its position as a global leader in the ship recycling sector
- **Technology integration** - Adoption of advanced technologies—such as automation, plasma cutting, and real-time monitoring systems—will be key to improving operational efficiency and safety.
- **Regulatory compliance and sustainability** - Ensuring adherence to global standards including the Hong Kong Convention (HKC), EU Ship Recycling Regulation (EU SRR), and the Basel Convention will be crucial for maintaining long-term sustainability and international competitiveness.

Table 9-1: Actionable roadmap

Action area	Key actions
Infrastructure investments	- Upgrade crane capacities, introduce automated cutting. - Implement RFID tracking & digital workflow management.
Layout optimization	- Extend plots towards seaside/landside for better block processing. - Utilize land behind plots for dismantling to reduce congestion.
Workforce management	- Upskill workers for modernized equipment & optimized workflows to reach 1.0-2.0 LDT/worker/day.
Strategic mergers & compliance	- Consolidate smaller inefficient plots into optimized larger units. - Ensure compliance with HKC & EU SRR standards.

- Based on the above proposals, the total estimated cost for the enhancement and expansion of the Alang ship recycling facility is approximately ₹1,417.80 crore, to be implemented over three phases spanning the next 15 years and above for GMB.
- This estimate excludes the cost of plot development, backup yard and scrap reseller shops, which are expected to be undertaken by respective stakeholders. These components have been detailed separately in the cost estimates section.

9.2

Key strategic recommendations

- Adoption of modified controlled landing method for Alang
 - Develop modified controlled landing infrastructure suited to Alang's site conditions, including engineered impermeable flooring, reinforced slopes, and integrated drainage systems.
 - Ensure primary cutting operations are conducted on impermeable flooring in compliance with EU SRR requirements.
 - Utilize well-engineered hardstands, winching systems, and airbag-assisted or equivalent vessel positioning mechanisms for improved control and safety.
- Optimization of plot size and land utilization
 - Small plots (30–80 m waterfront width)
 - Extend plot length up to 200–215 m (beyond which diminishing returns are expected).
 - Upgrade crane capacity, introduce technology enhancements, and invest in workforce upskilling.
 - Medium plots (80–100 m waterfront width)
 - Increase plot length to 200–215 m.
 - Improve block handling through twin processing lines and automated crane systems.
 - Large and very large plots (120 m, 240 m, 300 m waterfront width)
 - Enable parallel processing for multi-ship dismantling operations.
 - Integrate automation, RFID tracking, and robotic dismantling systems.
 - Waterfront width optimization
 - 120 m: Suitable for standalone large plots.
 - 240–300 m: Enables multi-ship dismantling, requiring proportional infrastructure and operational upgrades.
- Infrastructure and environmental upgrades
 - Equip primary cutting zones with reinforced concrete surfaces or steel plates to contain pollutants.
 - Implement advanced drainage systems with sediment traps, oil-water separators, and wastewater treatment provisions.
 - Upgrade hazardous waste storage facilities to prevent leaks and cross-contamination.
 - Deploy digital tracking systems for waste management and environmental compliance monitoring.

- Pilot model recycling plot for EU SRR compliance
 - Develop a fully EU-compliant pilot plot to serve as a regulatory test site, training ground, and demonstration facility.
 - Collaborate with government bodies, shipowners, and international agencies for technical assistance and funding.
 - Integrate real-time environmental monitoring systems for on-site compliance validation.
- Capacity expansion and phased growth strategy (2025–2040)
 - Phase 1 (2025–2027): Optimize current plots, pilot automation initiatives & Expand operations into CRZ-II.
 - Phase 2 (2028–2038): Advance into CRZ-IA zone (approx. 1.9 km), deploying fully optimized recycling plots of 11.3 M LDT.
 - Phase 3 (2039+): Advance further into CRZ-IA zone (approx. 5 km), if required based on the market.
- Policy and regulatory enhancements
 - Introduce government-led incentives for transitioning to the controlled landing method.
 - Mandate training programs for hazardous material handling, safety compliance, and automation use.
 - Implement strict compliance audits via accredited third-party agencies.
- Technological and operational improvements
 - Use GPS-guided winching systems and airbag-assisted ship movement technologies for precise positioning.
 - Integrate robotic dismantling, plasma cutting tools, and RFID-enabled tracking for improved efficiency and traceability.
 - Install real-time pollutant monitoring sensors within drainage systems to enable automatic containment and alerts.
- Long-term planning for sustainable ship recycling
 - Expand and modernize the centralized waste treatment facility (TSDF) for hazardous waste handling.
 - Conduct regular audits and engage third-party verifiers to build international credibility and trust.
 - Adapt expansion and infrastructure strategies based on evolving global ship recycling trends and market forecasts.

Annexure A: Compliance with guidelines

1. HKC (The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009)

The HKC sets rigorous standards focusing on safe working practices, comprehensive hazardous material handling, robust environmental protections and proper infrastructure. Both the operational systems and physical layout must work together to minimize risks and ensure sustainable recycling.

The operational and infrastructural requirements drawn from IMO's resources are summarized in succeeding paragraphs:

- **Operational requirements (Procedural and Management Systems):** The HKC's operational requirements envisage that the recycling process is carried out safely, with minimal risk to human health and the environment.
 - **Ship Recycling Facility Plan (SRFP):** The facility must have an approved SRFP comprising:
 - Procedures for safe and environmentally sound recycling
 - Emergency preparedness and response
 - Management of hazardous materials
 - Waste management protocols
 - Worker health and safety measures
 - Facility layout and operational flow
 - Maintenance of infrastructure and equipment
 - Inventory of Hazardous Materials (IHM) management
 - Facilities must review the IHM provided by the shipowner
 - Must plan for the safe removal and handling of hazardous material
 - **Safe work procedures:** Standard Operating Procedures (SOPs) must be implemented for:
 - Hot work (cutting and welding)
 - Confined space entry
 - Lifting and material handling
 - Decontamination processes
 - Handling and neutralizing hazardous substances
 - Emergency shutdown
 - Firefighting and rescue operations
 - Worker safety and health:
 - Personal Protective Equipment (PPE) provision and enforcement

- Regular health check-ups and medical facilities onsite
 - Training programs on safety, first aid and hazardous material handling
 - Incident reporting and investigation systems
 - Restricted access to high-risk areas
 - **Waste management:** The waste management must focus on following aspects
 - Identification, segregation, storage, treatment and disposal of waste
 - Secure storage of hazardous waste with secondary containment
 - Proper documentation of all waste streams
 - Agreements with authorized waste disposal and treatment companies
 - **Environmental protection measures:** Implement suitable procedures to prevent and respond to:
 - Oil spills
 - Air emissions
 - Water contamination
 - Soil pollution
 - Stormwater management and runoff control to be ensured
 - **Documentation and record keeping:** The plot owner/management must maintain detailed records of:
 - Incoming ships and their IHM's
 - All hazardous materials removed and their disposal
 - Waste management logs
 - Training and health records of workers
 - Environmental monitoring data
 - Inspection and audit reports
 - **Emergency preparedness and response:** Following measures must be in place
 - Onsite firefighting systems and trained firefighting teams
 - Spill containment and recovery equipment
 - Evacuation plans and drills
 - Coordination with local emergency services
 - Regular review and testing of emergency plans
 - Continuous improvement requirements
 - Regular internal and external audits
 - Feedback systems to improve processes
 - Incident analysis and corrective action implementation
- **Infrastructural requirements (Physical setup and facilities):** These requirements are specified in accordance with HKC requirements to ensure that the ship recycling plot is equipped to safely handle and process vessels without causing environmental damage.

- **Impermeable working surface:** A concreted area or equivalent impermeable flooring where:
 - Hazardous materials are removed
 - Cutting operations are carried out
 - Must have a drainage system to collect and treat runoff
 - Drainage and effluent treatment
 - Network of closed drainage collecting contaminated water
 - Effluent Treatment Plant (ETP) to treat water before discharge
 - Oil-water separators
 - Monitoring points for water quality
- **Hazardous waste storage:** Designated, weatherproof hazardous waste storage areas with:
 - Secondary containment
 - Labelling of hazardous materials
 - Segregation of incompatible materials
 - Security to prevent unauthorized access
 - Ship containment infrastructure
 - Berthing arrangements to secure ships during dismantling
 - Block and tackle systems to prevent ship movement
 - Hull support systems to avoid grounding damage and minimize spill risk
 - Material handling and lifting equipment
 - Cranes and lifts suitable for heavy parts
 - Forklifts and trucks for internal transport
 - Decontamination stations for equipment
 - Access control and perimeter security
 - Fencing around the facility
 - Controlled entry and exit points
 - Worker identification systems
 - Firefighting infrastructure
 - Fire hydrants strategically placed across the plot
 - Fire extinguishers in key areas
 - Firewater storage tanks
 - Fire alarms and communication systems
 - First aid and medical facilities
 - Onsite first aid centre
 - Ambulance availability
 - Emergency showers and eyewash stations
 - Isolation areas for contaminated injuries
 - Air emission controls
 - Extraction systems for fumes from cutting

- Filters or scrubbers to control particulates and gases
- Monitoring stations for air quality
- Waste processing units
- Oil recycling or storage tanks
- Solid waste compaction and bundling areas
- Segregation zones for ferrous and non-ferrous metals
- Lighting and signage
- Adequate lighting for night operations
- Safety signage, including hazard warnings and emergency exits
- Monitoring infrastructure
- Groundwater monitoring wells
- Air quality sensors
- Noise level monitoring if near residential areas

2. EU Ship Recycling Regulation (EU SRR) Requirements

The **EU SRR (Regulation (EU) No 1257/2013)** aims to ensure that ship recycling takes place in safe, environmentally sound conditions, especially for ships flying the flag of EU member states, by regulating both ships and recycling facilities.

The EU SRR emphasizes **strict environmental controls, worker safety, traceable waste management and continuous oversight** with higher infrastructural standards than HKC. Facilities must be fully equipped, authorized and monitored to recycle EU-flagged ships responsibly.

A detailed breakdown of the requirements of the European Union Ship Recycling Regulation (EU SRR), divided into Operational Requirements and Infrastructural Requirements, covering all mandatory elements are summarised below: -

- **Operational requirements:** These define the procedures, systems and controls required for the safe and environmentally responsible recycling of ships.
 - **Ship Recycling Facility Plan (SRFP):** Must have a comprehensive and approved SRFP that covers:
 - Operational procedures for environmentally sound recycling
 - Risk assessment and mitigation strategies
 - Emergency preparedness and response
 - Monitoring and reporting mechanisms
 - Management of hazardous materials
 - Infrastructure and equipment maintenance schedules
 - Training programs for workers
 - **Inventory of Hazardous Materials (IHM) Handling:** Facilities must review and assess the IHM of each incoming ship. Procedures must ensure that there is no release of hazardous materials into the environment. Ensure identification, safe removal and proper handling of:
 - Asbestos

- PCBs
- Ozone-depleting substances
- Mercury
- Lead
- Hexavalent chromium
- Antifouling compounds
- Other materials listed in Annex I and II of the EU SRR
- Waste management: Full lifecycle management of waste to be ensured including:
 - Segregation
 - Labelling
 - Storage
 - Treatment and disposal via authorized facilities
 - Tracking and documentation of waste streams
 - Agreements with licensed waste handlers for offsite disposal
- Health and safety management: Ensure safe working conditions covering:
 - PPE provision and enforcement
 - Regular health monitoring of workers
 - Training in hazardous material handling, emergency response and safe dismantling
 - Health surveillance programs
- Environmental monitoring and protection: Prevent and control emissions to:
 - Air (dust, fumes, gases)
 - Water (runoff, spills)
 - Soil (leakage of hazardous substances)
- Continuous monitoring systems to assess environmental quality
- Spill containment and response plans
- Emergency preparedness: The plot must have plans and equipment for:
 - Firefighting
 - Oil and chemical spill response
 - Medical emergencies
 - Evacuation procedures
 - Regular emergency drills
- Authorization and certification: The ship recycling facilities must:
 - Be authorized by their national competent authority
 - Undergo periodic audits and inspections
 - Submit reports and records on recycling operations
 - Be listed in the European list of approved ship recycling facilities to handle EU-flagged vessels
- Documentation and Reporting: The facilities must maintain detailed records of:

- Incoming ships
- Removed hazardous material
- Waste management and disposal
- Environmental monitoring results
- Worker health records
- Emergency incidents and responses
- Continuous improvement
- Implement feedback systems
- Periodic internal reviews and external audits
- Corrective and preventive actions after incidents or non-compliance

- **Infrastructural requirements:**

- **Impermeable flooring and containment:** Impervious surfaces (e.g. concrete) in all areas where:
 - Hazardous materials are handled
 - Cutting and dismantling occur including primary cutting
 - Implement systems to prevent soil and groundwater contamination
 - Collection of runoffs for treatment to be ensured
 - Drainage and wastewater treatment
 - Fully contained drainage networks
 - Effluent treatment plants to handle contaminated water
 - Zero discharge of pollutants beyond permitted levels
 - Regular water quality monitoring
 - Hazardous waste storage areas
 - Secured, covered and secondary-contained zones for hazardous materials to be provided
 - Clear labelling and segregation of waste types to be undertaken
 - Fire protection in storage areas to be ensured by maintaining safe distances from fire hazards and providing necessary measures
- **Safe berthing and ship handling:** The facilities must have systems to:
 - Secure vessels during dismantling
 - Prevent accidental movements (blocking and stabilization systems)
 - Minimize the risk of spills during beaching or landing (if allowed) or alongside operations
- **Equipment for safe operations:** The facilities must have followed suitable equipment:
 - Heavy lifting equipment (cranes, winches) with routine safety inspections
 - Decontamination stations
 - Mobile and fixed cutting equipment with fume extraction systems
 - Fire safety infrastructure requirements
 - Fire detection and suppression systems across the site

- Dedicated firefighting equipment and trained personnel
- Firewater storage and delivery systems
- Medical and emergency facilities
- Onsite first aid stations
- Emergency showers and eye wash stations
- Immediate access to medical assistance
- Safe muster points and evacuation routes
- **Air emission controls:** Following systems to be incorporated:
 - Fume capture and filtration for cutting operations
 - Dust suppression systems
 - Monitoring of workplace air quality
- Waste handling and processing facilities:
 - Segregation areas for metals (ferrous and non-ferrous)
 - Oil recovery and storage tanks
 - Compaction, bundling and storage facilities for recyclables
- Designated areas for dismantling specific ship components (e.g. engine rooms)
- Perimeter security and access control:
 - Secure fencing of the entire site
 - Entry control points
 - Visitor management systems
- Lighting and safety signage features:
 - Adequate illumination for night operations
 - Visible and durable safety signage indicating hazards, emergency routes and restricted zones
- Environmental monitoring infrastructure requirements: Onsite monitoring stations for
 - Air quality
 - Water discharge
 - Groundwater wells
 - Noise monitoring where applicable

3. Indian Ship Recycling Act, 2019

The **Indian Ship Recycling Act, 2019** was enacted to align India's ship recycling industry **mirroring** the **Hong Kong International Convention (HKC)** standards and promote environmentally sound and safe recycling practices in the country, particularly in major plots like Alang. The Act mandates compliance with safety, health and environmental protections.

It legally enforces high standards for infrastructure, environmental protection, worker safety and waste management, ensuring the long-term sustainability of India's ship recycling industry. Since, these requirements mirror the HKC requirements that have been discussed earlier, the same is not repeated hereunder.

Annexure B: Statistical analysis of all plots

Mean, Median, Standard Deviation, Spread and variability of LDT productivity per unit area in m² for overall as well as in various plot size clusters has been obtained and is tabulated below:

1. Statistical results

- The mean maximum achieved productivity/unit area/year is 6.786 LDT/m² for all 124 plots
- The median of maximum achieved productivity/unit area/year is 5.78 LDT/m² for all 124 plots
- The range of maximum achievable productivity per year is 1.0 to 23.7 LDT/m²/year
- It is seen that both the mean and median of the max LDT/unit area/year are higher than the estimated average productivity of 5.74 LDT/m²/year based on maximum projected annual capacity of 4.5 M LDT/year for Alang Soshiya yard (if all 153 plots are considered). It indicates that the Alang plots have potential to achieve higher production capacity despite the fact that the last 09 years of data pertains to the decline period of ship recycling cycle.

Table B-1: Cluster wise statistical analysis of all plots

Width Category	% of Plots by waterfront width	Min	Max	Std deviation	mean	median
		LDT/m ² /year				
30-50 m	39.5	1.4	22.7	4.1	7.5	6
51-80 m	41.1	1.6	23.7	3.6	6.5	5.6
81-100 m	8.9	2.5	6.3	1.2	4.3	4
101-135 m	5.6	1	11.7	3.6	6.1	6.4

The key inferences drawn from the cluster wise statistical analysis are as under:

30-50 m: This category contains (39.5%) of plots and is a popular size range for waterfront properties.

- **LDT/m² Range:** The unit area productivity 1.4 to 22.7 suggests very high variability in the productivity.
- **Standard deviation:** 4.1, indicates high variability in productivity values.

- **Mean:** 7.5 is quite lower compared with highest productivity which is considered as abrasion.
- **Median:** 6.0, suggests that most plots are closer to the lower end of the LDT/m² range.

51-80 m: it constitutes 41.1% of plots, indicating this has been the most favoured size range for waterfront developments.

- **LDT/m² Range:** 1.6 to 23.7 shows high variability in productivity values.
- **Standard deviation:** 3.6 is slightly lower than the 30-50 m category. It indicates more consistent per unit area productivity in this category.
- **Mean:** 6.5, slightly lower than the previous category.
- **Median:** 5.6 is closer to the lower end of productivity.

81-100 m: This category has a smaller proportion with just 8.9% of plots by waterfront. It is a less common segment with larger yet constrained width.

- **LDT/m² Range:** 2.5 to 6.3 shows low variability and higher consistency.
- **Standard deviation:** 1.2 is the lowest among all categories which indicates highly consistent LDT/m² values.
- **Mean:** 4.3, lower than smaller categories which could possibly be due to lower business during the period of business decline in ship recycling industry.
- **Median:** 4.0. It closely aligns with the mean which shows minimal skewness in the productivity values for this category.

101-135 m: Only 5.6% of plots fall into this category, indicating that it is the least common range. This could possibly be due to limited availability. Other insights are as under:

- **LDT/m² Range:** 1.0 to 11.7 indicates moderate variation.
- **Standard deviation:** 3.6, suggests moderate variability.
- **Mean:** 6.1, close to the 51–80-meter category which suggests that these plots have comparable productivity values with smaller plots mean.
- **Median:** 6.4 is slightly higher than the mean, indicating some plots have higher productivity.
- In this category, the higher mean and median could also be because of their capability to handle larger and multiple ships and better layouts.

2. Deeper analysis of top 25% performers LDT/m² statistics by width category

The statistical analysis of LDT/m² for the top 25% performers in each waterfront width category is provided in the table below. It includes the mean, maximum value, minimum value, median and standard deviation for each category.

Table B-2: Cluster wise statistical analysis of top 25% performers

Width Category	Min	Max	mean	median	Std deviation
	LDT/m ² /year				
30-50 m	5.48	5.48	10.42	11.25	11.25
51-80 m	3.41	3.41	8.8	7.28	7.28
81-100 m	5.27	5.27	5.49	5.49	5.49
101-135 m	11.66	11.66	11.66	11.66	11.66

3. Inferences drawn from the analysis of top 25% Performers' LDT/m² statistics by Waterfront width category

30-50 m category:

- Smaller plots in this range have std dev of 3.9. High performing plots are well-utilized and deliver consistent high productivity per unit area. This could be due to their compact size, making them operationally dense and efficient.

51-80 m category:

- This category shows the highest variability (std dev = 5.32) among all categories which indicates that productivity depends heavily on specific plot operations and management. The range of LDT/m² (3.41 to 23.73) suggests that while some plots may be performing exceptionally well, others have lower efficiency even among the top performers.
- Median (7.28) is below the mean, suggesting a skewed distribution where a few exceptionally high-performing plots pull the average upward.
- **Balanced performance:** The plots in this category combine moderate cumulative LDT with decent LDT/m². They likely handle a mix of medium to large ships, making them versatile.

81-100 m category:

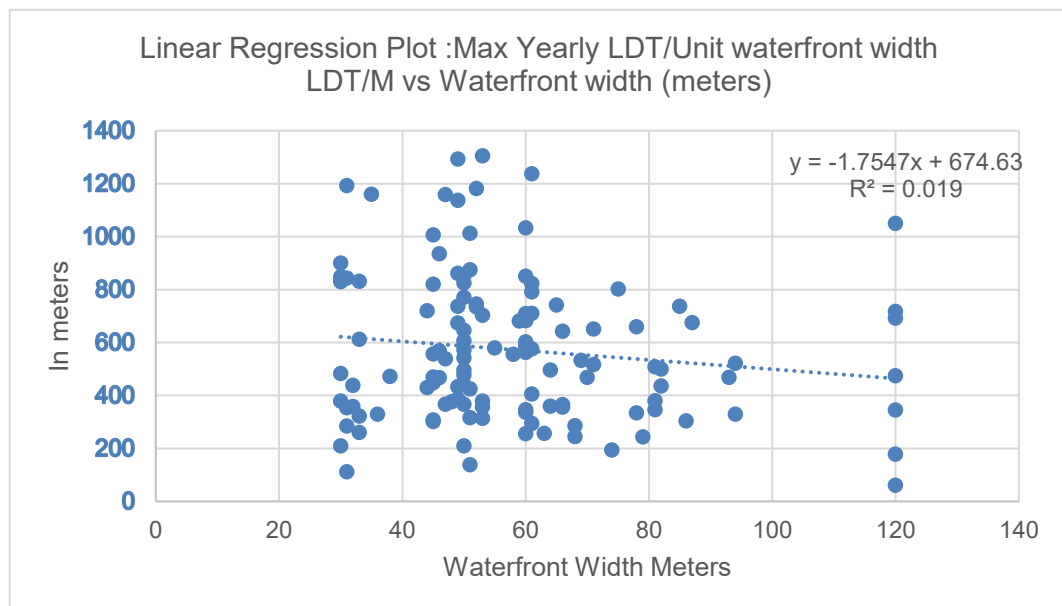
- This category demonstrates extremely low variability (std = 0.31) which indicates consistent productivity among the top performers. The tight range (5.27 to 5.71) reflects that these plots have steady operations but lower productivity.
- **Specialized operations:** Plots in this range typically show lower LDT/m² but consistent cumulative LD. This could be due to the reason that these plots may be handling specific types of operations (e.g. complex ships or specialized tasks or probably due to poor management across the category).
- **Underutilization:** The lower productivity per unit area may indicate that these plots may not be fully utilized compared to smaller ones during the period of decline.

101-135 m category:

- There is only one plot in this top 25% category as the data field is very small (only 07 plots).
- The high LDT/m² of this plot suggests that it is a well-managed and specialized plot among the top performers which could be handling large specific ship types. It's relatively high cumulative LDT but moderate per unit area productivity suggest that this plot handle unique or high-tonnage operations.
- Despite lower numbers, these plots may cater to high-value ship recycling projects, which justifies their presence among top performers.

Annexure C: Regression and co-relation analysis of historical plot data

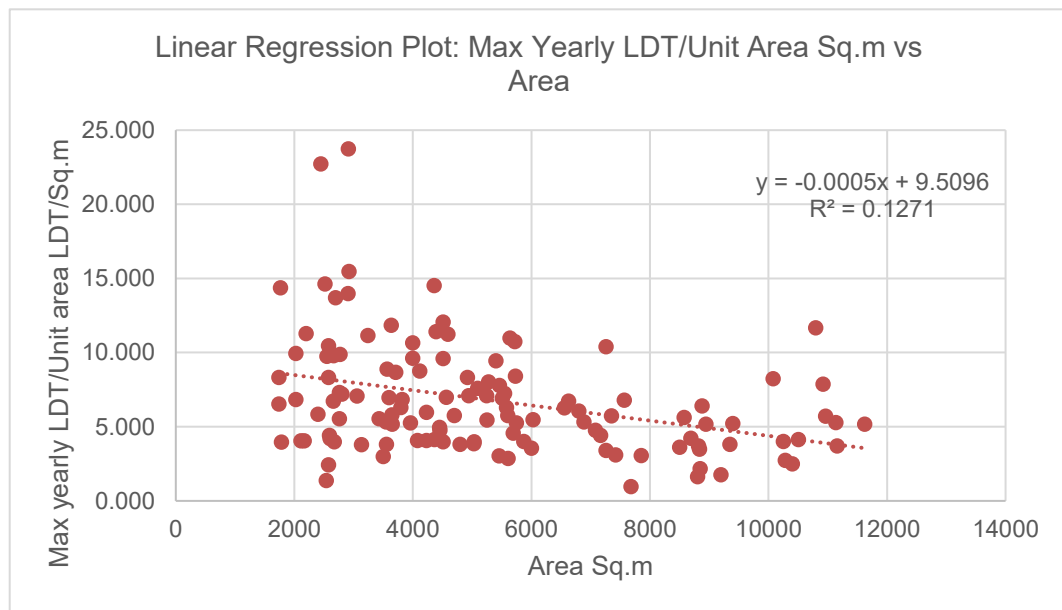
Figure C-1: Regression plot: Waterfront width vs. Highest LDT/Unit waterfront width (last 09 Years)



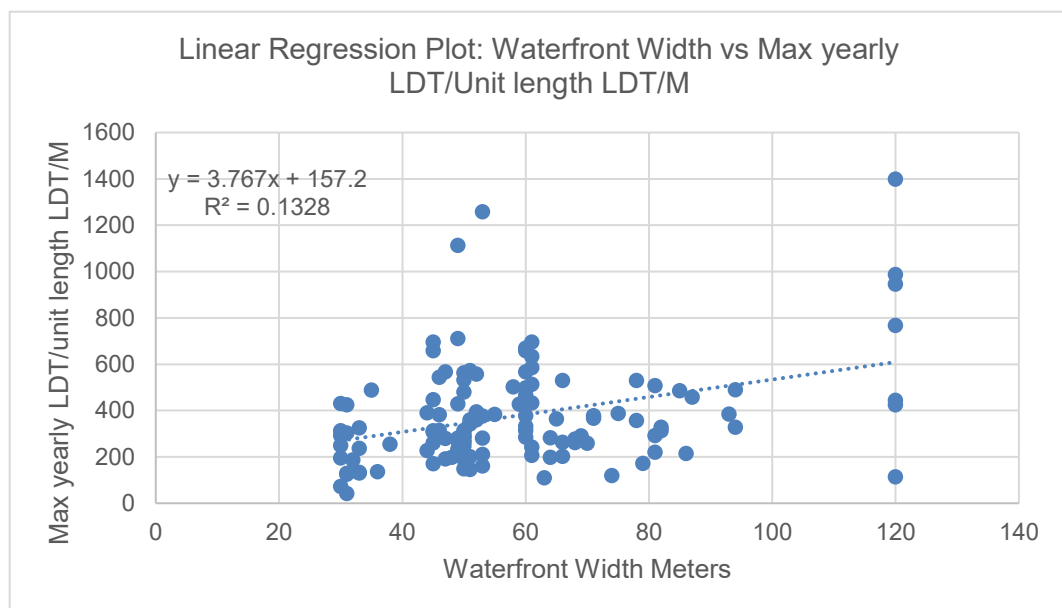
The regression plot above shows the relationship between waterfront width and the highest LDT/unit waterfront width.

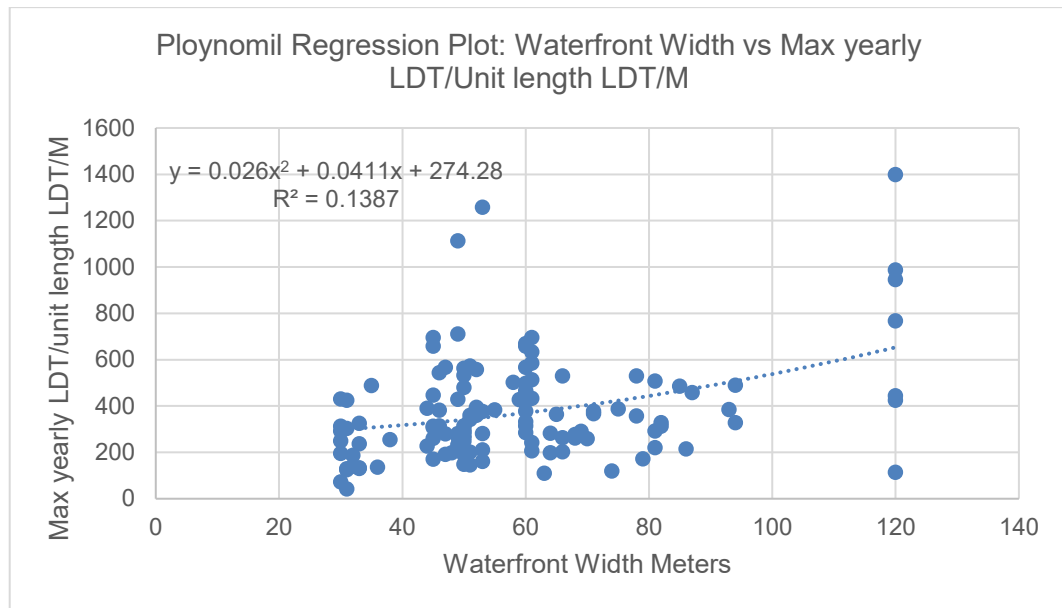
Interpretation:

- **Trend:** The regression line and low R^2 value of 0.019 suggests a weak negative relationship which indicates that with increase in waterfront width, the productivity may reduce slightly.
- **Outliers:** Some data points deviate significantly from the trend as was also observed from statistical analysis.

Figure C-2: Regression plot: Area vs. Highest LDT/Unit area**Interpretation:**

- **Trend:** The regression plot suggests a weak negative correlation between the area and highest LDT/unit area.
- **Inference:** Larger plot areas might not improve the productivity (LDT per unit area), but the relationship is not strong. This indicates that plot area alone is not a dominant factor in determining unit area productivity.
- **Outliers:** There are a few smaller areas which exhibit exceptionally high productivity that could be due to operational or plot specific efficiency.

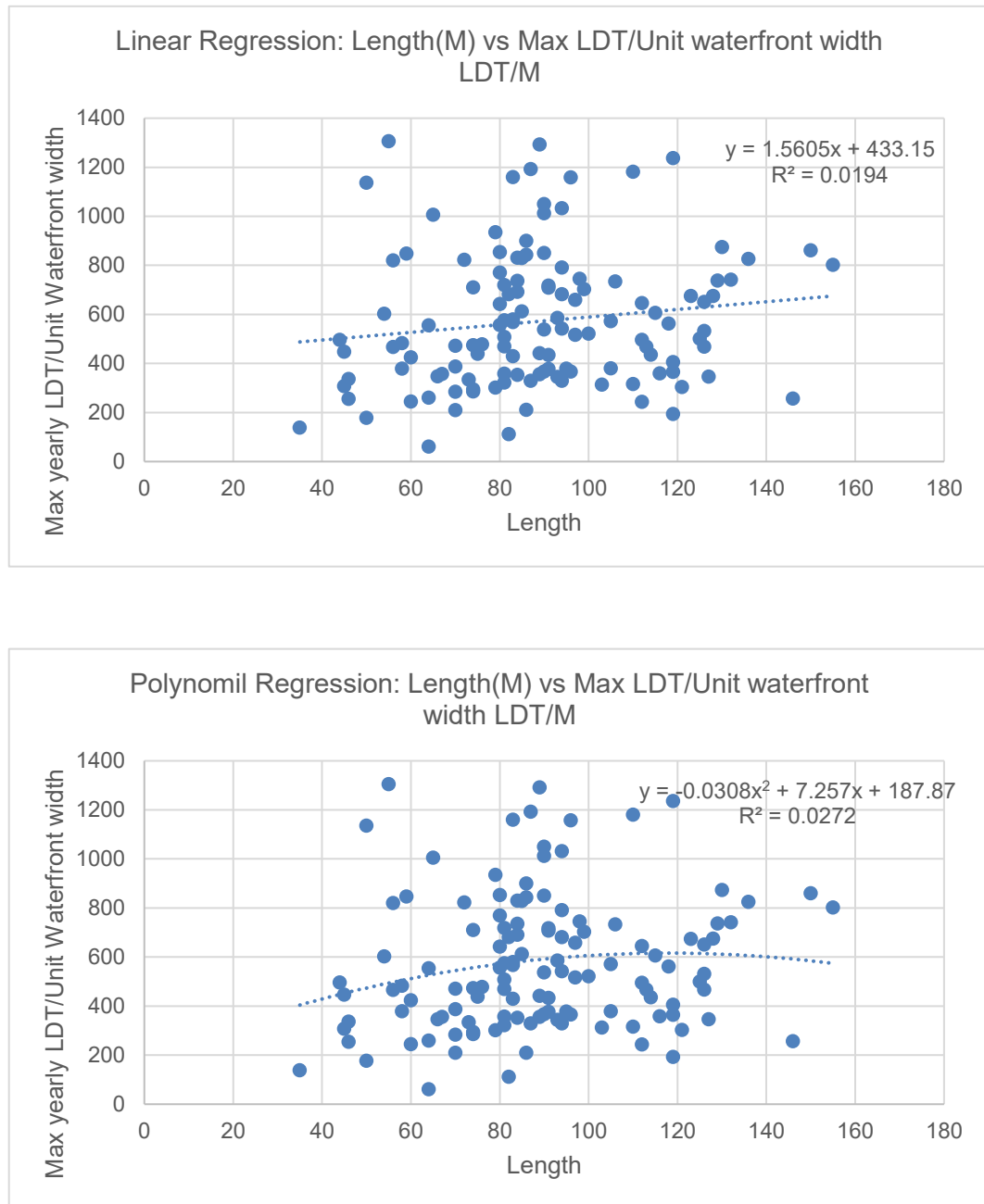
Figure C-3: Linear and polynomial regression: Waterfront width vs. Max LDT per unit length



The regression plots above show the relationship between waterfront width (m) and max LDT per unit length, with the red line representing the best linear fit. The low R^2 value of 0.133 from linear regression and of 0.139 from polynomial regression indicates a weak positive correlation between the two variables. The polynomial regression suggests a slight curvature, reflecting that the relationship between waterfront width and max LDT per unit length may not be purely linear.

Inference:

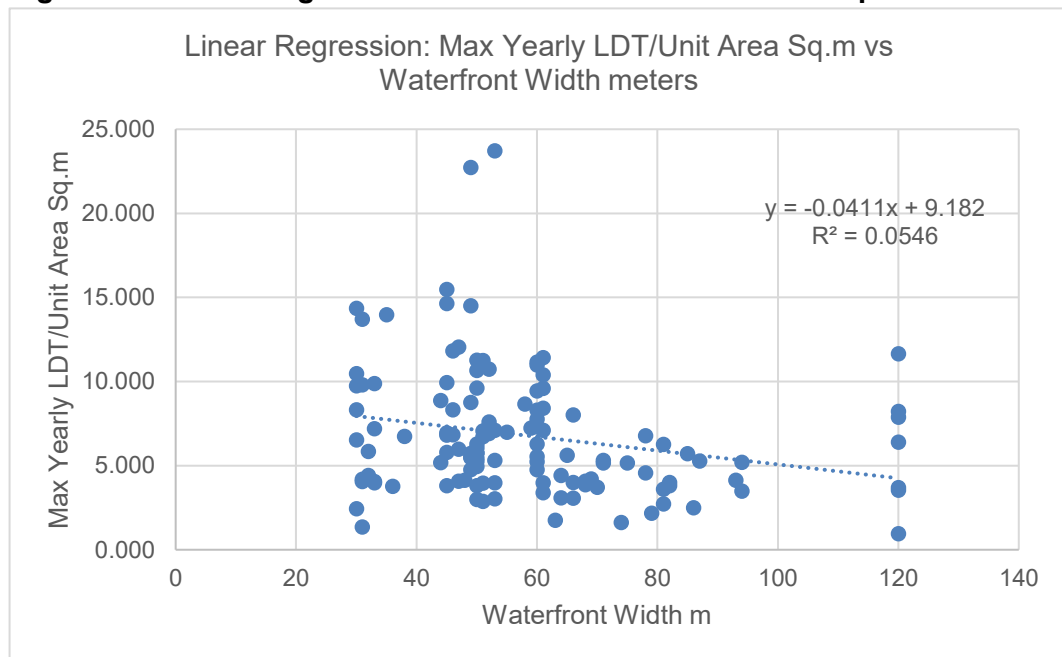
- **Weak positive corelation.** This regression shows a weak positive correlation ($R^2 = 0.133$) between waterfront width and Max LDT per Unit Length. This suggests that increasing waterfront width leads to a slight increase in Max LDT per Unit Length, but the relationship is not strong. It could be inferred that larger waterfront plots can though handle more production per unit length, but other factors, such as layout, equipment and operational efficiency are likely to play a more significant role.
- The data points are highly scattered, indicating significant variability in Max LDT per unit length for similar waterfront widths. This means that ship recycling efficiency is not solely dependent on waterfront width. Factors such as ship type/complexity, worker productivity and infrastructure utilization may drive this variability.
- The maximum LDT per unit length values is seen at both smaller (e.g. 40-60 m) and larger (e.g. 100-120 m) widths, but there is no clear trend favouring one range.
- **Key finding:** While increasing waterfront width has some positive impact on Max LDT per unit length, the relationship is weak, and efficiency is highly dependent on operational and process factors.

**Figure C-4: Linear and polynomial regression: Max LDT/Unit waterfront width
Vs Length****Inference from the plots:**

- **Linear regression:** R^2 value approx. 0.02 shows a very a weak positive relationship between Max LDT per unit waterfront width and length, **indicating a very tendency for efficiency to improve with increase in length**. However, the very low R^2 value (2%) shows this relationship is not significant and other variables are likely to play a much more critical role.
- **Polynomial regression:**
 - **Coefficient for x (linear term) = 7.257:** The linear term suggests a slight upward trend in y as x increases.

- **Coefficient for x^2 (quadratic term) = -0.031**: The quadratic term implies that this increase is not constant and diminishes for larger values of x , potentially peaking and then decreasing.
- **R^2 Value: 0.027** (very low) which suggests that co-relation is very weak and that the model does not adequately explain the variation which indicates that other factors might play a more significant role
- **Interpretation**: The unit waterfront width productivity very slightly increases with increase in length due to unblocking of process lines and meeting of operational and compliance related complexities but the returns are diminishing beyond a point.

Figure C-5: Linear regression: Waterfront width vs. Max LDT per Unit area



Comparison with earlier findings:

- Reinforcement of diminishing returns:
 - The scatter plot and regression line reaffirm the observation that wider waterfronts do not significantly increase productivity per unit area (LDT/m²). However, larger waterfronts allow the plots to accommodate multiple and larger ships.
 - Similar to the earlier findings, the regression shows a weak negative relationship between waterfront width and productivity per unit area. This suggests that other factors, such as operational practices or layout design may play a more significant role.

Differences in perspective of various regression plots:

- LDT per Unit Area vs. LDT per Unit Length Vs LDT per Unit Waterfront Width:
 - Earlier analyses of LDT per unit Length emphasized the influence of waterfront width on berthing capacity and ship handling efficiency.

- The Analysis of LDT/unit waterfront width tries to bring out effect of increase of length of existing plots to analyse improvement in productivity and diminishing returns beyond a point.
- In contrast, LDT per unit area focuses on overall space utilization efficiency. It shows that larger plots (with greater area due to wider waterfronts) often suffer from underutilized or non-productive space which might adversely affect their unit area productivity.
- The LDT per unit area regression and LDT per unit waterfront width do not fundamentally alter earlier findings but provide a complementary view highlighting the importance of effective space utilization in addition to berthing capacity. These regressions also bring out the diminishing returns associated with larger plots beyond a certain point either in length or in width.

Annexure D: Baseline

industrial analysis

of plots (*Case studies*)

1. Case study 1: Small plot (plot no 30)

- **Dimensions:** 51 m waterfront × 130 m length
- **Max crane lifting capacity:** 18 tons per block
- **Cutting rate:**
 - Approx. 5–6 blocks/day/ship
 - Approx 100 LDT/day maximum (limited by layout)
 - Workers requirement at this production level ~150 workers
- **Processing time per block of upto 18 Tons:**
 - Cutting: 2–3 hours
 - Dismantling & Segregation: 2–3 hours
 - Total Time: 4–6 hours

Productivity analysis:

- **Average cutting time per block:** Approx. 18 tons in 4–6 hours.
- **Unit area productivity:**
 - Plot Area: 51 m × 130 m = 6,630 m².
 - LDT per Day per m²: 100 LDT/day/ 6630 m²~0.015 LDT/m²/day~ 4.5 LDT/m²/year (300 workdays per year basis). This is much below the mean value (7.5) and median value (6.0) in this category of plots as well as the average achievable unit area productivity of Alang-Sosiya yard (5.74 LDT/m²/year) and there is a scope for improvement in the yard's performance
 - Workers Productivity: 100 LDT/day /150 workers= 0.66 LTD/Worker/day ~200 LDT/worker/year (300 work days)
- **Current Annual Capacity (in LDT)** Using 300 working days/year (accounting for downtime):
 - Daily Max: 100 LDT/day.
 - Annual Capacity: 100×300=30,000 LDT/year
- Actual maximum production achieved per year in last 09 years despite declined market=44570 LDT in 2017~149.13 LDT/day

- Actual maximum productivity /unit area achieved/year in year 2017~44570 LDT/day/6630 m²~6.75 LDT/m²/year (300 work day basis) in year 2017.

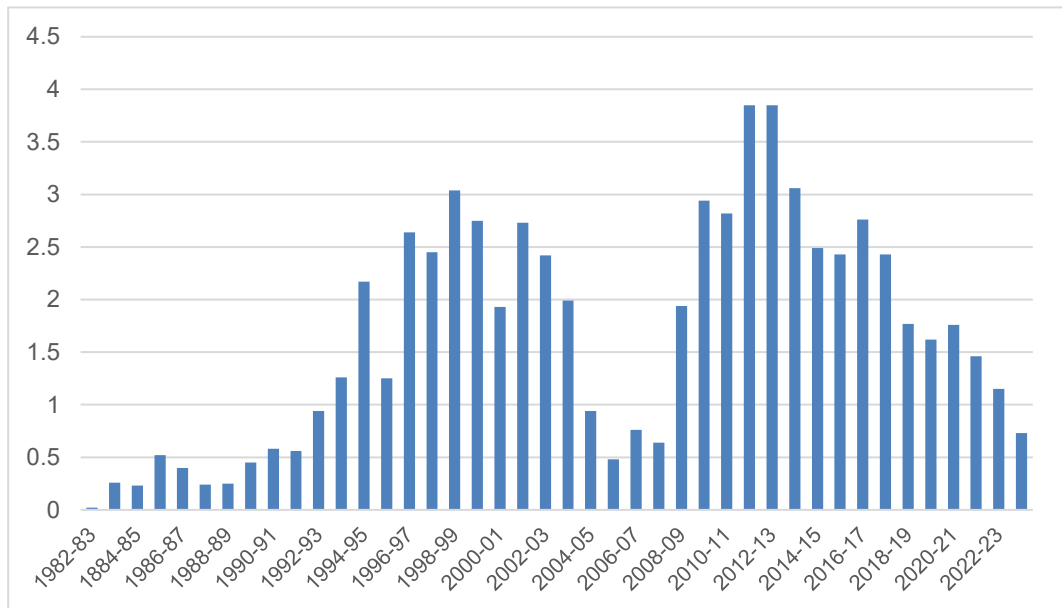
Figure D-1: Plot no 30 (JRD Industries)



Source: J.R.D Industries

Predictions for productivity linked with Alang-Sosiya yard data

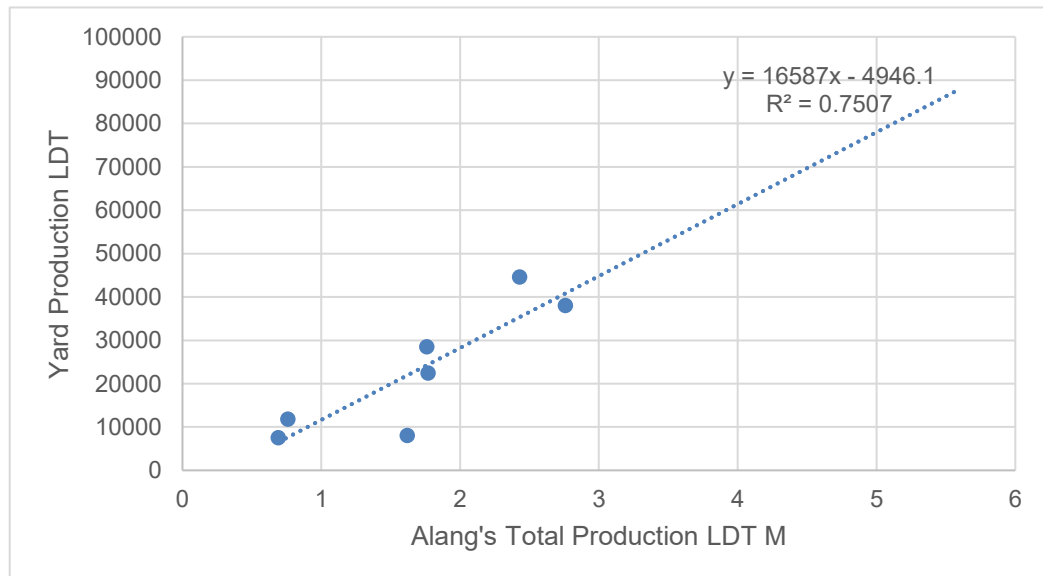
Achievable productivity of this plot linked with Alang Sosiya yard is analysed. Maximum handling capacity of Alang Sosiya yard has been stated to be 4.5 M LDT per year and the yearly production data is provided in historical production data below.

Figure D-2: historical production data at Alang

Source: GMB

The extrapolated production and productivity projections for plot no 30

On the basis of past actual production data of plot no. 30 of last 09 years and actual overall historical production data of last 09 years for Alang yard as derived from GMB's source, following extrapolated projections linked with Alang Sosiya yard data and future projections are derived:

Figure D-3: Plot level Production LDT vs Alang's Total LDT M extrapolation

$R^2=0.75$ indicates a good fit for extrapolation.

Table D-1: Productivity derived from extrapolation

	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	Year 2023	Year 2024	Year 2025	Year 2029	Year 2030
Total Production M LDT	2.76	2.43	1.77	1.62	1.76	0.76	0.69	1.5	4.5	5.6
Plot level Production LDT	38036	44569	22413	8025	28514	11827	7555.0	19935	69696	87942
Plot level Productivity LDT/m ²	5.74	6.72	3.38	1.21	4.3	1.78	1.14	3.01	10.51	13.26

It is derived that when the Alang yard reaches 4.5 M LDT/year operation level, this plot has the potential to reach approx. 69696 LDT per year or 232 LDT per day or **10.51 LDT/m²/Year productivity**.

Hypothetical scenario analysis

Further analysing if this extrapolated projection of 69696 LDT can be translated into ship recycling production based on ground reality:

A 50-meter waterfront width plot can at any given point of time can take a maximum of one vessel of approx. 38 to 42 m beam with approx. 270 to 320 m length (LOA), approx. 180000 to 200000 DWT and approx. 35000 to 40000 Light displacement tons (LDT).

Now, based on multiple discussions with the plot owners with over 5 to 15 years of experience in ship recycling at Alang, it was deduced that for a vessel of such dimensions, at least 20 to 25 days would be required for initial preparation, cleaning, removal of hazardous material and safe to work certification. The cutting and dismantling would take approx. 04 months @ approx. 300 LDT per day resulting in approx. 36000 LDT. Additional approx. 15 days would be required for engine room dismantling and sorting complexities etc. This would be possible if the plot increases its crane capacity to lift around 30 tons block and improves cutting rates so that at least upto 8-10 blocks of upto 30 tons each can be dismantled on daily basis.

Accordingly, in one year, it would be possible to dismantle at the most two vessels of approx. 36000 LDT translating into approx. 70000-72000 LDT per year. A conservative estimate would be to go for 80% of the daily capacity to 240 LDT/day i.e. 60000 LDT per year.

Analysis for additional capacity and productivity for plot no 30

To achieve an additional capacity of upto 240 LDT/day (80% of 300 LDT per day), considering the current constraints of plot area, crane capacity and technology, Analysing the following considerations:

- **Increase plot length**

Extending the plot length may allow for more ships to be processed simultaneously.

- Current plot area: 51 m x 130 m = 6630 m²

- Increase plot length to say 220 m (additional 90 m either seaside or behind the plot northwest side of land)
- Increased No of workers estimate = approx. 220 workers (discussions with stakeholders)
- Revised plot area with same waterfront: 51 m x 220 m = 11,220 m²
- Revised Unit Area Productivity per day ~ (240 LDT/11220 m²~0.0213 LDT/m²/day) = 6.39 LDT/m²/year which is well within median and mean values for this size as well as quite conservative compared with extrapolated projections.
- With improvement in layout, crane capacity (say 30 tons) and optimum worker allocation per block to avoid congestion, upto 8-10 blocks of 30 tons can be processed, which means that~ 240 LDT/day is achievable.
- Revised Worker Productivity with 240 LDT/day with 220 workers = 240/220 LDT per worker per day = 1.09 LDT per worker per day ~ 327 LDT per worker per year (300 workdays)
- Productivity potential: The layout should allow for the efficient positioning of ships side-by-side and processing of blocks end-to-end without bottlenecks with increased length.

- **Additional crane capacity**

Having more higher capacity cranes can speed up the lifting and moving processes.

- Current limit on crane lifting capacity: 18 tons per block
- Proposed crane upgrades: Introduce an additional crane with a higher capacity (e.g.30 tons per block). This can reduce the bottleneck effect during lifting and moving.

- **Technology upgrades**

Investing in advanced cutting and dismantling technologies can significantly increase cutting rates and reduce total block processing time.

- Current cutting rate: 5–6 blocks/day/ship
- Upgraded cutting technology: Advanced plasma or laser cutting technology or improved interpersonal co-ordination amongst cutting teams even with conventional cutting methods can increase the rate to 8-10 blocks/day/ship. Each block could be upto 30 tons
- Potential impact: Improved technology can help achieve the desired additional capacity upto 240 LDT/day/ship capacity as a conservative estimate (**or even higher**).

- **Optimizing resource utilization**

- Implementing proper workflow coordination, worker management and various resource management systems can help better utilize the resources which can help reduce the per block processing time by 10-20%.

- **Additional area usage**

- Expanding or using additional areas for dismantling/processing, segregation and storage and by optimizing the layout for efficient dismantling and

segregation, the flow can be made smoother so that productivity per area increases.

Summary

Table D-2: Summary of potential improvements possible in small plots

Improvement	Current capacity	Revised capacity	Possible impact
Increased plot length	51 m x 130 m	51 m x 220 m	Increased processing potential.
Increased crane lifting capacity	18 tons/block	30 tons/block	Faster lifting/moving.
Cutting technology upgrades	5-6 blocks/day	8-10 blocks/day	Higher cutting rates.
Unit area productivity	4.5 LDT/m ² /year	6.39 LDT/m ² /year	Improvement
Optimizing worker utilization	Regular~0.66 LDT/worker/day	Optimized ~1.09 LDT/worker/day	Improved worker productivity.
Additional area usage	Limited	Expanded	Smoother workflow, reduced bottlenecks.

By combining these methods, it is considered possible to increase the capacity from the current 30,000 LDT/year to potentially 60,000-70,000 LDT/year.

2. Case study 2: medium size plot (plot no 11)

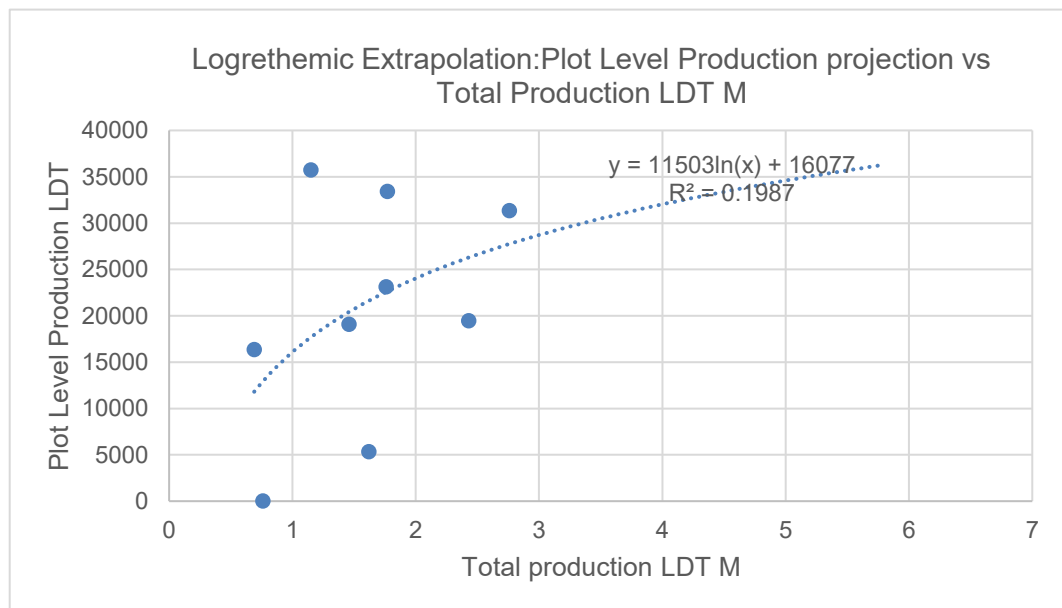
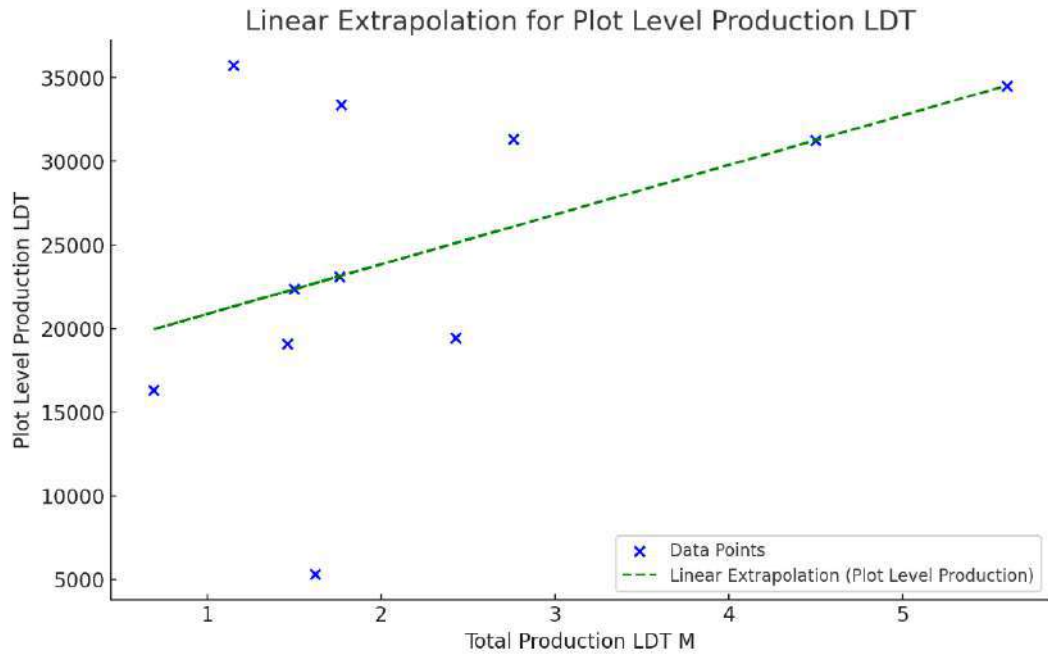
- **Plot size** = 82 m waterfront x 111 m = 9102 m²
- Current strength of workers~ 250 workers
- **Current achievable maximum production** with the same plot size: 150 LDT/day.
- **Annual achievable productivity** (assuming 300 working days): 45000 LDT/year
 - Unit area productivity = 45000/9102 = 4.94 LDT/m²/year
- Actual maximum production achieved per year in last 09 years despite declined market=35735 LDT in 2022~119 LDT/day

Predictions for productivity linked with Alang-Sosiya yard data

Achievable productivity of this plot linked with Alang Sosiya yard is analysed. Maximum handling capacity of Alang Sosiya yard has been stated and considered to be 4.5 M LDT per year and the yearly production data is provided in Annexure L.

The extrapolated production and productivity projections for plot no 11

On the basis of past production data of plot no. 11 and data for Alang yard for last 09 years as per historical production data plot above, following extrapolated projections are derived for future capacity.

Figure D-4: Extrapolation for plot level production LDT and Total production LDT M

Logarithmic fit has the best fit on the basis of $R^2=0.1987$.

Table D-3: productivity derived from extrapolation

	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	Year 2023	Year 2024	Year 2025	Year 2029	Year 2030
Total Production M LDT	2.76	2.43	1.77	1.62	1.76	1.46	1.15	0.76	0.69	1.5

	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	Year 2023	Year 2024	Year 2025	Year 2029	Year 2030
Plot level Production LDT (Linear)	31320	19452	33395	5308	23117	19082	35735	0.00	16327	22359
Plot level Production LDT (Linear)			-	-	-	-	-	20740	33377	35893
Plot level Productivity LDT/m ² (Linear)	3.44	2.14	3.67	0.58	2.54	2.1	3.93	0	1.79	2.46
Plot level Productivity LDT/m ² (Linear)			-	-	-	-	-	2.28	3.67	3.95

From the past data analysis and extrapolation, it is derived that when the Alang yard reaches 4.5 M LDT/year operation level, this plots no 11 has the potential to reach approx. 33377 LDT per year or **3.44 LDT/m²/Year productivity** target with the same yard area and same setup. The maximum achievable productivity projection when the Alang yard market is 5.6 M LDT is 3.95 LDT/m²/year as per logarithmic fit whereas the maximum achieved productivity in this category (80-100 m waterfront width) of plots was 6.3 LDT/m²/year in last 09 years data. It is pertinent to mention that as per statistical analysis, the 80-100 m waterfront width category plots have shown least productivity values/unit area as well as lowest mean and median in last 09 years amongst all categories.

Accordingly, though not much promise in terms of per unit area productivity can be expected statistically from this category of plots and we will assume maximum achievable productivity as 6.3 LDT/m²/year, however we will explore ways to achieve such results.

Hypothetical scenario analysis

Further analysis of ship recycling production based on ground reality:

An 82-meter waterfront width plot can at any given point of time can take a maximum of two vessels side by side of approx. 35 to 37 m beam with approx. 250 to 270 m length (LOA), approx. 140000 to 160000 DWT and approx. 24000 to 27000 Light displacement tons (LDT) each.

Now, based on deep dive through discussions with the plot owner and ship recycling supervisors at Alang, it was deduced that for each vessel of such dimensions, at least 18 to 20 days would be required for initial preparation, cleaning, removal of hazardous material and safe to work certification. The cutting and dismantling would take approx. 04 months @ approx. 200 LDT per day in each dismantling line resulting in approx. 25000 LDT per ship dismantling line. Additional approx. 15 days would be required for engine room dismantling and sorting etc.

- **Scenario 1:** the plot increases its crane capacity to lift around 200 tons block and improves cutting rates so that at least upto 01 blocks of upto 200 tons in each dismantling line x 2 dismantling lines can be dismantled on daily basis.

- **Scenario 2:** Alternately, if the crane capacity is limited to 100 tons/ block, the cutting rates should be improved so as to process at least 2 x 100 blocks in each of the two dismantling lines per day making it approx. 400 LDT/day

Accordingly, in one year, it would be possible to dismantle at the most four vessels of approx. 24000-27000 LDT translating into approx. **96000 to 108000 LDT** per year. A conservative estimate would be to go for a max capacity of 400 LDT/day with 240 cutting/dismantling days, 60 preparation days, 30 days for engine room and 65 non-productive days. Effectively, it would result in average approx. 350 LDT/day max achievable productivity for the yard.

However, current yard dimensions do not permit unblocking of this potential and increase in plot length is one viable option.

Analysis for enhanced capacity of the plot

It is opined that the plot's overall production capacity can be enhanced by opting for two parallel processing lines and unblocking process lines by adding additional area by extending length upto 80-100 m either seaside or landside for cutting and back for block processing and other activities.

- **Cutting speeds**
 - **Block size limitation:** Maximum current cutting capacity is 100 tons per block per ship due to process bottlenecks at the primary cutting level and subsequent processing. This can be improved by use of superior cutting technologies such as plasma cutting where required and improved cutting management plan to manage complexity.
 - **Crane lifting capacity is 200 tons:** This is considered adequate for the desired capacity achievement
 - **Estimated cutting and processing Speed:** ~ 3-4 hrs for cutting 3-4 hrs for dismantling and 2-3 hrs for segregation and processing~ Total 8-10 hours per block.
 - In an 8-10 hours productive time available per day between tides, at least two blocks of 100 tons each can be cut currently, but there is bottleneck in terms of processing area due to limited length. If length is increased adequately, two block of 100 tons per day per ship can be cut and processed in 8-10 hours of productive time per day during low tide.
- **Unit area productivity achievable with the same area with better productivity**
 - **Plot Area:** 82 m×111 m=9102 m²
 - Annual productivity estimate: 6.3 LDT/m²/year
- **Production achievable with the extended length upto 200 m and max achievable productivity**
 - Revised Plot Area: 82 m×200 m=16400 m²
 - Annual production achievable
 - Estimate @ 6.3 LDT/m²/year= 6.3 x16400 =103,320 LDT/year
 - Daily production achievable with 16400 m² area

- Estimate @ $6.3 \text{ LDT/m}^2/\text{year} = 344 \text{ LDT/day}$

We will go with the estimate of approx. 350 LDT per day @ $6.3 \text{ LDT/m}^2/\text{year}$ achievable by extending length from 111 to 200 m and with approx. 350 workers and a better layout and material flow which was also the opinion of plot management during technical discussions.

Current worker productivity achievable $\sim 150 \text{ LDT}/250 \text{ workers} \sim 0.6 \text{ LDT/Worker/day} \sim 180 \text{ LDT/Worker/year}$ (300 work days)

Worker productivity achievable with additional land $\sim 350 \text{ LDT}/350 \text{ workers} \sim 1.0 \text{ LDT/Worker/day} \sim 300 \text{ LDT/Worker/year}$ (300 work days)

Insights

- **Constraints to address:**
 - Cutting complexity during primary cutting limits block size to 100 tons therefore lifting capacity (200 tons available) is underutilized.
 - The secondary and tertiary cutting and further processing is limited due to limited length and area.
 - Operational time limit due to tides.
- **Productivity enhancement:**
 - Improving cutting speeds, managing complexity and Increasing block sizes (if feasible) to utilize lifting capacity more effectively.
 - Stagger operations to maximize efficiency during low tide.
 - Increase length to increase area and reduce bottlenecks.
- **Future expansion needs:**
 - Additional land length (80-100 m) along with suitable measures related to co-ordination, workflow and use of technologies can unlock lot more capacity. Use 2 parallel production lines for two ships side by side with unblocking of processing lines with increased length upto 200 m.

3. Case study 3: Large plot (Plot V-1)

- Dimensions of waterfront plot V-1: 120m waterfront × 90m length.
- **Additional processing land area behind plot:** This yard has expanded its operations through acquisition of roughly 65000 m² land behind the plot northwest out of which Approx 120 m x 175 m = 21,000 m² is projected for industrial activity. However, it was observed that out of this additional 175-meter length, the actual concentration of industrial activities was seen limited to 125-130 m length of additional area contributing to production, storage and other activities.

Maximum limit on crane lifting capacity is approximately 280-300 tons/block due to cutting complexities otherwise the lifting of up to 1750 tons is possible with the available crane.

Actual maximum production achieved per year in last 03 years despite declined market was reported to be 96672 LDT in 2021 which is $\sim 322 \text{ LDT/day}$

- **Current achievable cutting rate:**

- 1 block of 300 tons/day/ship and can handle 2 ships side by side which means overall 2 blocks of 300 tons each/day.
- This translates into ~600 tons/day (regular); during peak demand, it can reach up to 4 blocks of 300 tons each per day i.e. 1,000–1,200 tons/day (maximum limit on capacity because of waterfront width).
- In 2010, this plot had reached a stated output of 1000 LDT/day during dismantling of one of the largest oil tankers with approx. 83000 LDT
- **Time per 300 tons block:**
 - Cutting: 4–5 hours
 - Dismantling, Segregation, Storage: 5–7 hours
 - Total Time: 9–12 hours
- **Workers required:** Current worker strength is approx. 360

At maximum desired capacity of approx. 1000-1200 tons per day, workers requirement would be approx. 600 workers (based on discussions with yard management).

Productivity analysis:

- Average cutting speed per block: 300 tons in 9–12 hours translate into 25–33 tons/hour per block. For 600 LDT/day regular in 12 hours would translate into ~ 50 tons/hour overall.
- Current achievable worker productivity: 600 LDT/350 workers~1.71 LDT/Worker/day~514 LDT/Worker/Year (300 workdays)
- Estimated worker productivity at desired maximum capacity 1200 LDT/600 Workers~ 2 LDT/Worker/day~600 LDT/Worker/Year (300 Workdays)
- **Unit area productivity:**
 - **Industrial plot area:** $120 \text{ m} \times 90 \text{ m} + 120 \times 175 \text{ m}^2 = 31,800 \text{ m}^2$ (whole industrial area is considered for conservative approach though active additional length is limited to 125-130 m).
 - **Current achievable Productivity per unit area:** $600 \text{ LDT} / 31,800 \text{ m}^2 \approx 0.019 \text{ LDT/m}^2/\text{day} \approx 6.97 \text{ LDT/m}^2/\text{Year}$ (300 work days basis) (at regular capacity) (Conservative approach has been adopted by including the whole area for productivity calculation)
 - **Maximum desired productivity per unit area:** $1200 \text{ LDT} / 31,800 \text{ m}^2 \approx 0.0377 \text{ LDT/m}^2/\text{day} \approx 11.32 \text{ LDT/m}^2/\text{year}$ (at desired capacity with additional measures). It is pertinent to mention that close to this level of productivity has already been achieved by this yard in 2010 while dismantling an 83000 LDT oil tanker.

Predictions for productivity linked with Alang-Sosiya yard data

Achievable productivity of this plot linked with Alang Sosiya Yard is analysed. Maximum handling capacity of Alang Sosiya yard has been stated to be 4.5 M LDT per year and the yearly production data is provided in .

The extrapolated production and productivity projections for Plot no 11

On the basis of past production data of plot no. 11 of last 09 years and last 09 years historical production data for Alang yard from the above plot, following extrapolated projections are derived for future productivity in line with Alang yard projections

Figure D-5: Linear vs polynomial fit for plot level production

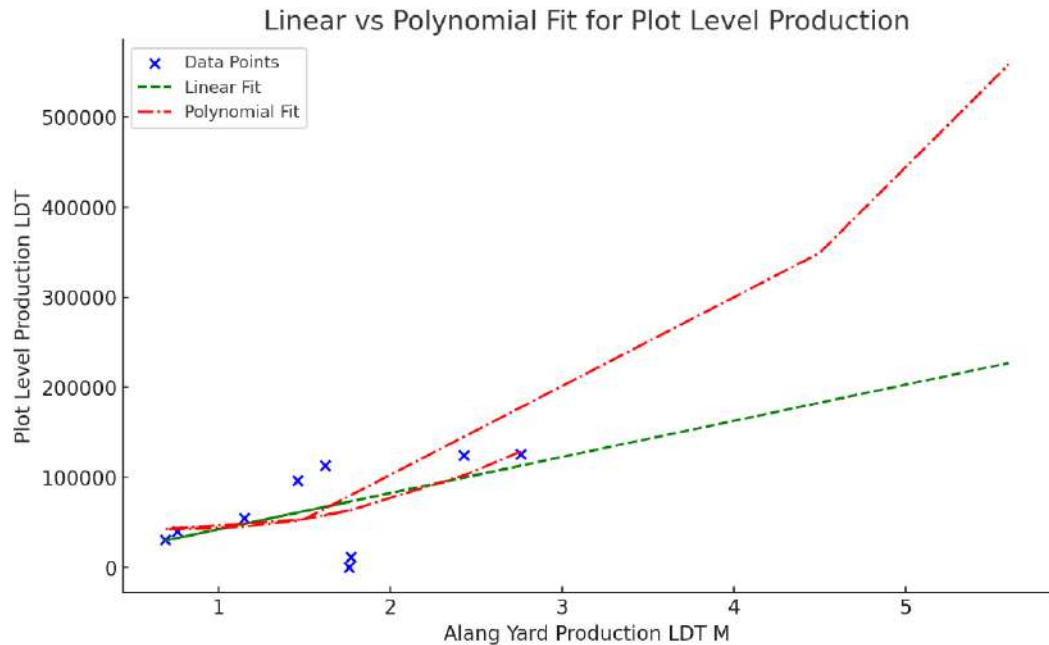


Table D-4: Prediction results for linear vs polynomial fit

	Year 2016	Year 2017	Year 2018	Year 2019	Year 2021	Year 2022	Year 2023	Year 2024	Year 2025	Year 2029	Year 2030
Total Production M LDT	2.76	2.43	1.77	1.62	1.46	1.15	0.76	0.69	1.5	4.5	5.6
Plot level Production LDT (Linear)	1259 74	1246 34	1173 2	1133 96	9667 3	5429 3	4028 8	3041 6	6236 4	1827 88	2269 44
Plot level Productivity LDT/m ² (Linear)	11.7	11.5	1.09	10.5	8.95	5.03	3.73	2.82	5.78	16.9	21
Plot level Production LDT (Polynomial)								5345 8	3491 66	5582 62	5345 8
Plot level Productivity LDT/m ² (Polynomial)								4.95	32.3	51.7	4.95

On the basis of the extrapolated results of the GMB data, the predicted unit area productivity is 16.92 LDT/m²/year basis linear fit and 32.31 LDT/m²/year basis polynomial fit.

However, considering that yard V-1 has achieved past production results with additional 21000 m² area behind the plot that must be considered for normalizing the predicted values; Accordingly corrected value of unit area productivity predictions when Alang reaches 4.5 M LDT would be:

$16.92 \times 10800 / (10800 + 21000) = 5.9 \text{ LDT/m}^2/\text{year}$ as a conservative estimate (linear fit) And
 $32.3 \times 10800 / 31800 \sim 11.0 \text{ LDT/m}^2/\text{year}$ as an optimistic estimate (Polynomial fit)

Analysis for maximum achievable optimistic annual capacity (in LDT)

Using 300 working days/year (accounting for downtime):

- **Annual capacity:** $11.0 \times 31800 = 349,800 \text{ LDT/year}$ (optimistic Estimate)
- Daily max achievable capacity $\sim 1170 - 1,200 \text{ LDT/day}$ (with additional measures).

This has been corroborated by the fact that this plot had actually achieved around 1000 LDT per day in 2010 with the existing layout. An improvement in the layout and facilities is expected to add additional capacity.

Hypothetical scenario analysis

Let us further analyse if this extrapolated optimistic projection of 349800 LDT can be translated into ship recycling production based on ground reality:

A 120-meter waterfront width plot can at any given point of time can process as follows:

- **Scenario 1:** two vessels of VLCC size or capsized or large ships with approx. 55 m beam with approx. 350 to 400 m length LOA) with upto maximum 60000 Light displacement tons (LDT) each vessel. Each ship is expected to take upto 6 months including preparation and engine room handling

Each ship with 60000 LDT @ 600 LDT per day requires approx. 100 days of cutting and processing time + 30 days of preparation + 30 days for complexities and engine room handling. Accordingly total 04 ships with 60000 LDT each can be processed translating into 240000 LDT/year duly considering the preparation time, complexities, engine room and downtime.

- **Scenario 2:** One ULCC or large vessel upto 65 m beam and 400-450 m LOA with upto 80000 LDT and One more ship of approx. 40 m beam and 270-330 m LOA with upto. 45000 LDT

Large vessel with 80000 LDT: 45 days for preparation + 133 days of cutting and processing time @ 600 LDT/ship/day + 45 days for handling complexities and engine room translating into 223 days. In a calendar year of 365 days with 300 workdays, $300/223 = 1.34$ such ships with $80000 \times 1.347 = 107623 \text{ LDT/year}$ can be processed in a single processing line.

In the second processing line, we have a vessel with 40000 LDT = 20 days of preparation time + 20 days of engine room and complexities + 67 days of cutting and processing @ 600 LDT/day per line = 107 days per vessel. With approx. 300 workdays in a year, this translates into $300/107 = 2.8$ such vessels with $40000 \times 2.8 = 112000 \text{ LDT per year}$

Total approx. annual capacity in both the processing line = $112000 + 107623 = 219623 \text{ LDT/year}$

- **Scenario 3:** Upto three vessels of 35-meter LOA and 250-270 m LOA with approx. 30000 LDT per vessel side by side in three different processing lanes.

For each processing line: 20 days for ship preparation+15 days for engine room and handling complexities + 50 days for cutting and processing @600 LDT/day =85 days per ship. So, in 300 workdays, $300/85=3.52$ ships of 30000 LDT each can be processed which is equivalent to 105600 LDT per line

Since we have three dismantling lines, it is possible to achieve approx. $105600 \times 3 = 316800$ LDT/year in 300 workdays.

Based on above three different scenarios, it is deduced that the annual capacity of plot V1 can reach between 219623 LDT/year (6.9 LDT/m²/year conservative estimate) to 316800 LDT/year (9.96 LDT/m²/year optimistic Estimate) per year for the above discussed scenarios. Of course, the overall output of the yard will also depend upon complexity of the vessel, business available, availability of workers, market conditions, types of vessels available for dismantling amongst many other factors and infinite number of combinations are possible.

Annexure E: Optimization of plot sizes

1. Small plot (plot no. 30)

Current state assessment of small plot

We analyse the current operational metrics:

- **Plot size:** 51 m × 130 m = 6,630 m²
- **Production:**
 - Max capacity: 30,000 LDT/year.
 - Actual recent production in year 2017: ~44570 LDT/year (~149 LDT/day on 300 workday basis).
- **Worker and area productivity:**
 - 0.015 LDT/m²/day or ~4.5 LDT/m²/year.
 - 0.66 LDT/worker/day or ~200 LDT/worker/year.

Impact of length extension

For each 50 m increment in plot length (keeping the same waterfront width of 51 m)

Table E-1: Impact of length extension over productivity

Plot Length (m)	Area (m ²)	Production Capacity (LDT/year)	Approx. Unit Area Productivity (LDT/m ² /year)	Workers Needed	Worker Productivity	Observation
130	6,630	30,000	4.5	150	200	Baseline
180	9,180	41,500	4.61	185	224	Moderate gains
220	11,220	72000	6.39	220	318	Plateau starts
280	14,280	70,000	4.90	240	291	Diminishing Returns. Poor proximity relationship. Nil gains beyond a point.

Explanation: This reduction in unit area productivity with increase in length beyond a point is due to diminishing returns as the overall production output does not increase (actually may reduce due to proximity relation and logistical complexity) but the area increases. It is possible to happen when the additional area is less efficiently utilized due to several factors, such as:

- For a 51 m waterfront width plot (constrained waterfront), it may be possible to achieve upto 240 LDT/day with increased crane capacity (30) tons, increased length and improved cutting speeds and with use of technology and co-ordination, however further

increase as the block processing may not keep in pace as the additional material movement with additional load may clog the process lines. In addition, there are bound to be workflow and logistics challenges encountered with increased length beyond a point. Therefore, the growth in capacity and productivity is not considered linear with increase in length beyond a certain point.

- **Space management and logistical challenges:**

As the plot length expands, it may become harder to optimally utilize the additional space. The increased length may lie idle or might introduce longer travel times for workers, tools and materials resulting in delays and inefficiencies and impacting productivity adversely.

- **Workforce distribution:**

When the plot length increases, maintaining an efficient distribution and monitoring of workers across the entire area may become difficult for the management. At some point, the added workforce may not be as effective in utilizing the extra space as more workers may lead to diminishing worker productivity due to crowding, coordination issues or lack of specific tasks for additional workers.

- **Machine and equipment limitations:**

A larger plot would need additional machinery or tools to maintain the same level of productivity. However, with the waterfront width constrained, as the plot length increases beyond a certain point, the additional equipment may not necessarily justify return on investment due to clogging with additional load. Also, some sections of the plot may experience underutilization, while others may face bottlenecks.

- **Operational and maintenance costs:**

More land also means higher costs for infrastructure, utilities, waste management and higher overall maintenance and operational costs eroding additional gains in production beyond a point.

Summary of the reduction in productivity:

The reduction in area productivity beyond 200-220 m length is expected due to a combination of logistical complexities, expanded workforce and diminishing returns on equipment and space usage. While the area continues to grow, the return on that extra area becomes less and less. In conclusion, the plateau effect starts to emerge as the plot length increases because the additional area beyond 220 m no longer provides proportional gains in efficiency, leading to diminishing returns.

Conclusions:

Optimal length increase: Extending up to 220 m for this plot size yields noticeable productivity gains with increased crane capacity, high cutting speed and block processing and layout efficiency. Beyond this, gains are expected to diminish.

2. Medium plot (plot no. 11)

Current operational metrics

- **Plot Size:** 82 m×111 m=9102 m²

- **Workers:** 250 workers.
- **Current maximum achievable daily production:**
- 50 LDT/day =45,000LDT/year (300 working days).

Extension scenario

If this plot is extended to 82 m × 200 m, increasing the plot area for a new total area of 16,400 m² with an additional 100m towards seaside or behind the plot, additional block processing and other activities may be undertaken.

Constraints and bottlenecks

- Cutting and processing speeds:
 - Maximum achievable throughput per block: Approx. 10 hours/block.
 - Limitation: With 10-12 hours available due to tide restrictions, simultaneous block cutting requires additional cranes and equipment.
 - Crane Limitation: Current crane (200 tons) can handle larger blocks, but layout design may restrict efficient use of crane capacity.
 - The block size is limited to 100 tons per block due to cutting complexities.
- Diminishing returns:

Gains are expected to diminish beyond approx. 200-220 m plot length due to constraints on cutting speed, block processing time (10 hours), waterfront width and workflow restrictions and logistics complexities as bottlenecks as explained earlier in case study 1.

Table E-2: comparison table

Parameter	Current plot (9102 m ²)	Extended plot (16,400 m ²)	Observation
Plot Area (m ²)	9102	16,400	Area doubles
Max Daily Capacity (LDT)	150	350 targets	substantial increase
Unit Area Productivity	Approx. 0.0164 LDT/m ² /day	Approx. 0.0213 LDT/m ² /day	Slight decline beyond 200-220 m length (Due to scaling complexities and diminishing returns)
Workers	250	350	Proportional increase
Worker Productivity (LDT/worker/year)	180	300	Slight decline beyond 200-230 M length (Due to diminishing returns)
Annual Capacity (LDT/year)	45,000	Approx. 104,000 (Conservative estimate)	Significant increase in capacity. Beyond 200-220 M length, the growth in capacity is not expected to be linear unless there is an increase in waterfront width

Improvements suggested:

- **Plot extension:**
Extend to 82 m × 200 m for optimal capacity increases.

- **Infrastructure upgrades:**

Additional cranes and cutting equipment to minimize time bottlenecks.

Layout redesign for better processing flow.

- **Technology upgrades:**

Introduce advanced cutting and automate dismantling and segregation to improve worker productivity.

- **Diminished returns beyond 200-220 m:**

Gains are expected to diminish significantly beyond this extension due to layout inefficiencies and operational constraints. Further, since the annual output is unlikely to increase beyond a limit as explained earlier, the increase in area will only reduce unit area productivity.

3. Large Plot

Current operational metrics

- **Plot size (original):** 120 m×90 m=10,800 m²
- **Additional processing area:** 21,000 m² (approx. 120 m x 175 m)
 - Total Industrial Area: 31,800 m²
 - Case 1: If total area contributing to actual production is considered for productivity estimate = 31800-6000 = 25800 m²(Approx 6000 m² area is almost unutilized but is part of the industrial plot)
 - Case 2: If all of 31800 m² is considered for estimation of unit area productivity
- **Workers:** 360 (regular) increasing to 600 at maximum capacity.
- **Current achieved production:**
 - Regular: 600 LDT/day
 - Maximum achievable with same setup but better layout, better systems and optimum efficiency: 1,200 LDT/day

Constraints and bottlenecks

- **Crane capacity:**
 - Current cranes can handle 300 tons/block
 - Lifting up to 1,750 tons is theoretically possible but not practical
- **Cutting and processing rates:**
 - At regular capacity: 9–12 hours/block will limit total daily output to 2 blocks/day for simultaneous ship processing.
 - At maximum capacity: 4 blocks/day require efficient block flow and coordination.
- **Waterfront width:**
 - Limitation of 120m restricts simultaneous ship processing to 2 ships(large).

- To process faster, staggered or advanced block processing facilities are necessary.

Recommendations (Infrastructure enhancements):

- **Crane upgrades:**
 - Add cranes capable of processing larger blocks to reduce block handling time.
 - Introduce mobile cranes in the expanded processing area for flexibility.
- **Process flow:**
 - Optimize the layout of the additional 21,000 m² to minimize block transfer time.
 - Use the land for parallel dismantling and segregation to streamline the process.
- **Technology upgrade:**
 - Invest in automated cutting and segregation tools to further increase productivity.

Table E-3: Mitigation suggestions for possible complexities

Parameter/Aspect	Regular operations	Enhanced max capacity	Enhanced max capacity	Observation
		Case 01	Case 02	
Plot Area (m ²)	31,800	25,800	31,800	Area utilization is optimized with 125 m additional length translating into 25800 m ² total usable area.
Max Daily Capacity (LDT)	600	~1,200	~1,200	Possible to achieve 100% increase in capacity.
Workers	360	600	600	Workers number increase proportionally.
Worker Productivity (LDT/worker/year)	513	526	526	Increase with advanced measures such as training, technology etc.
Annual Capacity (LDT/year)	180,000	~ 219623 to 316800	~ 219623 to 316800	Higher capacities achievable through process and technology upgrades.
Unit Area Productivity	~0.019 LDT/m ² /day	~0.028 to 0.040 LDT/m ² /day	~0.023 to 0.033 LDT/m ² /day	Significant improvement.

Key insights

- Maximum production target achievable: 316800 LDT/year(optimistic).
- Adjusted capacity to bottlenecks, inefficiencies and uncertainties @75% of the target capacity = 0.75×316800 LDT/year = 237600 LDT/year
- Estimate of production based on least productive Scenario = 219623 LDT/year. We would like to go with the most conservative of all the estimates for capacity-based recommendations.
- Optimal worker utilization: At peak production level, the worker requirement is approx. 600 workers with diminishing returns beyond this number.
- Limitations: waterfront width (120 m) restricts multiple ship handling capacity.

By leveraging additional land effectively and adopting technology and infrastructure upgrades, this plot can target to achieve its maximum adjusted potential of **219623 LDT/year**. Accordingly, the adjusted max target productivity/unit area would be 6.9 LDT/m²/Year (0.023 LDT/m²/day) if 31800 m² area is considered (with 6000 m² redundant area) or 8.51 LDT/m²/Year (0.028 LDT/m²/day) with 25800 m² area if only active plot area is considered. Worker level target productivity would be 1.22 LDT/Worker/Day or 366 LDT/Worker/Year

Based on the above analysis of the three plots, **it is evident that increase in length beyond a certain point (around 215-220 m in this case) will not give better result.**

Analysis for optimum waterfront width and length for maximum productivity

To determine the optimal dimensions, we will consider the following:

- Waterfront width:
 - It directly determines the number of ships that can be recycled simultaneously.
 - Additional width would provide diminishing returns if layout and cranes are not adjusted accordingly.
- Plot length:
 - Length increase allows for efficient workflow, storage, dismantling and segregation.
 - Beyond a certain length, gains diminish by operational and logistical inefficiencies/complexities as explained earlier.
- Lifting and processing capacity:
 - Factors such as crane lifting capacity, cutting speeds and worker efficiency would influence how the area is utilized. Increasing crane capacity beyond a point may give diminishing returns due to complexities in cutting larger blocks.

4. Very large plot: Impact of increasing waterfront width to 240 m

Analysing plot width of 240 m with the parameters obtained in the earlier case studies.

- Target (achievable) productivities (Per m² of plot area per day):
 - For 50 m width: 0.0213 LDT/m²/day
 - For 82 m width: 0.021 LDT/m²/day (conservative estimate)
 - For 120 m width: 0.023 LDT/m²/day (conservative estimate by inclusion of redundant area) and 0.028 LDT/ m²/day by considering only active area.
- Capacity potential:
 - Productivity improvement with the waterfront width increase was not established through the regression analysis, however, larger plots do have potential for higher capacity primarily due to better space utilization, capability to handle larger and complex ships, better investment options for technologies due to scale, more efficient crane movements and layout optimization etc.
- Multiple ship scenario:

Increasing the waterfront width to 240 m allows:

- It is possible to accommodate upto 5-6 medium ships (30-40 beam) side-by-side or 3-4 large ships (50-60 M beam) side-by-side with clearance.
- Significant reduction in operational delays is possible due to advanced layouts, higher crane capacity coverage and smoother block process flow.
- Based on current trends and diminishing returns principle, the productivity of 240 m can be considered as same (on conservative basis) as for a 120 M plot but the capacity would be double proportionally. Also, better flexibility will be allowed to handle multiple ships. Accordingly, a target of 2 x 219623 LDT/year (2x capacity of 120 M plot) = 439246 LDT/year is considered as a conservative achievable estimate and 2 x 316800 = 633600 LDT/year is considered as optimistic target during the peak of ship recycling cycle. The effect is considered similar to joining of the two 120 m waterfront plots without considering additional gains beyond the already derived gains except what is possible due to layout optimization, scaling of technological improvements and efficient crane utilizations etc.

Effective layout for large and medium ships

For a 240-meter Waterfront:

- Large ships:
 - Beam: 45–60 m.
 - Layout: Accommodates 3-4 large ships in combination side-by-side, leaving necessary clearances.
- Medium ships:
 - Beam: 35–40 m.
 - Layout: Accommodates 5-6 medium ships in combination side-by-side with necessary clearances.

Total proposed area

The usable area for the plot: Width 240 m, Proposed length = 215 m (based on 120 m plot)

Area=width x length=240 m×215 m=51600 m²

Productivity per m²

- Using the conserving production figure of 439246 LDT/year, the productivity (Conservative) value of **0.028 LDT/m²day or 8.51 LDT/m²/year** for a **240-meter waterfront width** (based on the earlier curve extrapolation):

Conservative Production Estimate (LDT/year) =4,39,246 LDT/year

Capacity projections

Adjustments for Further Real-World Bottlenecks: Since we have already considered the capacity based on most conservative estimates derived for 120 m waterfront width plot, it does take into account the bottlenecks and real-world scenarios therefore, though further adjustment is not considered necessary however for uncertainties, a 10% reduction is still accounted.

- **Productivity reduction (90%):** To account for Operational inefficiencies and uncertainties at 90% of production.

Adjusted target Productivity = $1518 \times 0.90 = 1366$ LDT/day = **409860 LDT/year** (300 workdays) per Unit

Worker productivity

To determine the ideal number of workers and their productivity for a 240 m x 215 m plot, we need to analyse the relationship between plot size, worker count and productivity.

We approach this problem by first assuming that there are no changes related to layout or technology improvements:

- Analyse data trends

The data captured from the case studies at maximum productivity and capacity shows a pattern of increasing worker productivity as the plot size and worker count increase.

Here's a summary of the data:

Table E-4: Mitigation suggestions for possible complexities

Plot Size (m ²)	Workers	Productivity (LDT/Worker/Day)
11,660	220	1.05
16,400	350	1.0
25,800	600	1.39 (conservative) to 1.76 (optimistic)

Observations:

- Worker count increases roughly in proportion to plot size (not linearly but approximately).
- Productivity per worker also increases with plot size which could be likely due to better layout and resource optimization on larger plots but upto certain limited length (215 m in this case).

a. Methods to determine ideal worker count and productivity

- Regression analysis
 - We will use linear regression to model the relationship between plot size, worker count and productivity for the 51,600 m² plot based on trends.
- Expert judgment
 - We will use expert input/judgement to validate findings.
 - It is assumed that larger plots may allow more automation or better workflow optimization, impacting worker productivity positively.
- Extrapolating for 51,600 m² Plot
 - Based on trends, we hypothesize:
 - Worker count increases with plot size.
 - Productivity improves due to scale efficiencies.

Step-by-step estimation

- Worker count estimate:

Approximation: Worker count scales with plot area

From the data for 31500 m² plot:

- Worker count per m² = 600 workers/25,800 m² = 0.023 workers/m²
- Extrapolating: Workers for 51,600 m² = 51,600 m² × 0.023 ≈ **1,200 workers**

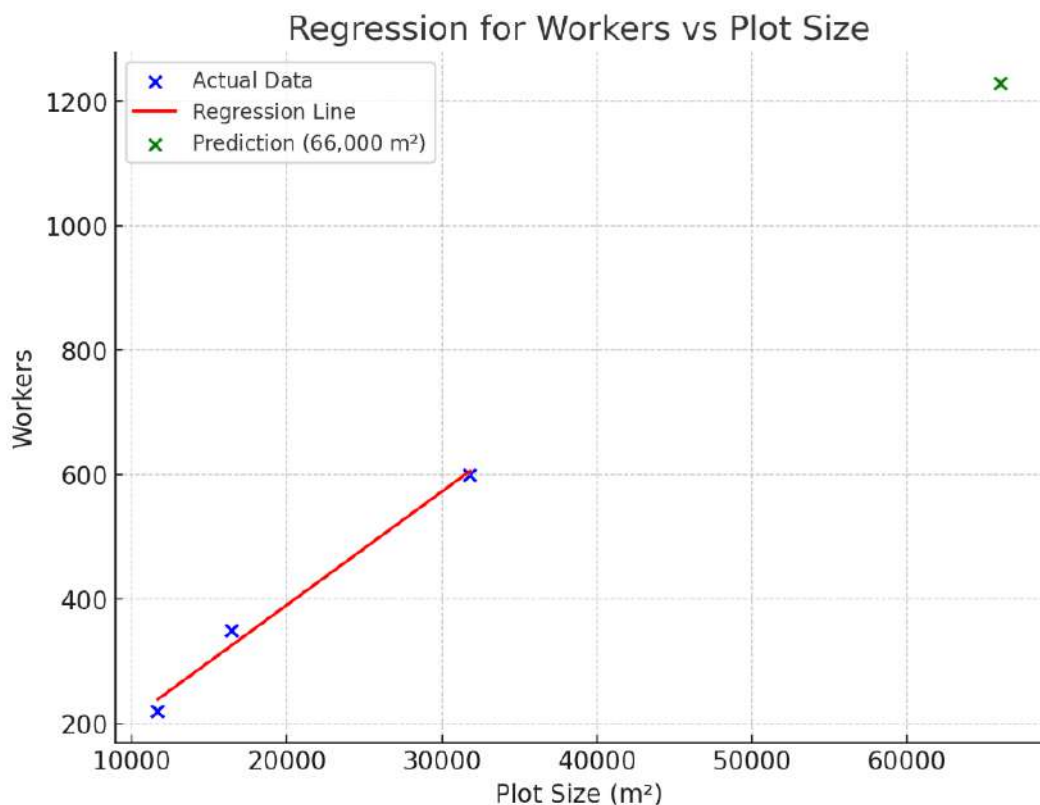
- Productivity estimate:

Productivity increases with plot size, but likely at a diminishing rate.

- Small to medium plots: Worker Productivity growth is flat
- Large plots: Growth slows beyond a certain expansion

Replicating 120 m plot values, the worker level productivity might **reach 1.39 (conservative) to 1.76 LDT/worker/day (optimistic) on a 51600 m² plot with diminishing returns.**

Figure E-1: Regression based best-fit estimate for worker count



For a plot size of 51600 m² based on the regression-based predictions are as follows:

Workers vs. Plot size:

- Workers: Approximately 1,228.87
- R² Value: Approximately 0.99

- The regression provides an excellent fit, indicating a strong relationship between plot size and the number of workers required.

If we assume technological improvements and layout optimization, both the productivity per worker and operational efficiency can be expected to increase.

We can incorporate this assumption into the analysis for the 51,600 m² plot:

Adjustments for technological improvements and layout optimizations

1. Technology enhancements:

- Advanced cutting/lifting equipment can reduce task completion time and improve safety, leading to higher productivity.
- Digital monitoring systems (e.g. digital tracking, integrated planning system) could improve workflow coordination.
- Technological advancements may yield upto 5–10% increase in productivity depending on the scale and type of technology implemented.

2. Optimized layout:

- A well-designed layout would minimize material handling time and worker fatigue.
- Efficient zoning for dismantling, storage and material transport can further increase output.
- Layout optimization could add another 5–10 % efficiency improvement by reducing wasted motion and delays.

Revised estimate for the 51,600 m² Plot

1. Worker count adjustment:

With improved productivity, fewer workers will be needed for the same workload. However, to fully utilize the larger plot and maintain optimal efficiency:

- Original estimate: ~1,200–1,225 workers.
- Adjusted for improvements: ~1,000–1,100 workers. (let's go with 1100 workers)

1. Worker productivity adjustment (around 10% improvement):

Incorporating the technology and layout improvement:

- Baseline productivity: 1.39 to 1.76 LDT/worker/day
- Adjusted productivity =1.51 to 1.92 LDT/worker/day

Table E-5: Final Estimate for 51,600 m² Plot with Technological Improvements

Factor	Without Improvements	With Improvements
Worker Count	~1,200	~1,100

Factor	Without Improvements	With Improvements
Productivity	~1.39 to 1.78 LDT/worker/day	~1.51 to 1.92 LDT/worker/day
Total Capacity	~1366 LDT/day (adjusted & conservative)	~1490 LDT/day (adjusted & conservative)

1. Very large plot (300 m waterfront width): impact of increasing waterfront width to 300 m

Now, based on previous analysis for 240 m width plot, we will use the same productivity levels for extrapolating to 300 m width plot.

From the parameters obtained through 240 m width Plot:

Multiple ship scenario: Extrapolation to 300 m:

- Increasing the waterfront width to 300 m allows:
 - It is possible to accommodate upto 6-7 medium ships (30-40 beam) side-by-side or 4-5 large ships (45-60 m beam) side-by-side with clearance.
 - Significant reduction in operational delays is possible due to advanced layouts, higher crane capacity coverage and smoother block process flow.
- Based on current trends and diminishing returns principle, the productivity of 300 m can be considered as same (on conservative basis) as for a 120 m and 240 m plot, but the capacity would be higher proportionally. Also, better flexibility will be allowed to handle multiple ships. Accordingly, a target of 2.5×219623 LDT/year (2.5 capacity of 120 m plot) = 549057 LDT/year is considered as a conservative achievable estimate and 2.5×316800 = 792000 LDT/year is considered as optimistic target during the peak of ship recycling cycle. The effect is considered similar to joining of the 2.5 times 120 m waterfront plots without considering additional gains beyond the already derived gains except what is possible due to layout optimization, scaling of technological improvements and efficient crane utilizations etc.

Effective layout for large and medium ships

For a 300-meter Waterfront:

Large Ships:

- Beam: 45–60 m.
- Layout: Accommodates 4-5 large ships in combination side-by-side, leaving necessary clearances.

Medium Ships:

- Beam: 30–40 m.
- Layout: Accommodates 6-7 medium ships in combination side-by-side with necessary clearances.

Total proposed area

The usable area for the plot: Width 300 m, Proposed length = 215 m (based on 120 M plot)

Area=Width Length=300 m×215 m=64500 m²

Step 2: Productivity per m²

Using the conserving production figure of 549057 LDT/year, the productivity (Conservative) value of **0.028 LDT/m²day or 8.51 LDT/m²/year** for a **300-meter waterfront width** (based on the earlier curve extrapolation):

Conservative Production Estimate (LDT/year) =5,49,057 LDT/year

Or 1830 LDT/day (based on 300 workday per year estimate)

Capacity projections

Adjustments for further real-world bottlenecks since we have already considered the capacity based on most conservative estimates derived for 120 m waterfront width plot, it does take into account the bottlenecks and real-world scenarios therefore, though further adjustment is not considered necessary however for uncertainties, a 10% reduction is still accounted.

Productivity reduction (90%): To account for operational inefficiencies and uncertainties at **90% of production.**

Adjusted target productivity=1830×0.90=1647 LDT/day =494100 LDT/year (300 work days) per unit

Worker productivity and worker count estimate

To determine the ideal number of workers and their productivity for a 300 m x 215 m plot, we would use extrapolation of the data for 240 m plot

Worker count estimate

Previous scaling factor ≈ 0.023 workers/m² (*Using the same scaling method*)

- Workers for 64,500 m²: 64,500 m²×0.023=1,483.5≈1,480–1,500 workers

With technological improvements a further reduction in number of workers can be achieved by around 10-15%

- Reduction of ~10-15%. 1,500×0.90=1,350 workers.
- Estimate: ~1,350 workers (optimized operations).

Worker productivity estimate

Following the diminishing returns trend and earlier improvements:

- Baseline productivity likely between **1.39 to 1.76 LDT/worker/day**.
- With improvements (~10%): 1.53 to 1.94 LDT/worker/day.

Annexure F: Step-by-Step Ship recycling procedure

Suggestive (but not limited to) step-by-step ship recycling procedure for Alang ship recycling plots following beaching / controlled landing method

1. Pre-arrival preparations

- Obtain Inventory of Hazardous Materials (IHM) from the shipowner.
- Assign a specific bay for the incoming vessel.
- Prepare the winch system for controlled landing.
- Confirm readiness of:
 - Drainage channels
 - Sediment traps
 - Storm water tanks
 - Crane & vehicle movement areas

- All other actions to be completed as necessary

2. Controlled landing & positioning

- Bring the vessel during high tide under own power/assisted by tugs.
- Guide it onto the intertidal compacted area (~20–40 m zone).
- Use heavy duty winches (with necessary mechanical advantage) duly assisted by supporting infrastructure such as airbags, ultra-low friction high strength marine grade padding, steel rollers etc. to pull the vessel beyond HTL as required (based on cutting strategy) into the impermeable slope zone (Primary Cutting Zone).
- Secure the vessel in position.

3. Initial safety & environmental actions

- Isolate all hazardous compartments.
- Drain bilge water, oil residues, and fuel into designated oily water drain tanks.
- Conduct gas-free certification.
- Ensure fire suppression systems, PPE, and emergency response team (Zone E) are ready.

4. Primary cutting (beyond HTL on impermeable zone)

- Begin cutting above-deck structures, masts, funnel, cranes. Blocks size can be planned as per cutting strategy and crane capacity.
- Use of plasma cutting or cold cutting tools to minimize sparks would be better.
- Drain any contained fluids into drain channels and tanks.
- Debris goes to:
- Tertiary Cutting (Zone B, Zone C)
- Non-ferrous / additional storage

5. Crane-assisted secondary block removal

- Use mobile cranes and trailers in the Crane and Vehicle Movement Area to move large blocks to Secondary Block Zones B (hard surface) for further downsizing.
- Segregate blocks by type: steel, non-ferrous, reusable components.

6. Tertiary cutting & sorting

- Move manageable blocks to Tertiary Cutting Zones B and for sorting to zone C.
- Cut into:
 - Plates for resale
 - Scrap for melting
- Segregate into:
 - Steel plates and Finished products storage (Zone D)
 - Hazardous waste for segregation and storage (Zone C and Zone D)

7. Hazardous material management

- Asbestos, PCBs, heavy metals → Segregation Enclosure (Zone C) → Hazardous Store (Zone D)
- Provision of mobile HAZMAT removal kits and deployment of trained personnel at plot level in case of Hazardous materials needed to be removed within the vessel safely
- Transfer to approved TSDF facility from the Hazardous Storage Zone D
- Fluids, oils → stored in respective tanks
- Ensure drain filters, sediment traps, and oil separators are working during cuts

8. Recycling & dispatch

Finished steel and non-ferrous scrap moved to:

- Zone D (Finished Products Storage)
- Zone D Non-Ferrous Storage
- Reusable parts (engines, pipes, valves) moved to Workshops/Storage (Zone C/D) for segregation and resale.

9. Environmental & wastewater management

Drainage from cutting zones flows into:

- Oily Water Drain Tanks
- Storm Water Collection Tanks
- It is to be ensured that filters/sediment separators are cleaned periodically.
- Recycle water where possible or it should be sent for treatment.

10. Final cleaning, inspection & certification

- Clean impermeable surfaces and remove residual waste.
- Conduct soil, air, and water quality monitoring.
- Submit compliance reports to regulatory authorities (e.g. GMB, SPCB).
- Final inspection for HKC / EU SRR / ISO 30000 compliance.

Table F-1: Supporting operations (ongoing throughout)

Zone	Function
Zone E	Medical, admin, training, PPE
Zone D	Hazardous and non-hazardous storage
	Drainage, sediment filters, oily water management
Zone C	Product sorting, machinery rooms, oxygen cascade, workshops
Zone B	Secondary & tertiary cutting
Zone A	Primary cutting

Annexure G: Existing plots and layouts

1. Overview of existing ship recycling plots

Broad categorisation of plots has been maintained as specified in statistical analysis section.

a. Small size plots (30-50m waterfront width)

- **% of plots:** ~39.5%
- **Typical length:** ~100–130 meters
- **Typical area:** ~4,000–6,600 m²
- **Productivity:**
 - Median: ~6.0 LDT/m²/year
 - Max observed: ~15.48 LDT/m²/year (Top 25%)
- **Layout features:**
 - Single processing lane for one vessel at a time
 - Compact work zones for cutting, segregation, and temporary storage
 - Limited crane capacity (~18 tons/block)
- **Constraints:**
 - Congested layout
 - Low lifting capacity
 - High potential but underutilized without layout improvement
- **Optimization scope:**
 - Length extension to 200–220 m (if feasible)
 - Upgraded cranes and better block flow coordination

b. Medium size plots (51–80 m Waterfront Width)

- **% of plots:** ~41.1%
- **Typical length:** ~100–130 meters
- **Typical area:** ~6,000–10,500 m²
- **Productivity:**
 - Median: ~5.6 LDT/m²/year
 - Max observed: ~23.7 LDT/m²/year (Top 25%)
- **Layout features:**
 - Two processing lanes possible (parallel operations)

- Slightly better segregation and access paths
- Moderate crane capacity (upto 100-200 tons)
- **Constraints:**
 - Underutilized crane capacity due to cutting complexity
 - Limited space for sequential operations
- **Optimization scope:**
 - Length extension up to 200 m
 - Higher block cutting and faster turnover
 - Improved segregation zones
- c. Large and very large plots (81- 100 and 101 -135 m waterfront width)**
- **% of plots:** ~14.5% (combining 81–100 m and 101–135 m)
- **Typical length:** ~90–120 meters (plus extended back area in some cases)
- **Typical area:** ~10,000–31,800 m²
- **Productivity:**
 - Median: ~6.4 LDT/m²/year
 - Max achieved: ~9.96–11.0 LDT/m²/year
- **Layout features:**
 - Three or more processing lines possible
 - Large staging, dismantling, and segregation zones
 - Crane lifting capacity: up to 300 tons (practically limited to 175–200 tons per block)
- **Constraints:**
 - Logistical complexity (worker movement, material flow)
 - High fixed cost; requires sustained throughput
- **Optimization scope:**
 - Automation and robotics (long-term)
 - Better spatial zoning (staging, segregation, storage)
 - Use for high-value, large-volume ships (ULCC, VLCC, LNG)

Table G-1: Summary of plot layout

Plot Size	Strengths	Challenges	Best fit role
Small (30–50 m)	High per-area productivity, flexible, easier HKC compliance	Low capacity, crane/cutting limits	Ideal for specialized dismantling or ancillary recycling
Medium (51–80 m)	Balance of size and productivity, scalable	Underutilized equipment, crowding	Backbone for medium ships; suitable for phased modernization
Large (81–135 m)	High capacity, can handle mega ships, advanced equipment possible	Costly, complexity in layout	Ideal for flagship EU SRR-compliant plots; anchor facilities

2. Observations on some of the visited plots layouts

Plot 1: Functional layout with zoning and administrative setup

- **Key zones identified:**
 - **Intertidal landing area** → ship beaching and primary dismantling starts here.
 - **Clean cutting zone** (500.11 m²) → for contamination-free components (critical for EU SRR compliance).
 - **Oily block handling / Machinery storage** (252.54 m²) → Dedicated area reduces contamination spread.
 - **Stacking Zone** (531.56 m²) → Centralized for efficient material flow.
- **Notable features:**
 - Clearly marked winch areas and wire rope storage aligned with ship position.
 - Defined assembly and administrative block, indicating movement of supervision and logistics to landward edge.



Strengths

Feature	Assessment
Functional zoning	Cutting, oily handling, clean cutting, and storage zones are clearly delineated, supporting HKC/EU SRR intent to avoid cross-contamination

Feature	Assessment
Training & admin infrastructure	Two levels of offices, training rooms, and conference areas reflect emphasis on regulatory training, inspection readiness, and recordkeeping
Crane/winch positioning	Properly placed for vessel handling; wire rope zones are close to the primary cutting area
Clean cutting zone	Physically segregated space indicates focus on clean component disassembly (engines, electricals, non-ferrous)
Stacking area	Central location aids in smooth transfer of dismantled material; improves logistics

Compliance gaps:

Requirement	Deficiency
Impermeable flooring (intertidal cutting zones)	Not provided to prevent leakage of oil/fuel residues into soil/marine zone
Digital documentation interface	No indication of IHM tracking systems, barcoding zones, or segregated material id zones
Asbestos handling	No dedicated enclosure or decontamination chamber near dismantling areas
Environmental monitoring	No sampling point or groundwater monitoring setup shown — required for EU-approved yards

Other operational gaps

Issue	Observation
Stormwater runoff	No visible system for segregating stormwater from potentially contaminated areas
Vehicle/material flow paths	No marked internal pathways for forklifts, cranes, or trucks; may lead to congestion

Plot 2: Functional overview

- Key features:
 - Tertiary zone: 1,400 m² → Indicates capability for parallel operations.
 - Secondary zone: 300 m² → Intermediate cutting and transfer zone.
 - Dedicated Finished Product Storage, Oxygen Cascade, and Non-Ferrous Storage, Segregated hazardous and valuable components.
 - **Multiple cranes** installed across cutting and stacking zones.
 - **Emergency Infrastructure:** Fire tanks, hydrants, body showers, and emergency exits well marked.
- Yard characteristics:
 - This is a **mid-sized plot** (75 -80 m waterfront width) with deep inland extension.
 - Reflects many **EU SRR best practice alignment:** zoning, emergency response, material handling.
 - **Spatial zoning** is logically structured for simultaneous dismantling, sorting, and evacuation.



- Improvement suggestions:
 - Introduce **automated scrap conveyors** from tertiary to finished product zones.
 - Add **covered godown** or modular sheds for weather-sensitive components (electronics, copper).

Strengths

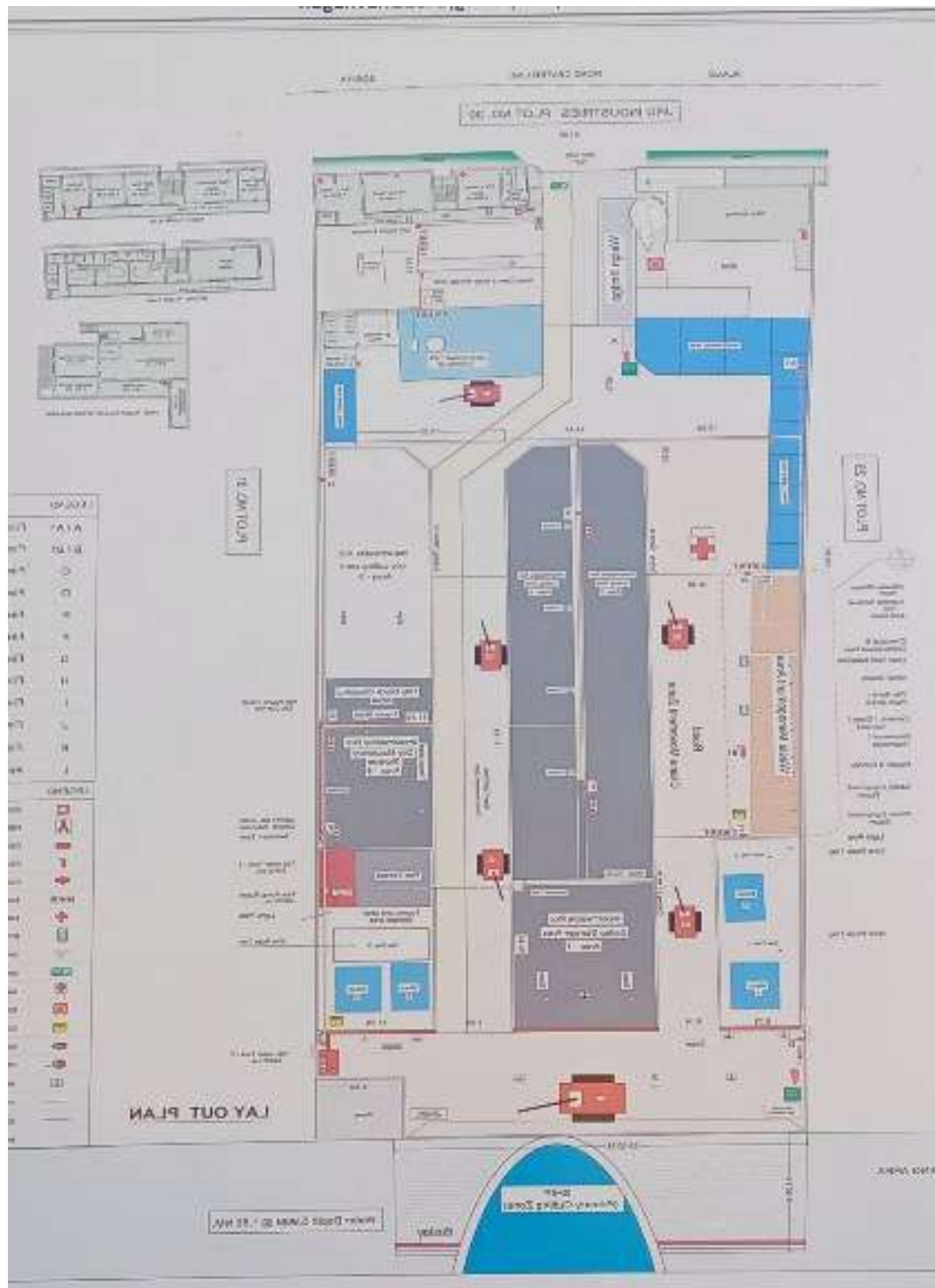
Feature	Observations
Clear process segmentation	Well-defined cutting zones by stage (primary → secondary → tertiary) enable clean and controlled dismantling flow
Crane deployment	Strategically placed for all zones, including stacking and oily block areas
Dedicated support facilities	First aid, rest room, emergency point, safety room, oxygen cascade system, storm water tank, and fire hydrants are all mapped out
Worker safety infrastructure	Eye wash stations, body shower units, and fire kits are clearly placed
Admin & training block	Inclusion of training rooms indicates intent toward HKC/EU SRR compliance readiness
Evacuation planning	Full legend and marked emergency access points provided — meets ILO/OSH planning norms

Operational & layout optimization opportunities

Area	Suggestion	Benefit
Hazardous waste area	Add isolated, ventilated shed for asbestos, mercury, PCB devices	Mandatory under EU SRR
Digital compliance station	Establish small admin hub for IHM recordkeeping, tagging, tracking	Enables audit readiness
Bunded flooring + drainage	Retrofit oil-prone zones with bunds, trenches, and separators	Environmental protection & HKC compliance
Clear segregation of recyclables	Divide non-ferrous, e-waste, salvageable spares with signage/fencing	Improves recovery value and reduces cross-contamination
Fire/spill drill zones	Conduct and mark fire drills and spill response routes regularly	Strengthens ILO/HKC emergency preparedness

Plot 3: Functional overview

Area	Description
Primary cutting zone	Facing the beach/intertidal zone; used for initial hull dismantling
Winch & wire rope areas	Located adjacent to cutting zone for pulling blocks
Stacking zone	Central zone for storing dismantled sections
Clean cutting zone	Segregated area for dismantling non-contaminated components
Oily block / machinery storage	A designated zone for handling heavier or oil-stained components
Admin block & assembly area	Near rear of the yard, includes training and administrative offices
Water tank / utility zone	For fire control or water access, present near the winch area



Strengths

Feature	Observation
Basic functional zoning present	The yard is clearly structured into primary work areas: cutting, stacking, and storage
Oily vs clean zones separated	The clean cutting area and oily block zone are physically distinct.
Winch area properly positioned	Aligns well with the intertidal beach landing for vessel block pulling

Training/admin infrastructure exists	Indicates orientation toward compliance, recordkeeping, and capacity building
Simple layout, easy flow	Compact flow from ship → dismantle → storage → exit with minimal overlap

Key deficiencies & gaps

Requirement	Deficiency
Impermeable flooring in cutting zone	Intertidal/primary cutting zone flooring is not impermeable.
Drainage and spill containment	No bunds, trenches, or oil-water separator identified, especially around oily block area
Emergency & PPE facilities	Missing clear emergency exit paths.
Waste stream control	Clean cutting and stacking zones not shown to have separate e-waste/non-ferrous sorting

Annexure H: Explanation of Unit Rates Used in Cost Estimates

Unit rates – Civil works

Hard impermeable pavement (RCC Pavement)

- **Unit:** sqm
- Key components:
 - Site clearance and removal of debris
 - Grading and levelling of natural ground
 - Compaction of virgin soil using vibratory rollers
 - Ground stabilization using cement-mixed sand (3–5% cement)
 - Laying of impervious membrane layer (200–300-micron HDPE or bituminous geomembrane) over compacted surface to prevent leachate or contaminant seepage
 - Rubble soling 150–200 mm thick, hand packed with blinding
 - Granular sub-base (GSB) ~200 mm
 - Dry Lean Concrete (DLC) ~100–150 mm
 - M35/M40 RCC pavement with reinforcement
 - Surface finishing, joint cutting, curing, sealant application
 - impervious layer under the slab
- **Assumed Thickness:** 300–350 mm (to accommodate heavy-duty vehicular loads such as forklifts, cranes, etc.)
- **Unit rate:** ₹4,500/sqm

RCC Retaining wall

- **Unit:** rm
- Key components:
 - Site clearance and setting out
 - Dewatering during excavation
 - Excavation in all types of soil
 - Temporary strutting/shoring of excavated trenches
 - Geotextile filter fabric along soil-retaining face
 - PCC 1:3:6 levelling course

- Formwork for vertical face and footing
- Reinforcement @ 150 kg/cum
- M40 grade RCC for wall and base
- Water-proofing treatment for soil-retaining face
- Weep holes at regular spacing
- Backfilling with granular material in layers
- Compaction of each layer with appropriate equipment
- Surface finishing and plaster (if exposed)
- **Unit rate:** ₹28,000/rm

Compound wall and gates- for ship recycling plot

Compound wall (RC Precast panel infill wall)

- **Unit:** rm
- **Key components:**
 - Precast RCC columns with inset column foundations and continuous tie beams
 - precast RCC infill panels (2.4 m height)
 - All elements precast off site
 - Cortina/barbed wire fencing
 - Includes formwork, lifting, placing, alignment, and installation
- **Unit rate:** ₹12,000/rm

Steel gate (15 m wide)

- **Unit:** each
- **Key components** - Double leaf structural steel gate with corrosion protection for marine exposure (epoxy zinc primer + polyurethane top coat) includes:
 - Fabrication, shop welding, galvanizing of accessories, guide rails, rollers, hinges, bearings, etc.
 - Foundations for steel gate columns
 - Full site assembly and installation
 - Provision of an overhead steel canopy structure in structural steel sections with purlins, cleats, bracings; complete with erection bolts and anchorage
- **Unit rate:** ₹12,00,000/unit

Steel gate (6 m wide)

- **Unit:** each
- **Key components** - Single or double leaf structural steel gate with corrosion protection for marine exposure (epoxy zinc primer + polyurethane topcoat) includes:
 - Fabrication, shop welding, galvanizing of accessories, guide rails, rollers, hinges, bearings, etc.
 - Foundations for steel gate columns

- Full site assembly and installation
- Provision of an overhead steel canopy structure in structural steel sections with purlins, cleats, bracings; complete with erection bolts and anchorage
- **Unit rate:** ₹3,50,000/unit

Compound wall and gates- for scrap shop/market

Compound wall (RC Precast panel infill wall)

- **Unit:** rm
- Key components:
 - Precast RCC columns with inset column foundations and continuous tie beams
 - precast RCC infill panels (2.4 m height)
 - All elements precast off site
 - Includes formwork, lifting, placing, alignment, and installation
- **Unit rate:** ₹10,000/rm

Steel gate (6 m wide)

- **Unit:** each
- **Key components** - Single or double leaf structural steel gate with corrosion protection for marine exposure (epoxy zinc primer + polyurethane topcoat) includes:
 - Fabrication, shop welding, galvanizing of accessories, guide rails, rollers, hinges, bearings, etc.
 - Foundations for steel gate columns
 - Full site assembly and installation

Unit rate: ₹2,45,000/unit

Storm water drain (RCC)

- **Unit:** rm
- Key components:
 - Site clearance and trench layout
 - Dewatering and shoring of trenches
 - Excavation in all soil strata
 - Laying geotextile fabric to prevent subgrade contamination
 - Sand/cushioning bed preparation
 - Placement of precast or cast-in-situ RCC U-drain or box drain (M30)
 - Reinforcement as per design
 - Formwork and concreting in case of cast-in-situ
 - RCC cover slabs with lifting hooks
 - Provision for drop inlets, junction chambers, and catchpits
 - Curing, finishing, and backfilling with compaction

- **Unit rate:** ₹16,000/rm

Utility tanks (RCC)

- **Unit:** per litre
- Key components:
 - Site clearance and setting out
 - Dewatering during excavation
 - Excavation in all types of soil with side support
 - PCC 1:3:6 base preparation
 - Geotextile layer beneath base slab (if required)
 - RCC tank structure in M30 with formwork and curing
 - Reinforcement as per design
 - Internal waterproofing including brush-bond or crystalline systems
 - Provision of access covers, ladders, pipe openings
 - Backfilling with selected material and compaction
 - External waterproofing or wrapping (bituminous or HDPE sheet) if below ground

Unit rate:

- Water tanks (fire/raw/domestic/rainwater): ₹12/litre
- Oil and foam tanks (chemical lining): ₹14/litre
- Oil-water separator (each): ₹9,50,000/unit

Buildings- for ship recycling plot

- **Unit:** sqm (total built-up area)

Admin building

- Key components:
 - **Foundation:** Isolated or combined RCC footings (min. M30)
 - **Structure:** RCC framed structure with brick/block infill
 - **Flooring & Finishes:** Vitrified tile flooring, putty and emulsion paint, weatherproof exterior paint
 - **Openings:** Aluminium/UPVC windows, laminated doors
 - **MEP:** Full electrical and plumbing installation, LED lighting, sanitary and water supply
 - **HVAC:** Ductable /split AC
- **Unit rate:** ₹46,000/sqm

RCC pump room

- Key components:
 - **Foundation:** M30 RCC footings

- **Structure:** RCC walls/slab with minimal finish
- **Flooring & Finishes:** IPS flooring, weatherproof paint
- **Openings:** MS shutters/vents
- **MEP:** Conduits, sleeves, basic wiring
- **Unit rate:** ₹30,000/sqm

RCC canteen & recreation room

- Key components:
 - **Foundation:** RCC footings with plinth beam
 - **Structure:** RCC framed with high roof clearance and ventilation
 - **Flooring & Finishes:** Vitrified tile, emulsion or oil-bound washable paint
 - **Openings:** Aluminium/UPVC windows with ventilators
 - **MEP:** Electrical and plumbing including kitchen exhaust and drainage
- **Unit rate:** ₹46,000/sqm

RCC storage/godown:

- Key components:
 - **Foundation:** RCC strip/combined footings
 - **Structure:** RCC frame with block infill, moderate height
 - **Flooring:** Trimix or IPS flooring
 - **Openings:** MS rolling shutter, ventilation grills
 - **MEP:** Basic wiring and lighting
- **Unit rate:** ₹20,000/sqm

Steel sheds (Workshop/Winch shed)

- Key components:
 - **Structure:** PEB type portal frame, GI roofing and sheeting
 - **Foundation:** RCC pedestal with anchor bolts
 - **Flooring:** PCC or trimix
 - **Openings:** Rolling shutter and louver ventilators
 - **Inclusions:** Structural steel fabrication, erection, sheeting, rainwater gutters
- **Unit rate:** ₹20,000/sqm

Buildings- for scrap shop/market

- **Unit:** sqm (total built-up area)

Shop & general building

- Key components:
 - **Foundation:** Isolated or combined RCC footings (min. M30)
 - **Structure:** RCC framed structure with brick/block infill

- **Flooring & Finishes:** Vitrified tile flooring, emulsion paint, weatherproof exterior paint
- **Openings:** Aluminium/UPVC windows, laminated doors
- **MEP:** Basic electrical and plumbing installation
- **Unit rate:** ₹10,000/sqm

Storage sheds (steel)

- Key components:
 - **Structure:** PEB type portal frame, GI roofing and sheeting
 - **Foundation:** RCC pedestal with anchor bolts
 - **Flooring:** PCC
 - **Openings:** Rolling shutter
- **Unit rate:** ₹7,000/sqm

Civil works related with utility

Note: All rates provided below are for civil works only and exclude the cost of pipes, cables, fittings, valves, and other utility components.

- **DG set foundation:** RCC foundation block in M30 with anti-vibration pad embedment, earthing conduit sleeves, surface finishing, grouting base plate
 - **Unit Rate:** ₹1,80,000/unit
- **Transformer foundation:** RCC pedestal with plinth curb wall, base rail grouting, cable conduit provision, fencing post inserts if required
 - **Unit Rate:** ₹1,50,000/unit
- **Underground cabling:** Trenching in soil/hard strata, sand bedding, RCC duct or open trench with cover slabs, backfilling and compaction. Cable supply and laying not included.
 - **Unit Rate:** ₹2,500/rm
- **Cable pull pits:** Precast RCC or cast-in-situ cable junction box with internal support hooks, lockable covers, drainage weep holes. Cable routing not included.
 - **Unit Rate:** ₹30,000/unit
- **High mast/Light pole Foundation:** M30 RCC pedestal foundation with insert bolts, anchor templates, GI earthing strip sleeve provision, compacted PCC surround
 - **Unit Rate:** ₹75,000/unit
- **Underground pipe works (FFTG):** Excavation, bedding, and civil trenching works only for fire water mains; includes thrust blocks, backfilling, and chamber works. Pipe supply and jointing excluded.
 - **Unit Rate:** ₹2,800/rm
- **Underground pipe works (DWS):** Civil trench works for distribution pipelines including bedding, backfilling, chamber formation and restoration. Pipe supply and connection excluded.

- **Unit Rate:** ₹ 2,600 /rm

Soft dredging

Excavation of soft rock (hard clay) upto 1.5 m depth including sorting out and stacking of useful materials and disposing off the excavated stuff upto 50 Meter lead including additional marine equipment's.

- **Unit rate:** ₹326 /m³

Unit rates –Electricity

11KV/ 433V step down transformer:

250 KVA Max. allowable losses at 50 % of rated load is 0.98 KW and at full load is 2.93 KW

- **Unit rate:** ₹5,63,005 /unit
- AMC SOR No. 10-1-1

H.T. VCB incoming & two outgoing 400 A:

250 KVA Max. allowable losses at 50 % of rated load is 0.98 KW and at full load is 2.93 KW

Key components:

Power factor meter

Digital KWH Meter - One No.

Electrical closing coil & short trip coil operating on 110V. D.C.- three sets

Instantaneous under voltage relay& Temperature rise Tripping Relay

necessary interconnection with air insulated high grade copper busbar

- **Unit rate:** ₹ 13,15,680/unit
- AMC SOR No. 10-1-4

Diesel generating set:

Continuous rating of 200 KVA, BHP not less than 254 BHP

- **Unit rate:** ₹ 12,60,680 /unit
- AMC SOR No. 10-4-2

AMF control panel:

AMF control panel for 200 KVA/250 KVA 3 phase DG set

- **Unit rate:** ₹ 2,20,509 /unit
- AMC SOR No. 10-4-3

Main LT panel:

AMF control panel for 200 KVA/250 KVA 3 phase DG set

- **Key components:**

- Four pole moulded case circuit breaker of 35 KA at 415 V
- Miniature circuit breaker single pole 6A to 25A
- 240 V MCB double pole switch for motor & inductive load
- 415 V MCB four pole for motor & Inductive load

- **Unit rate: ₹ 2,35,126/unit**

- AMC SOR No. 3-4-2
- AMC SOR No. 3-4-4
- AMC SOR No. 3-4-14
- AMC SOR No. 3-8-1
- AMC SOR No. 3-10-1-(B)
- AMC SOR No. 3-10-2
- AMC SOR No. 3-10-5
- AMC SOR No. 3-10-6
- AMC SOR No. 3-15-6
- AMC SOR No. 3-15-7
- AMC SOR No. 3-16-1
- AMC SOR No. 3-4-4

Pump panel:

AMF control panel for 200 KVA/250 KVA 3 phase DG set

- **Key components:**

- Four pole moulded case circuit breaker of 35 KA at 415 V
- Miniature circuit breaker single pole 6A to 25A
- 240 V MCB double pole switch for motor & inductive load
- 415 V MCB four pole for motor & Inductive load

- **Unit rate: ₹ 1,30,607 /unit**

GRP / FRP Ladder type Cable Tray:

Corrosion Resistant Polyester Flame Retardant U.V. Stabilized Resin System -
Manufactured from Pultruded Sections - Polyester Resin System, Glass Content: 55 – 60
%

- **Unit rate: ₹ 500 /rm**
- AMC SOR No. 4-10-1

Multistrand copper conductor cable

- **Unit rate: ₹ 1,500 /rm**

- AMC SOR No. 4-4-5

heavy duty flood light:

Key components:

- 8 units of 150-watt HPSV / Metal halide lamp
- Octagonal pole made from HR sheet steel

- **Unit rate: ₹ 50,000 /unit**
- **AMC SOR No. 6-1-4**
- **AMC SOR No. 2-11-1**

Unit rates - Plumbing

Domestic water supply system:

- Key components:
 - Pipe connection
 - Valves
 - Excavation and fillings
- **Unit rate: ₹ 20,00,000 /set**
- Market rate

Domestic water pump:

Fully Automatic hydro pneumatic booster system with cast iron housing Enclosure class IP44 minimum, with built in PTO motor protection and stainless-steel impeller pump with power 2.25 kw/3 HP, 3 phases and flow rate of -12cm²

- **Unit rate: ₹ 2,81,600 /set**
- GWSSB SOR No. 9-8-6

Water treatment plant and feed pump:

Vertical self-supporting pressure filter (PSF) all accessories, with pressure pump set air vent valve with piping, with initial charge of filter media for pressure sand filter with a capacity of 0.5 MLD

- **Unit rate: ₹ 6,28,636 /set**
- GWSSB SOR-WTP-SECTION-D

Rainwater transfer pump set:

Submersible single stage single entry pumps connected to submersible for 415 + 10% volts, 3 phase, 50 cycles A.C.

- **Unit rate: ₹ 17,000 /set**
- SOR No 9-8-6 (GWSSB)

Rainwater trenches and treatment system:

- **Unit rate: ₹ 40,00,000 /set**
- Market rate

Foam suppression system

- **Unit rate: ₹ 20,00,000 /set**
- Market rate

Fire water pump - Main:

Main fire pump, with a synchronous speed 1500 RPM, suitable for operation on 415 volts, 3 phase 50 Hz, AC supply with IP 55 protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS-325. 2280 lpm capacity with 70 m head.

- 2280 lpm at 56 m Head
- **Unit rate: ₹ 3,50,000 /set**
- CPWD SOR-DSR-AOR-SECTION-1

Fire water pump - Diesel pump:

Diesel driven pump, with a synchronous speed 1500 RPM, 12 /24 volts electric starting equipment.

- 2280 lpm at 56 m Head
- **Unit rate: ₹ 3,50,000 /set**
- CPWD SOR-DSR-AOR-SECTION-1

Fire water pump – Jockey pump:

Jockey pump, Suitable HP squirell cage induction motor TEFC type suitable for operation on 415 volts, 3 phase 50 Hz AC supply with IP 55 class of protection for enclosure, horizontal foot mounted type with Class-'F' insulation, conforming to IS: 325.

- 180 lpm at 56 m Head
- **Unit rate: ₹ 81,196 /set**
- CPWD SOR-DSR-AOR-SECTION-1

Gas line and associated costs for plots:

600 mm GI pipe, for gas supply to proposed ship recycling plots. Including excavation, fitting and other associated charges

- **Unit rate: ₹ 30,000 /rm**
- Market rate

Unit rates - Infrastructure for master plan

Roads

- Unit: **sqm**
- Rate: **₹3,000/sqm (bituminous surface),**
₹1,400/sqm (footpaths)
- Includes: Earthwork, GSB, WMM, DBM, BC layers; kerb stones; sub-base; and compaction. Footpath includes PCC base, tiling, and edge treatments.
- Bridge Cost: ₹1,00,000/sqm (based on structural steel or RCC configuration).
- References: TP Schemes, MoRTH Specifications and SOR from Gujarat NH Division.

Electrical infrastructure

XLPE armoured cable

- (A) 3 1/2 core 25 Sq. mm (16 Sq. mm 1/2 core) to (K) 3 1/2 core 400 Sq.mm (185 Sq. mmm 12 core)
- Rate: 179 – 1721/rm
- AMC SOR No. 4-3-3

RCC Hume Pipe

- 100 mm Dia to 450 mm Dia
- Rate: 224 – 452/rm
- AMC SOR No. 4-5-7

DWC Pipe

- 40 mm Dia to 100 mm Dia
- Rate: 107 – 725/rm
- AMC SOR No. 4-5-8

Precast RCC U-shape drain and cover – utility duct

- 750x750x2000 mm
- Rate: 9,830/unit
- Market rate

Bulette type CCTV camera

- 4MP fixed lens
- Rate: 16,100/unit
- Market rate

Fiber optic cable for CCTV

- Rate: 16/rm
- Market rate

Water supply infrastructure

Centrifugally cast DI class K9 pipe

- 100 mm – 300 mm
- Rate: 1,256 – 3,684/rm
- CPWD SOR No. 7591

Masonry chamber

- 120x120x100 cm upto 300 cm inside
- Rate: 26,163/unit
- CPWD SOR No. 18.35100 mm – 300 mm

Borewell

- 350 m well including labour
- Rate: 19,71,759/unit
- Based on quotation

Water tank (reservoirs)

- Underground tanks
- Rate: 12/Liter
- Overhead tanks
- Rate: 20/Liter
- Market rate

Pump house

- Rate: 30,00,000/set
- Market rate

Sewerage and stormwater infrastructure

RCC pipe NP2 class

- 250 - 1200 mm
- Rate: 375 – 3,825/rm

- CPWD SOR No. 1702-1712

Sewage treatment plant

- Including civil works and plant room
- Rate: 1,15,50,870/MLD
- GWSSB Sor-Part-2-Civil Sor-Section C

Masonry chamber

- 120x120x100 cm upto 300 cm inside
- Rate: 26,163/unit
- CPWD SOR No. 18.35

TSDf

WtE Incinerator

- Unit: per TPD
- Unit rate: ₹ 4,00,00,000
- References: Recent projects

Secured landfill

- Unit: per Ha
- Unit rate: ₹ 10,00,00,000
- References: Prefeasibility report

Effluent treatment plant

- Unit: per MLD
- Unit rate: ₹ 3,00,00,000
- References: Market rate

Public Housing Cluster & Social Infrastructure

Housing unit

- Unit: per unit
- Rate: ₹6,00,000/unit
- Includes: G+2 RCC construction, standard finishes, electrical and plumbing services, community access, stairwells and circulation.
- References: AMC reports.

Convenient shopping

- Unit: per m²
- Rate: ₹25,000/m²
- Includes: G+1 RCC structure, standard finishes, electrical and plumbing services.

Parks & open space

- Unit: per m²
- Rate: ₹ 960/m²

Dispensary

- Unit: per m²
- Rate: ₹25,000/m²
- Includes: Single storey RCC structure, standard finishes, electrical and plumbing services.

Internal roads

- Unit: per m²
- Rate: ₹1,930/m²
- Includes: 4.5 m carriage way + 2 m NMT

Other facilities

- Unit: Lump sum per facility
- Rates:
 - 50 bedded Mult speciality hospital: ₹1575 lakhs
 - Upgradation of training institute: ₹100 lakhs
- Includes: RCC structure, classrooms/wards, toilets, water supply, electrical, basic furniture, and landscaping.
- References: Gati shakti, TP Schemes and AMC reports.

Annexure I: Comparison of Alang with Bangladesh and Turkish recycling plots

Comparative overview of the major ship recycling plots in Chattogram (Bangladesh), Alang-Sosiya (India) and Aliğa (Turkey):

Category	Chattogram ^{1,2,3} , Bangladesh	Aliğa, Turkey ^{4,5}	Alang-Sosiya ^{6,7} , India	
			Existing	Proposed
Location	Sitakund coast, near Chattogram	Aliğa, Izmir Province	Gulf of Khambhat, Gujarat	
Established	Informally in 1960, officially recognized in 2011	1976	1983	-
Coastline length	Approximately 18 km	Approx. 112 Ha	Approximately 10 km	Approx 14.5 km
Number of yards / plots	Approximately 184 yards (70–80 active)	28 active yards operated by 22 companies ⁸	Approximately 153 plots (124 active)	Approximately 10-16 additional plots of 300 m x 215 m and 240 m x 215 m
Plot sizes	Small to medium Approx. 10000 to 20000 m ² Large: approx. 25000-45 000 m ² Very large (Few plots): approx. 50000-60000 m ²	Small: approx. 10500 to 18000 m ² Medium: approx. 18000 to 23600 m ² Large: few plots: approx. 28000-30000 m ²	Small: approx. 3000 to 10000 m ² Medium: 12000 to 15000 m ² Large: (Very few): approx. 15000 to 36000 m ²	Small: approx. 7000 to 20000 m ² Medium: 20000 to 25000 m ² Large: approx. 25000 to 32000 m ² Very Large: (New plots (51000 to 66000 m ²))

Category	Chattogram ^{1,2,3} , Bangladesh	Aliğa, Turkey ^{4,5}	Alang-Sosiya ^{6,7} , India	
			Existing	Proposed
Number of workers	Approximately 15,000 (mostly seasonal, day contracts)	Estimated to be 1200 to 1500 workers	Peak: upto 40,000; Current: approx. 3,500 no.	At least 28000-30000 at peak load with enhanced technology and training
Recycling method	Beaching	Landing method (partial beaching with stern afloat)	Beaching	Beaching cum Controlled landing
Ships recycled (Recent)	Not specified; historically high volume	Data not specified;	FY 2023–24: 125 ships (16-year low)	Target Approx. 11.3 M LDT by 2040
Worker origin	Mostly from northwest Bangladesh	From eastern Turkey	Migrants from Uttar Pradesh, Bihar, Odisha	
Accidents (2009–2018)	≥249 deaths, ≥1,028 severe injuries	Multiple fatalities; concerns over safety standards	No recent official count; historical safety concerns documented	Target to be fully compliant Safety and risk as per HKC, EU SRR
Health & safety	Minimal personal protective equipment (PPE), limited medical support, restricted unions	Improved practices; ongoing concerns about hazardous material exposure and accident rates	Improved PPE, medical checks in place; safety remains a concern	Target to be fully compliant health & Safety as per HKC, EU SRR
Environmental impact	High: toxic waste, marine pollution, lack of treatment facilities	Pollution from heavy metals and other contaminants; environmental monitoring indicates high pollution levels	Moderate to High: heavy metals, oil residues; improved regulations but environmental risks remain	Fully compliant as per HKC, EU SRR
Hazardous waste management	Poor; fake certificates, illegal dumping, resale of toxics	Improved management, concerns remain regarding certain waste streams like heavy metals and PCBs	Better enforcement; moving toward compliance with international standards	Target to be fully compliant as per HKC, EU SRR
Legal issues	Supreme Court orders (2009, 2016) ignored; weak enforcement	Subject to Turkish regulations; some yards removed from EU approved list due to safety concerns	Governed under Indian regulations; progress toward Hong Kong Convention compliance	Target to be fully compliant as per HKC, EU SRR and Indian Regulations

Category	Chattogram ^{1,2,3} , Bangladesh	Aliğa, Turkey ^{4,5}	Alang-Sosiya ^{6,7} , India	
			Existing	Proposed
International recognition	Criticized by NGOs, environmentalists	Recognized for improvements; still faces criticism for environmental and safety standards	Largest ship recycling yard globally; efforts to modernize and align with global norms	Target to become the fully compliant yard with full international recognition
Economic role	Major source of steel and employment in coastal Bangladesh	Significant contributor to local economy; supplies materials to steel mills in the region	Major contributor to Indian scrap steel market; declining activity impacting local economy	To contribute to growing Indian economy.

Note: The information above is based on publicly available data and may be subject to change as conditions evolve.

¹ <https://shipbreakingplatform.org/our-work/the-problem/bangladesh/>

² <https://shipbreakingplatform.org/>

³ Google earth

⁴ <https://news.mongabay.com/2024/12/shipbreaking-pollutes-turkiyes-coast-despite-european-cleanup-efforts/>

⁵ <https://shipbreakingplatform.org/wp-content/uploads/2023/12/Turkey-Report-2023-NGOSBP.pdf>

⁶ Primary and secondary research

⁷ https://www.hellenicshippingnews.com/#google_vignette

⁸ <https://shipbreakingplatform.org/wp-content/uploads/2023/12/Turkey-Report-2023-NGOSBP.pdf>

Annexure J: Alang SRY production data of 153 plots¹⁶ since 2016 (Arranged as per waterfront width)

¹⁶ Plot numbers cited are based on the 2024 configuration used for data analysis

Annexure K: Alang SRY plots¹⁷ ranking arranged in descending order based on production data

¹⁷ Plot numbers cited are based on the 2024 configuration used for data analysis

Annexure L: Earthwork calculations

Annexure M: Geotechnical parameters

Annexure N: Drawings

Along SRY plot ranking arranged in descending order based on production data																	
Plot No.	Waterfront width (m)	Length	Area (m ²)	Year wise LDT										Max Yearly LDT Output	Cumulative LDT	Max Yearly LDT/Unit Area (m ²)	
				2016	2017	2018	2019	2020	2021	2022	2023	2024					
74		30	59	1770	25428.6	0	9712.7	0	0	0	0	1197.11	3266.76	25429	39605	14.366	
75		30	55	1650	0	0	0	0	0	0	0	0	0	0	0	0	
76		30	85	2550	24872.82	8330.54	6355	5400.81	12741.5	10857.6	8995.09	3899.1	0	24873	81452	9.754	
82		30	86	2580	20947	27006.9	6921.57	25793	1566.71	6494.34	4868.09	1621.9	0	27007	95220	10.468	
94		30	58	1740	14492.72	3806.18	12459.01	0	0	0	0	0	0	14493	30758	8.329	
95		30	58	1740	0	9055	11363	0	0	0	0	0	0	11363	20418	6.53	
135		30	86	2580	0	0	0	0	646.77	6301.3	4855	3699.95	0	6301	15503	2.442	
83		31	82	2542	0	2153	1430	0	2212.06	2537.5	476.52	3472.6	0	3473	12282	1.366	
104		31	87	2697	0	0	0	0	0	0	0	0	0	0	0	0	
105		31	87	2697	36958.1	21942.6	11363		11845	9381.86	6546.54	7098.32	899.7	36958	106035	13.703	
108		31	84	2604	8082	2540.01	0	0	0	10943.6	6440.74	3816.62	0	10944	31823	4.203	
109		31	84	2604	0	0	0	0	0	0	0	0	0	0	0	0	
114		31	70	2170	8803.84	0	0	0	0	0	3566.4	3735.39	2488.83	8804	18594	4.057	
123		31	86	2666	26134.41	14189.75	0	3282	6734.59	5851.88	1809.7	1405.7		26134	59408	9.803	
112		32	81	2592	11446.9	8506.77	2337.67	0	11054	5617.79	0	0	0	11447	38963	4.416	
113		32	75	2400	4570.41	6424.5	8216.33	14031.33	13145	9330.87	2762.18	8080	0	14031	66561	5.846	
73		33	64	2112	0	0	0	0	0	0	1245.59	8580.1	3171.2	8580	12997	4.063	
77		33	85	2805	20196.1	11941.2	0	15194	15243	5701.18	3547.97	1290.55		20196	73114	7.2	
131		33	81	2673	7090	10636.8	7163.4	0	6417.94	0	5442.32	0	0	10637	36750	3.979	
134		33	84	2772	27408.3	17071.5	9543.92	5780	12722.6	7230.96	6732.19	0	0	27408	86489	9.888	
124		35	83	2905	40594.94	26978.2	37299.5	8407.42	11093.03	8477.89	10786.48	9173.61	3993.67	40595	156805	13.974	
154		35	88	3080	0	0	0	0	0	0	0	0	0	0	0	0	
84A		36	87	3132	11850	0	2105.78	5390.2	0	5409	0	7036	0	11850	31791	3.784	
71		38	70	2660	8875.28	17921.68	10013.45	5719.81	0	0	0	0	0	17922	42530	6.737	
84C		41	55	2255	0	0	0	0	0	0	0	0	0	0	0	0	
166 M 1		43	37	1591	0	0	0	0	0	0	0	0	0	0	0	0	
166 M 2		43	37	1591	0	0	0	0	0	0	0	0	0	0	0	0	
127M		44	81	3564	31649	0	9623	0	21731	0	1963	12380.8	0	31649	77347	8.88	
136M		44	83	3652	18908.41	866	11031.5	4055	9359	0	0	4672.2	0	18908	48892	5.178	
54		45	56	2520	13395	36894.66	21809.54	16902.9	21218	20912	14897.6	0	0	36895	146030	14.641	
85		45	81	3645	8048	9561.12	6088.9	7434.31	21132	6727.36	0	8013.99	0	21132	67006	5.798	
91M		45	65	2925	45268	7800.8	13286.19	20239.59	27852.6	22000	9697.15	13370	0	45268	159514	15.476	
99		45	45	2025	5161.8	0	0	0	5664	13828	0	0	0	13828	24654	6.829	
100M		45	45	2025	20126.18	0	0	0	0	0	0	0	0	20126	20126	9.939	
125M		45	79	3555	13563	0	13410.91	8002.33	5964	2536.88	0	0	0	13563	43477	3.815	
130M		45	80	3600	25043	10077.3	7007.2	7491.7	7931.8	7498.21	0	0	7964.6	25043	73014	6.956	
86		46	83	3818	10592.7	5340	26128.5	5837.05	12413.01	9586.96	0	6058	0	26129	75956	6.844	
93M		46	56	2576	17857	6761	13414.1	6579.21	21457	9995.12	12651.4	0	0	21457	88715	8.33	
128M		46	79	3634	35291.15	29726.7	11363	21768.35	31237.9	13213.2	6144	43008	0	43008	191752	11.835	
149 M		46	98	4508	0	0	0	0	0	0	0	0	0	0	0	0	
151 M		46	98	4508	0	0	0	0	0	0	0	0	0	0	0	0	
26		47	90	4230	6152.13	0	17241.5	0	0	0	0	0	0	17242	23394	4.076	
33		47	96	4512	11463	54440.32	0	12383.43	5790	27164	0	12659.79	0	54440	123901	12.066	
84B		47	90	4230	25279.95	0	648.13	717.63	0	0	17766.6	0	0	25280	44412	5.976	
56		48	91	4368	18092.3	18092.3	16065.3	14954.53	0	10845.72	14738.5	9257	8095.4	18092	110141	4.142	
24		49	150	7350	42174.2	0	33758.5	8965	40896.33	18882.9	32520.04	23740	26469.3	42174	227406	5.738	
28		49	91	4459	21253	15222	12441	13286	15736.1	10747.33	5327.14	13924.16	0	21253	107937	4.766	
35		49	84	4116	11463	0	25156.37	20996.12	13160	25669.6	22772.95	33716.3	36064	36064	188998	8.762	
38		49	123	6027	27212.7	23017.1	15804	0	27847.3	33033.4	0	14133.2	24271.4	33033	165319	5.481	
41		49	70	3430	11175.2	2781	18406.64	0	18982	15207.07	11946.5	18109.2	0	18982	96608	5.534	
44		49	68	3332	0	0	0	0	0	0	0	0	0	0	0	0	
61		49	89	4361	32185.71	35682.98	22092.1	63311.33	39462.28	46900.9	28484.65	23707	16627.2	63311	308454	14.518	
84E		49	50	2450	10253.2	55676.6	11363		15989.34	10254.05	0	2435	9911.54	55677	115883	22.725	
23		50	112	5600	26704.6	5281.2	32264.2	15686.68	24365	2591.6	8344.92	2966	0	32264	118204	5.761	
27		50	89	4450	9796	22077.7	8374.43	7171.51	0	0	19570.31	0	0	22078	66990	4.961	
31		50	94	4700	0	0	0	0	0	0	0	0	0	0	0	0	
32		50	96	4800	10958.3	10958.3	18307.22	12658.2	14740.49	6517.26	11635.99	0	0	18307	85776	3.814	
36		50	80	4000	38506.3	6516.3	20748.81	0	9107.26	2596.42	0	0	0	38506	77475	9.627	
39		50	136	6800	11763	35503.33	16683.21	0	41270.47	19030.2	9929	24294	0	41270	158473	6.069	
40		50	80	4000	33951.3	42671.49	22890.7	16160.4	24645	0	3153	14304.7	21266.3	42671	179043	10.668	
42		50	76	3800	23897	14669.4	18351.57	14829.02	12139.8	7154.94	5577.68	5577.68	0	23897	102197	6.289	
43		50	70	3500	9939.09	0	0	5068.88	1834.62	7830	0	5701	10479.91	10480	40854	2.994	
55		50	94	4700	27101.3	27101.3	17969.04	5144.22	11226.18	0	796.24	6499	0	27101	95837	5.766	
60		50	105	5250	16203.8	15081.94	28596.53	2378.99	15238.81	4239.62	2828.09	7481	0	28597	92049	5.447	
65		50	115	5750	27395	27395	0	21409.51	0	30296	0	0	0	30296	106496	5.269	
84F		50	44	2200	24808	1235.53	19270.3	798.54	4998.22	5430	0	2490.83	0	24808	59031	11.276	
30		51	130	6630	38036.34	44569.57	22413.14	8025	28513.97	0	0	11827.9	7555	44570	160941	6.722	
37		51	65	3315	0	0	0	0	0	0	0	0	0	0	0	0	
47		51	60	3060	21258.6	16636.8	21648.36	3346.32	21494.39	8728.72	0	7098.32	7591.01	21648	107803	7.075	
67		51	90	4590													

163	52	24	1248	0	0	0	0	0	0	0	0	0	0	0	0	0
29	53	103	5459	16595	16595	4758.52	0	0	0	0	0	0	0	16595	37949	3.04
45	53	95	5035	20046		12918.23	9556	0	5728.91	4603	14040	11184.8	20046	78077	3.981	
46	53	67	3551	18908	6866.48	16221.8	0	5452.43	9274.47	0	0	0	18908	56723	5.325	
59	53	99	5247	15531.92	37258.99	5229	8037	14432.88	14243.5	0	19408	0	37259	114141	7.101	
84D	53	55	2915	69181.2	11936.1	32710.51	36802.66	24884	16381.8	10633.98	19432.81	14503.32	69181	236466	23.733	
48	54	63	3402	0	0	0	0	0	0	0	0	0	0	0	0	
49	54	63	3402	0	0	0	0	0	0	0	0	0	0	0	0	
34	55	83	4565	18955.6	15162	31889.8	13140.45	22885	0	11148	0	0	31890	113181	6.986	
155 M	56	88	4928	0	0	0	0	0	0	0	0	0	0	0	0	
50	58	64	3712	32175.16	19831.57	6230.52	5157.62	17160.06	10099.25	10099.25	0	9146.7	32175	109900	8.668	
V-6	59	94	5546	32168.6	8760.7	40208.5	6938	21820	7948.72	18000.9	21731	2032.52	40209	159609	7.25	
89-M	60	65	3900	0	0	0	0	0	0	0	0	0	0	0	0	
97M	60	46	2760	0	7287.24	20192.28	0	10589.6	8342.49	0	0	0	20192	46412	7.316	
103M	60	54	3240	29681	17337.8	27293	22490.02	36170.23	19254.46	10224.01	0	0	36170	162451	11.164	
107M	60	91	5460	42497.6	27900.23	12340.38	14949.72	21275.15	22467.36	11004.45	9512.37	13704.3	42498	175652	7.783	
111M	60	82	4920	40914.2	28291.3	22905.3	8610	26777	18171	0	2402.5	7771	40914	155842	8.316	
115M	60	66	3960	20798.35	12450.33	10730.13	0	0	0	0	0	963.96	20798	44943	5.252	
117 M	60	60	3600	0	0	0	0	0	0	0	0	0	0	0	0	
133M	60	94	5640	61936.3	51526.41	16076	48425.6	28012	29165.46	15406.1	13535.2	17937.17	61936	282020	10.982	
141M	60	118	7080	33713	23719	9709.9	5306.47	13761.31	8441.5	9089.14	6776	0	33713	110516	4.762	
143 M	60	98	5880	0	0	0	0	0	0	0	0	0	0	0	0	
160M	60	90	5400	51027.5	10604.7	39606.6	28448	34603	16180	0	0	0	51028	180470	9.45	
161M	60	46	2760	9245	4200	15298.45	12485.67	0	0	0	0	0	15298	41229	5.543	
164 M	60	13	780	0	0	0	0	0	0	0	0	0	0	0	0	
169M	60	93	5580	19104.32	25514	2872.72	6048.99	1453.5	34460.2	32080.8	25711.25	35143.06	35143	182389	6.298	
63	61	81	4941	27941.8	35097	0	11153.65	27346.3	25388.7	0	12857.6	0	35097	139785	7.103	
64	61	74	4514	17957.8	14978.12	5986.9	1164.38	6620.24	10367.8	0	0	0	17958	57075	3.978	
78M	61	119	7259	51478.3	28966	44368.5	75449.1	46412	11272.01	70008.62	4750.95	30712.7	75449	363418	10.394	
81M	61	119	7259	22920.18	24121.56	22091.81	24132.1	24721.22	19811.69	0	24354.79	16227.6	24721	178381	3.406	
120M	61	72	4392	50169.73	0	28480.37	0	16903.27	14833.2	0	8989.49	2756.74	50170	122134	11.423	
121M	61	74	4514	24572	16327	43308.3	19891.39	0	21598.6	16722.7	7775	10412.6	43308	160608	9.594	
147 M	61	98	5978	0	0	0	0	0	0	0	0	0	0	0	0	
153M	61	94	5734	26115	29207.38	5540.61	48249.17	0	21941.72	0	0	0	48249	131054	8.415	
145 M	62	98	6076	0	0	0	0	0	0	0	0	0	0	0	0	
12	63	104	6552	0	0	0	0	0	0	0	0	0	0	0	0	
158M	63	146	9198	0	0	0	0	16170.42	11043.6	9947.38	9016	0	16170	46177	1.758	
21	64	116	7424	21187	10759	22985.4	0	15725.9	6720.3	0	0	8996.5	22985	86374	3.096	
22	64	112	7168	16345	16752.06	12527.01	5618	31711.43	13531.06	8761	12370.2	0	31711	117616	4.424	
19	65	132	8580	44864.54	31032.55	27885.22	23780	38143	8965	48211.26	15580	6984.8	48211	245446	5.619	
66	66	89	5874	18949.3	23507	9859.06	6927	13422	12111.73	0	0	0	23507	84776	4.002	
72	66	80	5280	4369.54	42399.18	0	0	23063.45	0	0	0	0	42399	69832	8.03	
140M	66	119	7854	13081.93	15878.35	24084	5708.96	8948.2	4330	4833.3	13452.71	0	24084	90317	3.066	
52M	68	74	5032	19430	19441	8741.34	2730	11191.56	8818.39	5314	5601.22	0	19441	81268	3.863	
87A	68	60	4080	9150.63	10185.38	7632.18	7853.11	12735.81	16653.67	4408.02	14435.77	1990.36	16654	85045	4.082	
17	69	126	8694	20740	36714.21	15864	0	0	0	0	0	0	36714	73318	4.223	
18	70	126	8820	30105.9	32751	19563	0	22565.72	0	10289.56	0	0	32751	115275	3.713	
20	71	126	8946	34713	24433.7	46221.6	0	46221.6	14800.43	24882.3	12154	10706.6	46222	214133	5.167	
68	71	97	6887	36682	11477.36	15210.95	15210.95	0	0	0	0	4999.55	36682	83581	5.326	
16	74	119	8806	0	0	0	0	0	0	1144.07	14300	0	14300	15444	1.624	
25	75	155	11625	60162	44969	26382.94	39778	0	41553.55	23191.54	28692.4	13305.9	60162	278035	5.175	
3	78	73	5694	15340.06	23807.48	14036.94	26082.58	17714		7916.44	15044.2	3869.7	26083	123811	4.581	
88	78	97	7566	51405	13822.5	36195.22	22703.25	32260.15	32493.06	33010.9	40214.28	31504	51405	293608	6.794	
8	79	112	8848	9045	14841.5	18300.27	3846.75	12597.45	18449	19257.44	0	3732	19257	100069	2.176	
1	81	127	10287	0	0	0	0	10233.34	23809.85	28041.26	7852.2	1259.73	28041	71196	2.726	
4	81	81	6561	9222.8	38929.94	41184.15	18344.32	30172.15	12072.5	23632.56	0	7785.28	41184	181344	6.277	
6	81	97	7857	0	0	0	0	0	0	0	0	0	0	0	0	
10	81	105	8505	30750.92	17805.5	12977.63	19033	20175.4	0	14938.2	9759	0	30751	125440	3.616	
9	82	125	10250	30865.02	41014.8	21779.16	23340.45	31932.4	35158.3	0	11197	0	41015	195287	4.001	
11	82	114	9348	31320	19451.5	33395.09	5307.53	23117	19082.25	35735.32	0	16327.43	35735	183736	3.823	
13	85	129	10965	46276.6	45498	31533.47	21413.68	46107.2	62653.21	46961.65	27401.7	34233.4	62653	362079	5.714	
15	86	121	10406	20170.61	20170.61	23937.79	11701.9	17624	17360.22	26074	0	6282.81	26074	143322	2.506	
69-M	86	95	8170	0	0	0	0	0	0	0	0	0	0	0	0	
2	87	128	11136	41358.41	20025.99	51829.61	33487.61	58733	20498.73	36722.91	29584.3	37038.58	58733	329279	5.274	
14	93	113	10509	43498	29561.28	42048.1	38139.32	24717.6	13906.8	0	21018	0	43498	212889	4.139	
5	94	100	9400	49008.4	0	36081.93	24250.93	32993.03	27104.54	0	23740	0	49008	193179	5.214	
7	94	94	8836	23625	30936.38	8064	0	0	0	0	0	0	30936	62625	3.501	
51	107	52	5564	0	0	0	0	0	0	0	0	0	0	0	0	
V-1	120	90	10800	125973.66	124634.4	11732.08	113395.9	0	96672.59	54293.36	40288.4	30415.81	125974	597406	11.664	
V-2	120	74	8880	32439.73	56867	28410.27	0	0	36453	26545.03	44524.92	52433.6	56867	277674	6.404	
V-3	120	68	8160	0	0	0	0	0	0	0	0	0	0	0	0	
V-4	120	84	10080	42274.5	82971.4	55076.69	12835.68	27577.87	24818.03	13382.48	0	0	82971	258937	8.231	
V-5	120	93	11160	37921.03	8520	37114	30653.16	41360.25	16257.33	37913.37	7638.79	13256.1	41360	230634	3.706	
V-7	120	91	10920	73162.22	86062.31	61381.08	69180.8	43551.53	20849.03	45906.65	26278.24	3173.8	86062	429546	7.881	
V-8	120	69	8280	0	0	0	0	0	0	0	0	0	0	0	0	
V-9	120	64	7680	1015	2071.3	0	0	7345.23	0	0	0	0	7345	10432	0.956	
V-10	120	50	6000	21297	0	0	0	0	0	0	0	0	21297	21297	3.55	

Along SRY production data of 153 plots since 2016 (Arranged as per waterfront width)													
Plot No.	Breadth (Sea front)	Length	Area (m ²)	Max Yearly LDT Output of 09 Years (2016-24)	Cumulative LDT	Max Yearly LDT/Unit Area (m ²)	Active Years	Average Active Yearly LDT	Average Active LDT/m ²	Normalized Max Yearly LDT/Unit Area	Normalized Avg Active LDT/ m ²	Ranking Score	Rank
84D	53	55	2915	69181.2	236466.4	23.7	9	26274	9	1	0.9	1.9	1
84E	49	50	2450	56676.6	115882.7	22.7	7	16554.7	6.8	0.96	0.67	1.63	2
54	45	56	2520	36894.7	146029.7	14.6	7	20861.4	8.3	0.6	0.83	1.43	3
100M	45	45	2025	20126.2	20126.2	9.9	1	20126.2	9.9	0.39	1	1.39	4
61	49	89	4361	63311.3	308454.2	14.5	9	34272.7	7.9	0.59	0.79	1.38	5
91M	45	65	2925	45268	159514.3	15.5	8	19939.3	6.8	0.64	0.67	1.31	6
67	51	90	4590	51637.6	139291.3	11.3	4	34822.8	7.6	0.45	0.76	1.21	7
103M	60	54	3240	36170.2	162450.5	11.2	7	23207.2	7.2	0.45	0.71	1.16	8
124	35	83	2905	40594.9	156804.7	14	9	17422.7	6	0.57	0.59	1.16	8
V-1	120	90	10800	125973.7	597406.2	11.7	8	74675.8	6.9	0.47	0.68	1.15	9
128M	46	79	3634	43008	191752.3	11.8	8	23969	6.6	0.48	0.65	1.13	10
74	30	59	1770	25428.6	39605.2	14.4	4	9901.3	5.6	0.59	0.54	1.13	10
105	31	87	2697	36958.1	106035.1	13.7	8	13254.4	4.9	0.56	0.47	1.03	11
133M	60	94	5640	61936.3	282020.2	11	9	31335.6	5.6	0.44	0.54	0.98	12
40	50	80	4000	42671.5	179042.9	10.7	8	22380.4	5.6	0.43	0.54	0.97	13
84	52	110	5720	61425.5	220561	10.7	7	31508.7	5.5	0.43	0.53	0.96	14
78M	61	119	7259	75449.1	363418.2	10.4	9	40379.8	5.6	0.41	0.54	0.95	15
33	47	96	4512	54440.3	123900.5	12.1	6	20650.1	4.6	0.49	0.44	0.93	16
160M	60	90	5400	51027.5	180469.8	9.4	6	30078.3	5.6	0.37	0.54	0.91	17
120M	61	72	4392	50189.7	122133.5	11.4	6	20355.6	4.6	0.46	0.44	0.9	18
35	49	84	4116	36064	188998.3	8.8	8	23624.8	5.7	0.34	0.55	0.89	19
94	30	58	1740	14492.7	30757.9	8.3	3	10252.6	5.9	0.32	0.57	0.89	19
82	30	86	2580	27006.9	95219.5	10.5	8	11902.4	4.6	0.42	0.44	0.86	20
134	33	84	2772	27408.3	86489.5	9.9	7	12355.6	4.5	0.39	0.43	0.82	21
95	30	58	1740	11363	20418	6.5	2	10209	5.9	0.24	0.57	0.81	22
84F	50	44	2200	24808	59031.4	11.3	7	8433.1	3.8	0.45	0.35	0.8	23
93M	46	56	2576	21457	88714.8	8.3	7	12673.5	4.9	0.32	0.47	0.79	24
121M	61	74	4514	43308.3	160607.6	9.6	8	20075.9	4.4	0.38	0.41	0.79	24
153M	61	94	5734	48249.2	131053.9	8.4	5	26210.8	4.6	0.33	0.44	0.77	25
76	30	85	2550	24872.8	81452.5	9.8	8	10181.6	4	0.39	0.37	0.76	26
127M	44	81	3564	31649	77346.8	8.9	5	15469.4	4.3	0.35	0.4	0.75	27
36	50	80	4000	38506.3	77475.1	9.6	5	15495	3.9	0.38	0.36	0.74	28
63	61	81	4941	35097	139785	7.1	6	23297.5	4.7	0.27	0.45	0.72	29
72	66	80	5280	42399.2	69832.2	8	3	23277.4	4.4	0.31	0.41	0.72	29
V-7	120	91	10920	86062.3	429545.7	7.9	9	47727.3	4.4	0.3	0.41	0.71	30
111M	60	82	4920	40914.2	155842.3	8.3	8	19480.3	4	0.32	0.37	0.69	31
50	58	64	3712	32175.2	109900.1	8.7	8	13737.5	3.7	0.34	0.34	0.68	32
123	31	86	2666	26134.4	59408	9.8	7	8486.9	3.2	0.39	0.29	0.68	32
47	51	60	3060	21648.4	107802.5	7.1	8	13475.3	4.4	0.27	0.41	0.68	32
V-2	120	74	8880	56867	277673.6	6.4	7	39667.6	4.5	0.24	0.43	0.67	33
97M	60	46	2760	20192.3	46411.6	7.3	4	11602.9	4.2	0.28	0.39	0.67	33
V-4	120	84	10080	82971.4	258936.6	8.2	7	36991	3.7	0.32	0.34	0.66	34
88	78	97	7566	51405	293608.4	6.8	9	32623.2	4.3	0.26	0.4	0.66	34
34	55	83	4565	31889.8	113180.8	7	6	18863.5	4.1	0.26	0.38	0.64	35
57	52	98	5096	38738	153566.2	7.6	8	19195.8	3.8	0.29	0.35	0.64	35
99	45	105	2025	13828	24653.8	6.8	3	8217.9	4.1	0.26	0.38	0.64	35
65	50	115	5750	30296	106495.5	5.3	4	26623.9	4.6	0.19	0.44	0.63	36
107M	60	91	5460	42497.6	175651.6	7.8	9	19516.8	3.6	0.3	0.33	0.63	36
71	38	70	2660	17921.7	42530.2	6.7	4	10632.6	4	0.25	0.37	0.62	37
77	33	85	2805	20196.1	73114	7.2	7	10444.9	3.7	0.27	0.34	0.61	38
41	49	70	3430	18982	96607.6	5.5	7	13801.1	4	0.2	0.37	0.57	39
24	49	150	7350	42174.2	227406.3	5.7	8	28425.8	3.9	0.21	0.36	0.57	39
30	51	130	6630	44569.6	160940.9	6.7	7	22991.6	3.5	0.25	0.32	0.57	39
38	49	123	6027	33033.4	165319.1	5.5	7	23617	3.9	0.2	0.36	0.56	40
V-6	59	94	5546	40208.5	159608.9	7.2	9	17734.3	3.2	0.27	0.29	0.56	40
169M	60	93	5580	35143.1	182388.8	6.3	9	20265.4	3.6	0.23	0.33	0.56	40
59	53	99	5247	37259	114141.3	7.1	7	16305.9	3.1	0.27	0.28	0.55	41
4	81	81	6561	41184.2	181343.7	6.3	8	22668	3.5	0.23	0.32	0.55	41
13	85	129	10965	62653.2	362078.9	5.7	9	40231	3.7	0.21	0.34	0.55	41
161M	60	46	2760	15298.4	41229.1	5.5	4	10307.3	3.7	0.2	0.34	0.54	42
58	52	106	5512	38148.2	152262.1	6.9	9	16918	3.1	0.26	0.28	0.54	42
42	50	76	3800	23897	102197.1	6.3	8	12774.6	3.4	0.23	0.31	0.54	42
113	32	75	2400	14031.3	66560.6	5.8	8	8320.1	3.5	0.21	0.32	0.53	43
39	50	136	6800	41270.5	158473.2	6.1	7	22639	3.3	0.22	0.3	0.52	44
130M	45	80	3600	25043	73013.8	7	7	10430.5	2.9	0.26	0.26	0.52	44
5	94	100	9400	49008.4	193178.8	5.2	6	32196.5	3.4	0.19	0.31	0.5	45
86	46	83	3818	26128.5	75956.2	6.8	7	10850.9	2.8	0.26	0.24	0.5	45
19	65	132	8580	48211.3	245446.4	5.6	9	27271.8	3.2	0.2	0.29	0.49	46
2	87	128	11136	58733	329279.1	5.3	9	36586.6	3.3	0.19	0.3	0.49	46
46	53	67	3551	18908	56723.2	5.3	5	11344.6	3.2	0.19	0.29	0.48	47
55	50	94	4700	27101.3	95837.3	5.8	7	13691	2.9	0.21	0.26	0.47	48
20	71	126	8946	46221.6	214133.2	5.2	8	26766.7	3	0.19	0.27	0.46	49
25	75	155	11625	60162	278035.3	5.2	8	34754.4	3	0.19	0.27	0.46	49
27	50	89	4450	22077.7	66990	5	5	13398	3	0.18	0.27	0.45	50
84B	47	90	4230	25280	44412.3	6	4	11103.1	2.6	0.22	0.22	0.44	51
28	49	91	4459	21253	107936.7	4.8	8	13492.1	3	0.17	0.27	0.44	51

85	45	81	3645	21132	67005.7	5.8	7	9572.2	2.6	0.21	0.22	0.43	52
V-10	120	50	6000	21297	21297	3.5	1	21297	3.5	0.11	0.32	0.43	52
56	48	91	4368	18092.3	110141	4.1	8	13767.6	3.2	0.14	0.29	0.43	52
115M	60	66	3960	20798.4	44942.8	5.3	4	11235.7	2.8	0.19	0.24	0.43	52
23	50	112	5600	32264.2	118204.2	5.8	8	14775.5	2.6	0.21	0.22	0.43	52
112	32	81	2592	11446.9	38963.1	4.4	5	7792.6	3	0.15	0.27	0.42	53
14	93	113	10509	43498	212889.1	4.1	7	30412.7	2.9	0.14	0.26	0.4	54
68	71	97	6887	36682	83580.8	5.3	5	16716.2	2.4	0.19	0.2	0.39	55
81M	61	119	7259	24721.2	178381	3.4	8	22297.6	3.1	0.11	0.28	0.39	55
3	78	73	5694	26082.6	123811.4	4.6	8	15476.4	2.7	0.16	0.23	0.39	55
17	69	126	8694	36714.2	73318.2	4.2	3	24439.4	2.8	0.14	0.24	0.38	56
26	47	90	4230	17241.5	23393.6	4.1	2	11696.8	2.8	0.14	0.24	0.38	56
60	50	105	5250	28596.5	92048.8	5.4	8	11506.1	2.2	0.19	0.18	0.37	57
136M	44	83	3652	18908.4	48892.1	5.2	6	8148.7	2.2	0.19	0.18	0.37	57
9	82	125	10250	41014.8	195287.1	4	7	27898.2	2.7	0.13	0.23	0.36	58
131	33	81	2673	10636.8	36750.5	4	5	7350.1	2.7	0.13	0.23	0.36	58
108	31	84	2604	10943.6	31823	4.2	5	6364.6	2.4	0.14	0.2	0.34	59
32	50	96	4800	16307.2	85775.8	3.8	7	12253.7	2.6	0.12	0.22	0.34	59
18	70	126	8820	32751	115275.2	3.7	5	23055	2.6	0.12	0.22	0.34	59
11	82	114	9348	35735.3	183736.1	3.8	8	22967	2.5	0.12	0.21	0.33	60
66	66	89	5874	23507	84776.1	4	6	14129.3	2.4	0.13	0.2	0.33	60
141M	60	118	7080	33713	110516.3	4.8	8	13814.5	2	0.17	0.16	0.33	60
87A	68	60	4080	16653.7	85044.9	4.1	9	9449.4	2.3	0.14	0.19	0.33	60
22	64	112	7168	31711.4	117615.8	4.4	8	14702	2.1	0.15	0.17	0.32	61
125M	45	79	3555	13563	43477.1	3.8	5	8695.4	2.4	0.12	0.2	0.32	61
V-5	120	93	11160	41360.2	230634	3.7	9	25626	2.3	0.12	0.19	0.31	62
114	31	70	2170	8803.8	18594.5	4.1	4	4648.6	2.1	0.14	0.17	0.31	62
7	94	94	8836	30936.4	62625.4	3.5	3	20875.1	2.4	0.11	0.2	0.31	62
45	53	95	5035	20046	78076.9	4	7	11153.8	2.2	0.13	0.18	0.31	62
73	33	64	2112	8580.1	12996.9	4.1	3	4332.3	2.1	0.14	0.17	0.31	62
64	61	74	4514	17957.8	57075.2	4	6	9512.5	2.1	0.13	0.17	0.3	63
52M	68	74	5032	19441	81267.5	3.9	8	10158.4	2	0.13	0.16	0.29	64
10	81	105	8505	30750.9	125439.6	3.6	7	17919.9	2.1	0.11	0.17	0.28	65
29	53	103	5459	16595	37948.5	3	3	12649.5	2.3	0.09	0.19	0.28	65
84A	36	87	3132	11850	31791	3.8	5	6358.2	2	0.12	0.16	0.28	65
87	51	35	1785	7070.8	19193.6	4	6	3198.9	1.8	0.13	0.14	0.27	66
138M	51	110	5610	16126.3	84432.6	2.9	7	12061.8	2.2	0.08	0.18	0.26	67
43	50	70	3500	10479.9	40853.5	3	6	6808.9	1.9	0.09	0.15	0.24	68
21	64	116	7424	22985.4	86374.1	3.1	6	14395.7	1.9	0.09	0.15	0.24	68
15	86	121	10406	26074	143321.9	2.5	8	17915.2	1.7	0.07	0.13	0.2	69
140M	66	119	7854	24084	90317.5	3.1	8	11289.7	1.4	0.09	0.1	0.19	70
1	81	127	10287	28041.3	71196.4	2.7	5	14239.3	1.4	0.07	0.1	0.17	71
135	30	86	2580	6301.3	15503	2.4	4	3875.8	1.5	0.06	0.11	0.17	71
8	79	112	8848	19257.4	100069.4	2.2	8	12508.7	1.4	0.05	0.1	0.15	72
158M	63	146	9198	16170.4	46177.4	1.8	4	11544.4	1.3	0.04	0.09	0.13	73
16	74	119	8806	14300	15444.1	1.6	2	7722	0.9	0.03	0.04	0.07	74
83	31	82	2542	3472.6	12281.7	1.4	6	2046.9	0.8	0.02	0.03	0.05	75
V-9	120	64	7680	7345.2	10431.5	1	3	3477.2	0.5	0	0	0	76

Earthwork volume calculations						
Earthwork calculation proposed recycling plots - Phase 1 - Block 1						
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Zone A	1 in 130	7.5	9.00	2093.52	1.50	3140.28
		8.5	9.00	3930.94	0.50	1965.47
		9.5	9.00	4442.95	-0.50	-2221.47
		10.5	9.00	2458.06	-1.50	-3687.10
		11.5	9.00	822.25	-2.50	-2055.63
Zone B	1 in 50	9.5	12.59	1405.21	3.09	4342.10
		10.5	12.59	2762.60	2.09	5773.83
		11.5	12.59	5585.52	1.09	6088.22
		12.5	12.59	13797.08	0.09	1241.74
		13.5	12.59	10477.07	-0.91	-9534.13
		14.5	12.59	7470.50	-1.91	-14268.66
		15.5	12.59	14418.10	-2.91	-41956.67
		16.5	12.59	11137.09	-3.91	-43546.02
		17.5	12.59	9376.01	-4.91	-46036.21
		18.5	12.59	1895.43	-5.91	-11201.99
Zone C	1 in 65	12.5	14.40	31.87	1.90	60.55
		13.5	14.40	459.93	0.90	413.94
		14.5	14.40	1142.80	-0.10	-114.28
		15.5	14.40	954.22	-1.10	-1049.64
		16.5	14.40	99.29	-2.10	-208.51
		17.5	14.40	3182.71	-3.10	-9866.39
		18.5	14.40	12536.73	-4.10	-51400.59
		19.5	14.40	8096.59	-5.10	-41292.61
		20.5	14.40	697.62	-6.10	-4255.48
Zone D	1 in 65	21.5	14.40	733.27	-7.10	-5206.22
		13.5	14.89	3.32	1.39	4.61
		14.5	14.89	411.44	0.39	160.46
		15.5	14.89	456.31	-0.61	-278.35
		16.5	14.89	66.97	-1.61	-107.82
		17.5	14.89	499.47	-2.61	-1303.62
		18.5	14.89	1741.72	-3.61	-6287.60
		19.5	14.89	3376.62	-4.61	-15566.22
		20.5	14.89	4192.55	-5.61	-23520.21
		21.5	14.89	2663.36	-6.61	-17604.81
				Total Cutting (m3)		-3,52,570.22
				Total Filling (m3)		23,191.21

Earthwork calculation proposed recycling plots - Phase 1 - Block 2						
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Zone A	1 in 130	6.5	9.00	3147.23	2.50	7868.08
		7.5	9.00	3155.00	1.50	4732.50
Zone B	1 in 50	7.5	12.59	1374.87	5.09	6998.09
		8.5	12.59	2594.21	4.09	10610.32
		9.5	12.59	5267.13	3.09	16275.43
		10.5	12.59	9133.79	2.09	19089.62
		11.5	12.59	9145.13	1.09	9968.19
		12.5	12.59	2557.02	0.09	230.13
		13.5	12.59	3545.08	-0.91	-3226.02
		14.5	12.59	1082.22	-1.91	-2067.03
		15.5	12.59	511.10	-2.91	-1487.31
		16.5	12.59	189.57	-3.91	-741.22
Zone C	1 in 65	11.5	14.40	54.81	2.90	158.94
		12.5	14.40	409.98	1.90	778.96
		13.5	14.40	1812.25	0.90	1631.03
		14.5	14.40	1495.05	-0.10	-149.50
		15.5	14.40	3779.41	-1.10	-4157.36
		16.5	14.40	5074.74	-2.10	-10656.95
Zone D	1 in 65	15.5	14.89	396.65	-0.61	-241.96
		16.5	14.89	4493.13	-1.61	-7233.94
		17.5	14.89	1173.29	-2.61	-3062.29
			Total Cutting (m3)			-33,023.58
			Total Filling (m3)			78,341.29

Earthwork calculation proposed recycling plots - Phase 1 - Block 3								
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)		
Zone A	1 in 130	5.5	9.00	10472.26	3.50	36612.63		
		6.5	9.00	3627.85	2.50	9055.67		
		7.5	9.00	1589.02	1.50	2377.42		
		8.5	9.00	993.58	0.50	492.97		
		9.5	9.00	3934.82	-0.50	-1982.55		
		10.5	9.00	17470.66	-1.50	-26273.19		
		11.5	9.00	3398.69	-2.50	-8509.80		
		12.5	9.00	550.87	-3.50	-1930.16		
Zone B	1 in 50	5.5	12.59	1473.89	7.09	10449.88		
		6.5	12.59	10941.01	6.09	66630.76		
		7.5	12.59	7860.31	5.09	40008.96		
		8.5	12.59	6852.68	4.09	28027.47		
		9.5	12.59	8895.43	3.09	27486.88		
		10.5	12.59	17923.25	2.09	37459.60		
		11.5	12.59	61601.92	1.09	67146.09		
		12.5	12.59	46982.06	0.09	4228.39		
		13.5	12.59	21151.30	-0.91	-19247.69		
		14.5	12.59	19852.73	-1.91	-37918.72		
		15.5	12.59	15911.87	-2.91	-46303.54		
		16.5	12.59	12302.39	-3.91	-48102.34		
17.5	12.59	847.80	-4.91	-4162.70				
Zone C	1 in 65	11.5	14.40	7.95	2.90	23.06		
		12.5	14.40	5737.00	1.90	10900.30		
		13.5	14.40	8972.91	0.90	8075.62		
		14.5	14.40	25914.00	-0.10	-2591.40		
		15.5	14.40	23063.02	-1.10	-25369.33		
		16.5	14.40	9137.30	-2.10	-19188.32		
Zone D	1 in 65	17.5	14.40	11045.00	-3.10	-34239.50		
		12.5	14.89	1997.24	2.39	4773.40		
		13.5	14.89	1570.95	1.39	2183.63		
		14.5	14.89	6145.06	0.39	2396.57		
		15.5	14.89	11818.72	-0.61	-7209.42		
		16.5	14.89	9244.60	-1.61	-14883.81		
		17.5	14.89	7214.50	-2.61	-18829.85		
				18.5	14.89	2371.15	-3.61	-8559.86
				Total Cutting (m3)		-3,25,302.17		
				Total Filling (m3)		3,58,329.31		

Total Phase - 1	Total Cutting (m3)	-7,10,895.97
Ship recycling plot earthwork volumes	Total Filling (m3)	4,59,861.80

Earthwork calculation proposed recycling plots - Phase 2&3						
Zone	Slope	Existing level (Avg	Average proposed l	Area	level diff	volume (m3)
ship recycling plot	1 in 50	3.5	11.74	2351	8.24	19372.24
		4.5	11.74	2494	7.24	18056.56
		5.5	11.74	4052	6.24	25284.48
		6.5	11.74	5097	5.24	26708.28
		7.5	11.74	12389	4.24	52529.36
		8.5	11.74	129757.00	3.24	420412.68
		9.5	11.74	433843.00	2.24	971808.32
		10.5	11.74	128697.00	1.24	159584.28
		11.5	11.74	168565.00	0.24	40455.60
		12.5	11.74	203598.00	-0.76	-154734.48
		13.5	11.74	111741.00	-1.76	-196664.16
		14.5	11.74	88152.00	-2.76	-243299.52
		15.5	11.74	93402.00	-3.76	-351191.52
Primary cutting zone	1 in 65	3.5	9.00	9849.00	5.50	54169.50
		4.5	9.00	4601.00	4.50	20704.50
		5.5	9.00	7267.00	3.50	25434.50
		6.5	9.00	18957.00	2.50	47392.50
		7.5	9.00	26828.00	1.50	40242.00
		8.5	9.00	29039.00	0.50	14519.50
		9.5	9.00	32177.00	-0.50	-16088.50
		10.5	9.00	12044.00	-1.50	-18066.00
		11.5	9.00	16363	-2.50	-40907.50
		12.5	9.00	5055	-3.50	-17692.50
		Total Phase - 2&3		Total Cutting (m3)		-10,38,644.18
		Ship recycling plot earthwork volumes		Total Filling (m3)		19,36,674.30

Earthwork calculation for Back-up Yard Zone - Phase 1						
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Backup yard	1 in 65	13.5	16.62	7265.00	3.12	22666.80
		14.5	16.62	19094.00	2.12	40479.28
		15.5	16.62	49770.00	1.12	55742.40
		16.5	16.62	71090.00	0.12	8530.80
		17.5	16.62	72590.00	-0.88	-63879.20
		18.5	16.62	95412.00	-1.88	-179374.56
		19.5	16.62	70332.00	-2.88	-202556.16
		20.5	16.62	61686.00	-3.88	-239341.68
		21.5	16.62	34832.00	-4.88	-169980.16
		22.5	16.62	17773.00	-5.88	-104505.24
		23.5	16.62	14489.00	-6.88	-99684.32
		24.5	16.62	14035.00	-7.88	-110595.80
		Total Phase - 1		Total Cutting (m3)		-11,69,917.12
		Back-up Yard Zone earthwork volumes		Total Filling (m3)		1,27,419.28

Earthwork calculation for Back-up Yard Zone - Phase 2						
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Backup yard	1 in 100	13.5	15.38	23210.00	1.88	43634.80
		14.5	15.38	109904.00	0.88	96715.52
		15.5	15.38	212178.00	-0.12	-25461.36
		16.5	15.38	60495	-1.12	-67754.40
		Total Phase - 2		Total Cutting (m3)		-93,215.76
		Back-up Yard Zone earthwork volumes		Total Filling (m3)		1,40,350.32

Earthwork calculation for Back-up Yard Zone - Phase 3						
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Backup yard	1 in 100	9.5	15.38	375909	5.88	2210344.92
		10.5	15.38	67594.00	4.88	329858.72
		11.5	15.38	79446.00	3.88	308250.48
		12.5	15.38	264819.00	2.88	762678.72
		13.5	15.38	28958	1.88	54441.04
		14.5	15.38	197688.00	0.88	173965.44
		16.5	15.38	63155	-1.12	-70733.60
		Total Phase - 3		Total Cutting (m3)		-70,733.60
		Back-up Yard Zone earthwork volumes		Total Filling (m3)		38,39,539.32

Earthwork calculation for Scrap Market Zone - Phase 1						
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Scrap market	1 in 50	13.5	19.39	909	5.89	5354.01
		14.5	19.39	756	4.89	3696.84
		15.5	19.39	5989	3.89	23297.21
		16.5	19.39	8703	2.89	25151.67
		17.5	19.39	6951	1.89	13137.39
		18.5	19.39	24036	0.89	21392.04
		19.5	19.39	46959	-0.11	-5165.49
		20.5	19.39	42740	-1.11	-47441.40
		21.5	19.39	52755	-2.11	-111313.05
		22.5	19.39	50156	-3.11	-155985.16
		23.5	19.39	12120.00	-4.11	-49813.20
		24.5	19.39	9915.00	-5.11	-50665.65
		25.5	19.39	12901.00	-6.11	-78825.11
		Total Phase - 1		Total Cutting (m3)		-4,99,209.06
		Scrap Market Zone earthwork volumes		Total Filling (m3)		92,029.16

Earthwork calculation for Scrap Market Zone - Phase 1

Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Scrap market	1 in 100	14.5	17.00	102853	2.50	257132.50
		15.5	17.00	100740	1.50	151110.00
		16.5	17.00	147987	0.50	73993.50
		17.5	17.00	60982	-0.50	-30491.00
		Total Phase - 2 Scrap Market Zone earthwork volumes		Total Cutting (m3)		-30,491.00
Total Filling (m3)				4,82,236.00		

Earthwork calculation for Scrap Market Zone - Phase 1						
Zone	Slope	Existing level (Avg)	Average proposed level	Area	level diff	volume (m3)
Scrap market	1 in 100	8.5	17.00	197043	8.50	1674865.50
		10.5	17.00	118791	6.50	772141.50
		11.5	17.00	127430	5.50	700865.00
		12.5	17.00	380830	4.50	1713735.00
		13.5	17.00	105704	3.50	369964.00
		14.5	17.00	121455	2.50	303637.50
		Total Phase - 3		Total Cutting (m3)		-
		Scrap Market Zone earthwork volumes		Total Filling (m3)		55,35,208.50

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SOIL PARAMETERS FOR VARIOUS LAYERS (FOR LAND BORE HOLES)

LAYER NO.	DESCRIPTION OF SOIL	TEST BORE	EXTENT OF LAYER		M CD OF LAYER		THICK-NESS OF LAYER	SOIL CLASS-FICATION	AVG. N-VALUE	CORE RECOVERY	RQD	FINE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	BULK DENSITY	SHEAR PARAMETERS		SETTLEMENT PARAMETERS		
			FROM	TO	FROM	TO										γ_b (gms/cc)	cohesion	Angle of Internal Friction	Coeff. of Volume Change	Undrained Modulus	Poisson's Ratio
			(M)	(M)	(M)	(M)						(%)	(%)	(%)	(%)		c (kg/cm ²)	ϕ (degree)	mv (cm ³ /kg)	E (kg/cm ²)	μ
1	Medium brown silty sand	LBH01	0.00	7.50	12.50	5.00	7.50	SM/SP	16			5	NP	-	-						
		LBH02	0.00	0.00	9.90	9.90	0.00	not encountered													
		LBH03	0.00	10.00	21.50	11.50	10.00	SC/SM-SP	23			15	45	19	26						
		LBH04	0.00	1.50	17.10	15.60	1.50	SP	16			6	NP	-	-						
		LBH05	0.00	5.55	16.80	11.25	5.55	SM-SP	22			4	NP	-	-						
		LBH06	0.00	0.00	20.00	20.00	0.00	not encountered				5	NP	-	-						
		LBH07	0.00	0.00	15.90	15.90	0.00	not encountered													
		LBH08	0.00	4.50	12.50	8.00	4.50	SM-SP	17			6	NP	-	-						
		LBH09	0.00	1.50	22.20	20.70	1.50	SP				21	NP	-	-						
		LBH10	0.00	5.60	16.50	10.90	5.60	SM-SP	26			13	NP	-	-						
	Min. Value		0.00	0.00	9.90	5.00	0.00		16			4	NP	-	-						
	Max. Value		0.00	10.00	22.20	20.70	10.00		26			21	45	19	26						
	Average Value		0.00	3.62	16.49	12.88	3.62		20			9	NP	-	-						
	Recommended		0.0	3.6	16.5	12.9	3.6	SM-SP	18			9	NP	-	-	1.8	0.0	32		180	0.35
2	Firm to stiff greyish clayey silt	LBH01	7.50	10.00	5.00	2.50	2.50	CI	6			68	41	16	25						
		LBH02	0.00	1.50	9.90	8.40	1.50					97	51	19	32						
		LBH03	10.00					not encountered													
		LBH04	1.50	1.50	15.60	15.60	0.00	not encountered													
		LBH05	5.55	5.55	11.25	11.25	0.00	not encountered													
		LBH06	0.00	0.00	20.00	20.00	0.00	not encountered													
		LBH07	0.00	4.50	15.90	11.40	4.50	CH	6			74	55	21	34						
		LBH08	4.50	7.50	8.00	5.00	3.00	CH	12			95	80	28	52						
		LBH09	1.50	6.00	20.70	16.20	4.50	CH	11			95	98	30	68						
		LBH10	5.60	5.60	10.90	10.90	0.00	not encountered													
	Min. Value		0.00	0.00	5.00	2.50	0.00		6			68	41	16	25						
	Max. Value		10.00	10.00	20.70	20.00	4.50		12			97	98	30	68						
	Average Value		3.62	4.68	12.88	11.25	1.78		9			86	65	23	42						
	Recommended		3.6	4.7	12.9	11.3	1.8	CH	7			86	65	23	42	1.8	0.3	0.0	0.016	74	0.50
3	Medium to dense sand/clayey sand	LBH01	10.00					not encountered													
		LBH02	1.50	6.00	8.40	3.90	4.50	SP/SC	18			4	NP	-	-						
		LBH03						not encountered													
		LBH04	1.50	15.60	15.60	15.60	0.00	not encountered													
		LBH05	5.55	5.55	11.25	11.25	0.00	not encountered													
		LBH06	0.00	1.50	20.00	18.50	1.50	SC													
		LBH07	4.50	4.50	11.40	11.40	0.00	not encountered													
		LBH08	7.50	10.00	5.00	2.50	2.50	SP	51			4	NP	-	-						
		LBH09	6.00	9.00	16.20	13.20	3.00	SM-SP	40			11	NP	-	-						
		LBH10	5.60	5.60	10.90	10.90	0.00	not encountered													
	Min. Value		0.00	1.50	2.50	2.50	0.00		18			4	49	23	26						
	Max. Value		10.00	15.60	20.00	18.50	4.50		51			29	49	23	26						
	Average Value		4.68	7.22	11.25	10.91	1.44		36			12	49	23	26						
	Recommended		4.7	7.2	11.3	10.9	1.4	SM-SP	27			12	49	23	26	1.9	0.0	34.0	-	408	0.35
4	Hard clayey silt	LBH01						not encountered													
		LBH02	6.00	10.00	3.90	-0.10	4.00	CH	36			77	61	25	36						
		LBH03						not encountered													
		LBH04	15.60	15.60	15.60	15.60	0.00	not encountered													
		LBH05	5.55	5.55	11.25	11.25	0.00	not encountered													
		LBH06	1.50	8.80	18.50	11.20	7.30	SC/CH	30			56	65	25	40						
		LBH07	4.50	10.00	11.40	5.90	5.50	CH	40			79	64	24	40						
		LBH08	10.00		2.50			not encountered													
		LBH09	9.00	10.00	13.20	12.20	1.00	CH	22			54	69	22	47						
		LBH10	5.60	5.60	10.90	10.90	0.00	not encountered													
	Min. Value		1.50	5.55	2.50	-0.10	0.00		22			54	61	22	36						
	Max. Value		15.60	15.60	18.50	15.60	7.30		40			79	69	25	47						
	Average Value		7.22	9.36	10.91	9.56	2.54		32			67	65	24	41						
	Recommended		7.2	9.4	10.9	9.6	2.5	CH	27			67	65	24	41	1.9	1.1	0.0	0.0041	270	0.50
5	Highly weathered to completely weathered rock/conglomerate/ cemented layers	LBH01						not encountered													
		LBH02						not encountered													
		LBH03						not encountered													
		LBH04	15.60	24.10	15.60	7.10	8.50	R	318												
		LBH05	5.55	10.00	11.25	6.80	4.45	R	306												
		LBH06	8.80	10.00	11.20	10.00	1.20	R													
		LBH07	10.00		5.90			not encountered													
		LBH08																			
		LBH09	10.00		12.20			not encountered													
		LBH10	5.60	10.00	10.90	6.50	4.40	R													
	Min. Value		5.55	10.00	-0.10	6.50	1.20		306												
	Max. Value		15.60	24.10	15.60	10.00	8.50		318												
	Average Value		9.36	13.53	9.56	7.60	4.64		312												
	Recommended		9.4	13.5	9.6	7.6	4.6	R	100							2.1	7.0	0.0		1500	0.3

NOTES: The design geotechnical parameters are based on empirical correlation with SPT N-values as per IS 6403, IS 2911 P1/S2 and CIRIA 143.

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LAYER NO.	DESCRIPTION OF SOIL	TEST BORE	EXTENT OF LAYER		M CD OF LAYER		THICKNESS OF LAYER	SOIL CLASSIFICATION	AVG. N-VALUE	CORE RECOVERY	ROD	FINE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	BULK DENSITY	SHEAR PARAMETERS		SETTLEMENT PARAMETERS				
			FROM	TO	FROM	TO											c	φ	Coeff. of Internal Friction	Angle of Internal Friction	Coeff. of Volume Change	Undrained Modulus	Poisson's Ratio
			(M)	(M)	(M)	(M)											(kg/cm ²)	(degree)	(cm ² /kg)	(kg/cm ²)	μ		
1	Stiff to very greyish clayey silt with lenses of cemented layer	MBH01	0.00	4.50	1.70	-2.80	4.50	CH				83	64	29	35								
		MBH02	0.00	1.50	2.30	0.80	1.50	CH/R		16	2	53	47	19	28								
		MBH03	0.00	4.50	0.10	-4.40	4.50	CH/R/CI	24	7	0	68	46	19	27								
		MBH04	0.00	4.50	1.40	-3.10	4.50	CI/R	16	11	0	53	42	17	25								
		MBH05	0.00	1.52	0.30	-1.22	1.52	R		11	0												
		MBH06	0.00	1.88	2.60	0.72	1.88	CI/R		12	0	100	50	22	28								
		MBH07	0.00	1.50	1.10	-0.40	1.50	CI				100	46	23	23								
		MBH08	0.00	1.50	1.90	0.40	1.50	CH				100	54	24	30								
		MBH09	0.00	4.50	1.00	-3.50	4.50	CH	21			98	68	29	39								
		MBH10	0.00	1.50	0.90	-0.60	1.50	CH															
		MBH11	0.00	4.50	1.10	-3.40	4.50	CH	17			81	76	29	47								
		MBH12	0.00	4.50	1.80	-2.70	4.50	CH	28			90	79	31	48								
		MBH13	0.00	1.50	0.70	-0.80	1.50	CH				88	60	28	32								
		MBH14	0.00	4.50	2.40	-2.10	4.50	CH/R	12			75	65	27	38								
		MBH15	0.00	1.50	1.50	0.00	1.50	CH				99	61	28	33								
	Min. Value	0.00	1.50	0.10	-4.40	1.50		12	7	0	53	42	17	23									
	Max. Value	0.00	4.50	2.60	0.80	4.50		28	16	2	100	79	31	48									
	Average Value	0.00	2.93	1.39	-1.54	2.93		20	11	0	84	58	25	33									
	Recommended	0.0	2.9	1.4	-1.5	2.9	CH	16	9	0	84	58	25	33	1.8	0.7	0.0	0.0070	158	0.50			
2	Medium to dense sand/clayey sand	MBH01	4.50	5.80	-2.80	-4.10	1.30	SP	29			3	NP	-	-								
		MBH02	1.50	6.55	0.80	-4.25	5.05	SP	29			5	NP	-	-								
		MBH03	4.50	6.80	-4.40	-6.70	2.30	SM-SP	28			7	NP	-	-								
		MBH04	4.50	6.65	-3.10	-5.25	2.15	SM-SP	22			6	NP	-	-								
		MBH05	1.52	6.90	-1.22	-6.60	5.38	SC	20			40	43	25	18								
								SM-SP	30			6	NP	-	-								
		MBH06	1.88	7.75	0.72	-5.15	5.87	SM-SP	30			7	NP	-	-								
		MBH07	1.50	3.00	-0.40	-1.90	1.50	SP	19			4	NP	-	-								
		MBH08	1.50	6.00	0.40	-4.10	4.50	SP	36			3	NP	-	-								
		MBH09	4.50	10.00	-3.50	-9.00	5.50	SM-SP	29			25	NP	-	-								
		MBH10	1.50	4.50	-0.60	-3.60	3.00	SC	35			41	59	28	31								
		MBH11	4.50	4.50	-3.40	-3.40	0.00	not encountered															
		MBH12	4.50	4.50	-2.70	-2.70	0.00	not encountered															
		MBH13	1.50	10.00	-0.80	-9.30	8.50	SM-SP	36			4	NP	-	-								
		MBH14	4.50	10.00	-2.10	-7.60	5.50	SP	51			4	NP	-	-								
	MBH15	1.50	4.30	0.00	-2.80	2.80	SP	28			3	NP	-	-									
	Min. Value	1.50	3.00	-4.40	-9.30	0.00		19			3	43	25	18									
	Max. Value	4.50	10.00	0.80	-1.90	8.50		51			41	59	28	31									
	Average Value	2.93	6.48	-1.54	-5.10	3.56		30			11	51	27	25									
	Recommended	2.9	6.5	-1.5	-5.1	3.6	SM-SP	25			11	51	27	25	1.9	0.0	33.0	-	369	0.35			
3	Very stiff to hard clayey silt	MBH01	5.80	5.80	-4.10	-4.10	0.00	not encountered															
		MBH02	6.55	6.55	-4.25	-4.25	0.00	not encountered															
		MBH03	6.80	6.80	-6.70	-6.70	0.00	not encountered															
		MBH04	6.65	6.65	-5.25	-5.25	0.00	not encountered															
		MBH05	6.90	6.90	-6.60	-6.60	0.00	not encountered															
		MBH06	7.75	7.75	-5.15	-5.15	0.00	not encountered															
		MBH07	3.00	4.50	-1.90	-3.40	1.50	CH	11			82	83	34	49								
		MBH08	6.00	10.00	-4.10	-8.10	4.00	CH	22			98	76	34	42								
		MBH09	10.00		-9.00			not encountered															
		MBH10	4.50	4.50	-3.60	-3.60		not encountered															
		MBH11	4.50	9.10	-3.40	-8.00	4.60	CH	38			94	89	35	54								
		MBH12	4.50	4.50	-2.70	-2.70	0.00	not encountered															
		MBH13	10.00	3.40	-9.30	-2.70	-6.60	not encountered															
		MBH14	10.00		-7.60			not encountered															
		MBH15	4.30	4.30	-2.80	-2.80	0.00	not encountered															
	Min. Value	3.00	3.40	-9.30	-8.10	-6.60		11			82	76	34	42									
	Max. Value	10.00	10.00	-1.90	-2.70	4.60		38			98	89	35	54									
	Average Value	6.48	6.21	-5.10	-4.87	0.29		24			91	83	34	48									
	Recommended	6.5	6.2	-5.1	-4.9	0.3	CH	17			91	83	34	48	1.9	0.7	0.0	0.0064	173	0.50			
4	Highly weathered to completely weathered rock/conglomerate/ cemented layers/ dense sand	MBH01	5.80	10.00	-4.10	-8.30	4.20	R	540	14	0												
		MBH02	6.55	10.00	-4.25	-7.70	3.45	R	390	13	0												
		MBH03	6.80	8.80	-6.70	-8.70	2.00	R	510	11	0												
		MBH04	6.65	10.00	-5.25	-8.60	3.35	R	145	8	0												
		MBH05	6.90	10.00	-6.60	-9.70	3.10	R	284	18	0	5	NP	-	-								
		MBH06	7.75	10.00	-5.15	-7.40	2.25	R	306	16	0												
		MBH07	4.50	10.00	-3.40	-8.90	5.50	SP/R	82	0	0	5	NP	-	-								
		MBH08	10.00		-8.10			not encountered															
		MBH09						not encountered															
		MBH10	4.50	10.00	-3.60	-9.10	5.50	CH/R	238	0	0	83	74	24	50								
		MBH11	9.10	10.00	-8.00	-8.90	0.90	CH/R	765	0	0												
		MBH12	4.50	10.00	-2.70	-8.20	5.50	SC/R	227	33	0	27	NP	-	-								
		MBH13	3.40		-2.70			not encountered															
		MBH14						not encountered															
		MBH15	4.30	10.00	-2.80	-8.50	5.70	R	405	18	0												
	Min. Value	3.40	8.80	-8.10	-9.70	0.90		82	0	0													
	Max. Value	10.00	10.00	-2.70	-7.40	5.70		765	33	0													
	Average Value	6.21	9.89	-4.87	-8.55	3.77		354	12	0													
	Recommended	6.2	9.9	-4.9	-8.5	3.8	R	100	12	0					2.1	7.0	0.0		1500	0.3			
5	Very stiff to hard clayey silt	MBH01	10.00	10.45	-8.30	-8.75	0.45	CH	18			67	79	34	45								
		MBH02	10.00	10.20	-7.70	-7.90	0.20	CH				88	70	28	42								
		MBH03	8.80		-8.70			not encountered															
		MBH04	10.00	10.12	-8.60	-8.72	0.12	CH															
		MBH05	10.00		-8.70			not encountered															
		MBH06	10.00		-7.40			not encountered															
		MBH07	10.00		-8.90			not encountered															
		MBH08						not encountered															
		MBH09						not encountered															
		MBH10	10.00		-9.10			not encountered															
		MBH11	10.00		-8.90			not encountered															
		MBH12	10.00		-8.20			not encountered															
		MBH13						not encountered															
		MBH14						not encountered															
		MBH15	10.00		-8.50			not encountered															
	Min. Value	8.80	10.12	-9.70	-8.75	0.12		18															
	Max. Value	10.00	10.45	-7.40	-7.90	0.45		18															

A



Additional EU SRR compliance		
Category	Requirement	Details
Environmental Protection Measures		
Impermeable Surfaces	Cover cutting zones including primary cutting zone and storage, segregation and scrap stacking areas	Concrete/zed, reinforced with drain collection system. Please refer to chapter 4 for details
Drainage System	4-5 km drainage lines plus drainage tanks, filters, traps and separators	Covers all cutting, stacking and storage zones and connecting to a central treatment facility
Wastewater Treatment Plant	Capacity: 250,000-300,000 litres/day	Treats runoff, oily residues and contaminated liquids. Includes oil-water separation plants and chemical treatment etc.
Stormwater Management	Stormwater tank capacity: approx. 2.0 million litres in 2-3 tanks distributed	Designed for heavy rainfall
Air Pollution Control	Mist cannons and fume extraction systems	Dust suppression and hazardous gas capture in cutting zones
Worker Safety and Welfare		
Worker Training	Training Rooms for at least 200 workers	Ship disarming, safety, compliances and hazardous material handling training
Medical Facility	At least 20-bed clinic	Includes toxicology support and decontamination room
Welfare Area	Minimum 2,000 m²	Restroom, showers, changing rooms, mess areas
Safety Equipment	PPE for each worker	Helmets, goggles, gloves, respiratory gear, fire extinguishers (1 per 100 m²)
Emergency Response	8-10 exit routes, fire hydrants at 40 m intervals	Emergency escape and fire response systems
Waste Management Infrastructure		
Hazardous Waste Zone	Approximate 2,000 m²	Lined with impermeable surfaces; ventilated storage for hazardous materials
Recycling Facilities	Shredding unit and preferably magnetic separator for ferrous and non-ferrous metals	Compacting and processing systems for efficient recycling
Oil Spill Containment	Oil waste fire pit, 350,000 litres capacity in 2-3 tanks	Spill kits and containment systems
Certification and Record-Keeping		
Auditable Records	Track waste quantities and destinations through digital tracking or maintaining auditable records.	To ensure environmentally sound recycling and disposal records are auditable.
Third-Party Audits	Quarterly audits	Ensure compliance with EU SSR and ISO 30000 standards

NOTES :-

1. All dimensions and levels are in meter unless noted otherwise.
2. This drawing should not be scaled. Only written dimensions should be followed.
3. All levels are related to chart datum (+0.0m).
4. Compliance verified with EU regulation.

- MERIZEN-1541-GMB-ALANG-FINAL-DWG-002
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-005

As of	24.11.2025	ISSUED WITH FINAL REPORT	APU	SK	TK
Size	Boreman Boreman	Purpose of revision	Drawn	Checked	Approved



Merizen

Client: **Gujarat Maritime Board (GMB)**

Project: **Master Planning for Capacity Enhancement and Expansion of Alang Sosiyia Ship Recycling Yard**

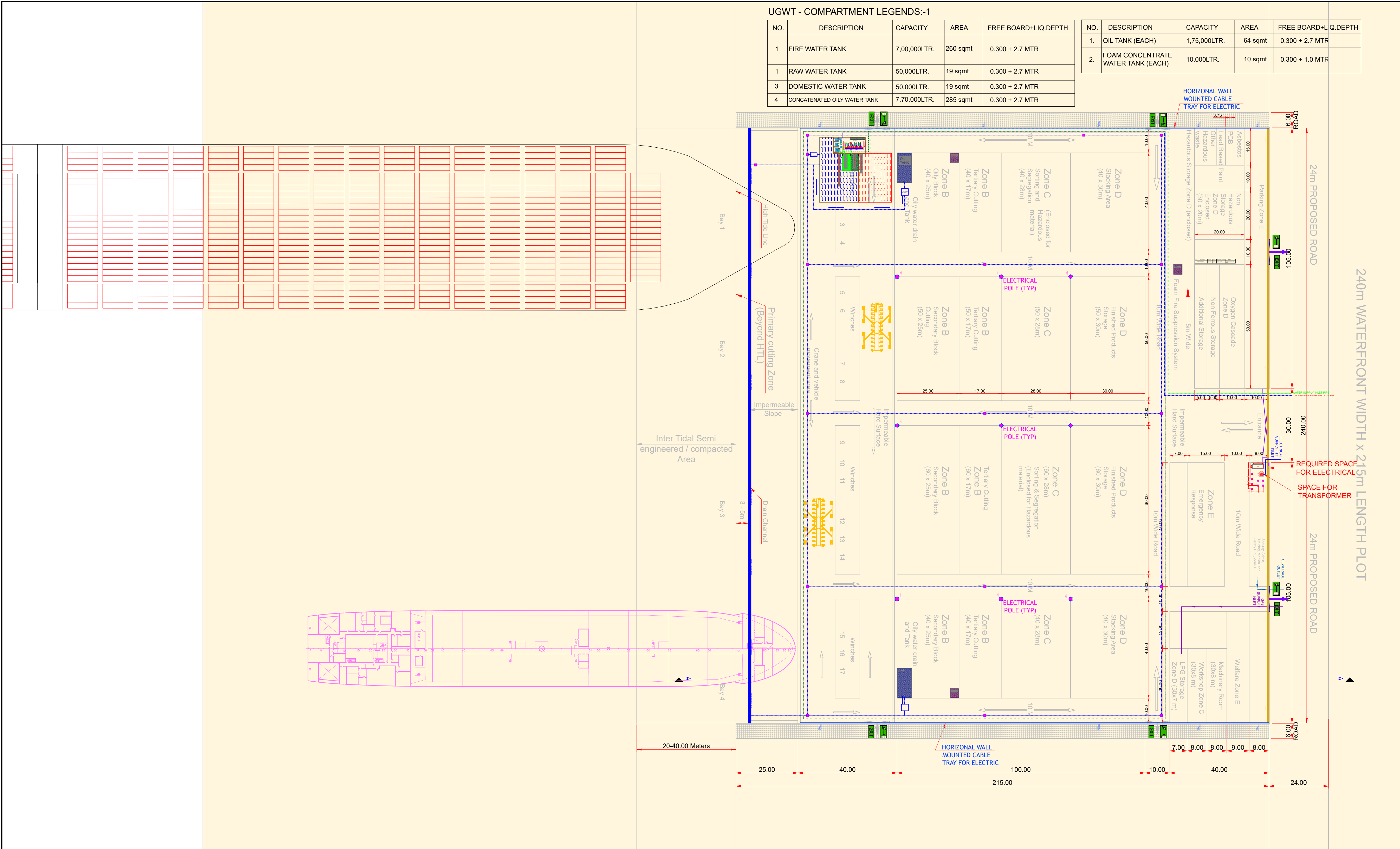
Drawing title: **PROPOSED PLOT LAYOUT-01**
240m WATERFRONT WIDTH x 215m LENGTH
PLOT

Drawing status: **Scale: 1 : 750 @A1** **Do not scale**

Drawing number: **MERIZEN-1541-GMB-ALANG-FINAL-DWG-001**

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on this drawing. Refer to the contract for full terms and conditions.

Rev: **A0**



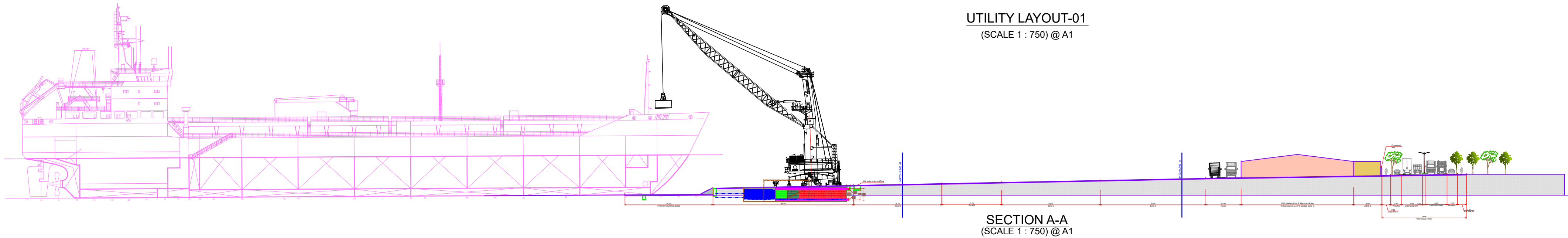
- NOTES :-
1. All dimensions and levels are in meter unless noted otherwise.
 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).
 4. Compliance verified with EU regulation.

LEGEND

WATER SUPPLY	—
RAIN WATER	—
FIRE FIGHTING	—
MANHOLE	■
CHANNEL	—

REFERENCE DRAWINGS :-

- MERIZEN-1541-GMB-ALANG-FINAL-DWG-001
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-002
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-005



FOR FINAL REPORT

NO.	DATE	REVISION	APPROVED	BY	DATE
AD	24.11.2025	SUBMITTED WITH FINAL REPORT	APU	SK	TK
Rev		Purpose of revision	Drawn	Checked	Approved

Client
Gujarat Maritime Board (GMB)

Project
Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

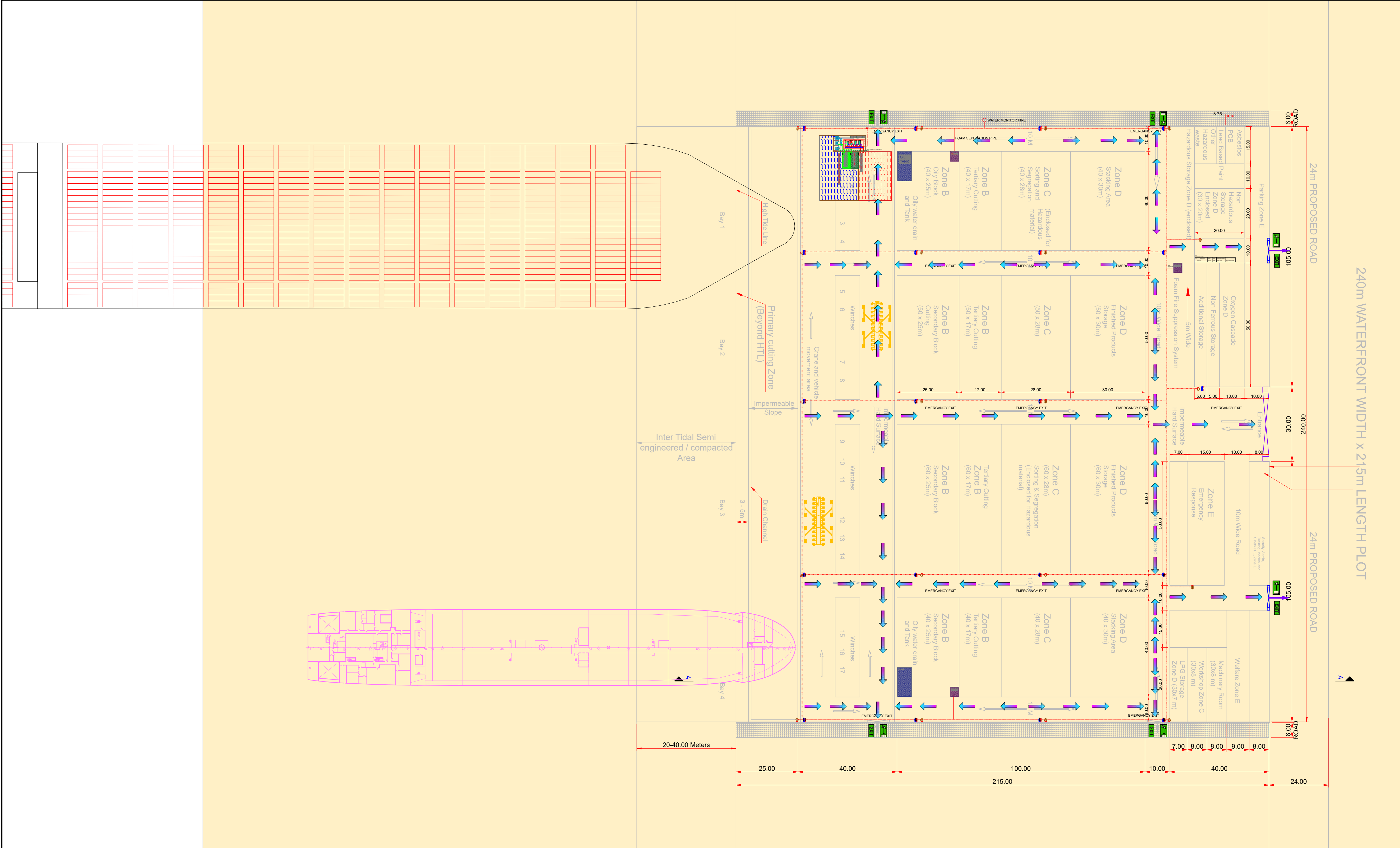
Drawing title
PROPOSED PLOT LAYOUT-01
UTILITIES PLAN

Drawing status
Scale
1: 750 @ A1
Do not scale

Drawing number
MERIZEN-1541-GMB-ALANG-FINAL-DWG-001A

Rev
A0

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- NOTES :-
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 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).
 4. Compliance verified with EU regulation.

LEGEND :-

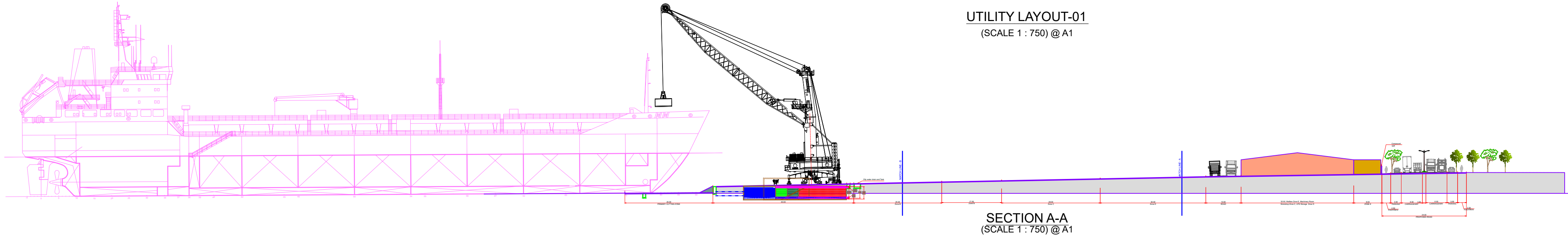
FIRE FIGHTING LINE	
HYDRANT VALVE (HV)	
FIRE EXTINGUISHER	

REFERENCE DRAWINGS :-

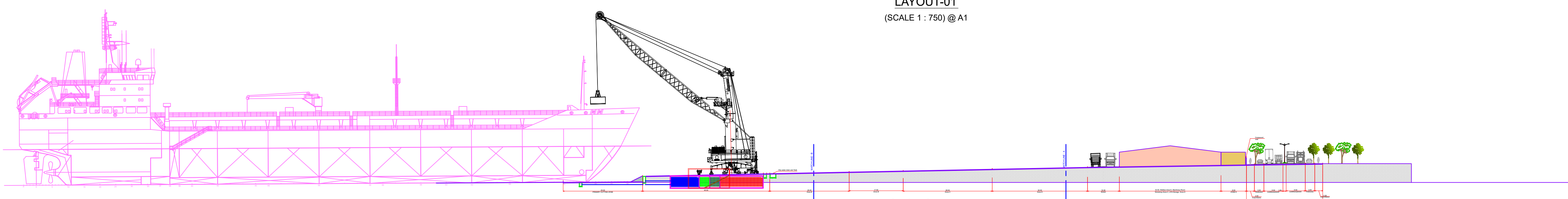
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-001
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-002
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-005

FOR FINAL REPORT

AD	24.11.2025	SUBMITTED WITH FINAL REPORT	APU	SK	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard					
Drawing title					
PROPOSED PLOT LAYOUT-01 UTILITIES PLAN					
Drawing status					
Scale					
1 : 750 @ A1					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-001B					
This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.					



- REFERENCE DRAWINGS :-**
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-001



SECTION A-A
(SCALE 1 : 750) @ A1

A0	24.11.2025	ISSUED WITH FINAL REPORT	APJ	SK	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved

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B



Recommended Facility Areas <i>(Suggestive Guidelines)</i>		
Zone	Facility	Approximate Area (m ²)
Zone A	Impermeable Primary Shipbreaking Zone	9000
	Jetties and Crane Hard, Winches and Crane Buffer area	13750
Zone B	Secondary Block cutting Zone	
Secondary Block Breaking	Tertiary Cutting Zone	10000
	City Block Zone (approx. 2000 m ²)	
Zone C	Sorting and Segregation Area	
Sorting, Segregation and	Machinery room	7500
	Workshop	
Zone D	Finished Product Storage	
Storage Areas	Steel And Scrap Stacking Zone	
	Benign Products Storage	10500
	Hazardous Stores	
	Non-Ferrous Storage	
	Oxygen, Plasma and PNG storage	
	Storm Water Tank> 2.0 million Litres	
	Fire Water Tank>700,000 Litres	2500
	City Water Tank>350,000 Litres	
Zone E:	Medical Room	
Administrative, Security, Emergency Response, Buffer Zones and Green Areas	Canteen and Recreation	
	Toilets and Bathrooms	
	Admin Building (Total)	
	Parking and Waiting Lounge	11250
	Oil Spill Kit, Fire Fighting and safety measures	
	Restroom	
	Safety Room/Emergency Point	
	Buffer Zones, Movement Zone and Greens	
	Total Area	64500

Equipment capacities	
Equipment Category	Quantity/Capacity
Cranes	24–28 units (3–4 heavy duty Portal/crawler/floating cranes of 150-300 tons, 5-6 heavy duty cranes of 100-150 tons, 8–9 heavy-duty crawler/mobile cranes of 25–100 tons and 8–9 mobile cranes of 10–40 tons).
Forklifts	8-12 units (3–5 tons capacity).
Excavators with Shears(optional)	5-6 units (20–40 tons).
Magnetic Scrap Handlers	5–6 units (1.5–4 tons lifting capacity).
Oxy-Acetylene Cutting Torches	Around 100-120 units.
Plasma Cutting Machines	10-12 units (cutting thickness up to 40 mm).
Hydraulic/Cold Cutting Saws	5-7 units.
Fire Extinguishers	180-220 units (dry powder and foam types).
Sand Buckets	90-110 buckets (50 litres each).
Fire Hydrants	Fire hydrants (spaced every 50 meters).
Foam-Based Fire Systems	3 foam tank (10,000-15,000 litres each).
Fire Truck	At least 1 truck equipped with foam and dry powder.
Winches	At least 20-23 heavy duty winch units (as per operational requirements) with multi pulley block system for mechanical advantage and necessary accessories.
Oil-Water Separators	At least 5-7 Units (10,000 litres/day each).
Wastewater Treatment Plant (WWTP) (Optional)	300000-350000 Litres/day
Mist Cannons	5-6 units (20-meter range).
Noise Level Meters	5 units.
Spill Containment Kits	8 kits for oil and chemical containment.
Body Showers and Eye Wash Stations	at least 10 stations.
Power (Domestic)	200 kW approximate
Solar Panels (Optional)	125-150 kW solar setup.
Generators (Optional)	2 units (150 kVA each).
Automated Inventory Management System (RFID Enabled)	One system for tracking of material and waste flow
Robotic controlled gas or plasma cutting tools(optional)	6-7 Units or appropriate numbers for precision and safe dismantling in hazardous zone
Fire Alarm System	The fire alarm system should provide coverage to both primary cutting Zone A (on ship) and Zone B
Accessibility Support	manlifts and staging as required

Additional EU SRR compliance		
Category	Requirement	Details
Environmental Protection Measures		
Impermeable Surfaces	Cover cutting zones including primary cutting zone and storage, segregation and scrap stacking areas	Concretized, reinforced with drain collection system. Please refer to chapter 4 for details
Drainage System	6-7 km drainage lines plus drainage tanks, filters, traps and separators	Covers all cutting, stacking and storage zones and connecting to a central treatment facility
Wastewater Treatment Plant	Capacity: 300,000-350000 litres/day	Treats runoff, oily residues and contaminated liquids. Includes oil-water separation plants and chemical treatment etc.
Stormwater Management	Stormwater tank capacity: approx. 2.5 million litres in 3-4 tanks distributed	Designed for heavy rainfall
Air Pollution Control	Mist cannons and fume extraction systems	Dust suppression and hazardous gas capture in cutting zones
Worker Safety and Welfare		
Worker Training	Training Rooms for at least 250 workers	Ship dismantling, safety, compliances and hazardous material handling training
Medical Facility	At least 25-bed clinic	Includes toxicology support and decontamination room
Welfare Area	Minimum 2,500 m ²	Restrooms, showers, changing rooms, mess areas
Safety Equipment	PPE for each worker	Helmets, goggles, gloves, respiratory gear, fire extinguishers (1 per 100 m ²)
Emergency Response	10-12 exit routes, fire hydrants at 40 m intervals	Emergency escape and fire response systems
Waste Management Infrastructure		
Hazardous Waste Zone	Approximate 2,500 m ²	Lined with impermeable surfaces; ventilated storage for hazardous materials
Recycling Facilities	Shredding unit and preferably magnetic separator for ferrous and non-ferrous metals	Compacting and processing systems for efficient recycling
Oil Spill Containment	oil waste water pit 400000 litres capacity in 3-4 tanks	Spill kits and containment systems
Certification and Record-Keeping		
Auditable Records	Track waste quantities and destinations through digital tracking or maintaining auditable records.	To ensure environmentally sound recycling and disposal records are auditable.
Third-Party Audits	Quarterly audits	Ensure compliance with EU SRR and ISO 30000 standards

NOTES :-

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4. Compliance verified with EU regulation.

REFERENCE DRAWINGS :-

- MERIZEN-1541-GMB-ALANG-FINAL-DWG-004
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-005

FOR FINAL REPORT

Rev	24/11/2025	ISSUED WITH FINAL REPORT	APJ	SK	TK
Rev	Business Date	Purpose of revision	Drawn	Checked	Approved

Merizen

Engineering & Construction

Client

Gujarat Maritime Board (GMB)

Project

Master Planning for Capacity Enhancement and Expansion of Alang Sosisiya Ship Recycling Yard

Drawing title

PROPOSED PLOT LAYOUT-02
300m WATERFRONT WIDTH x 215m LENGTH
PLOT

Drawing status

Scale

1 : 150 (B-1)

Do not scale

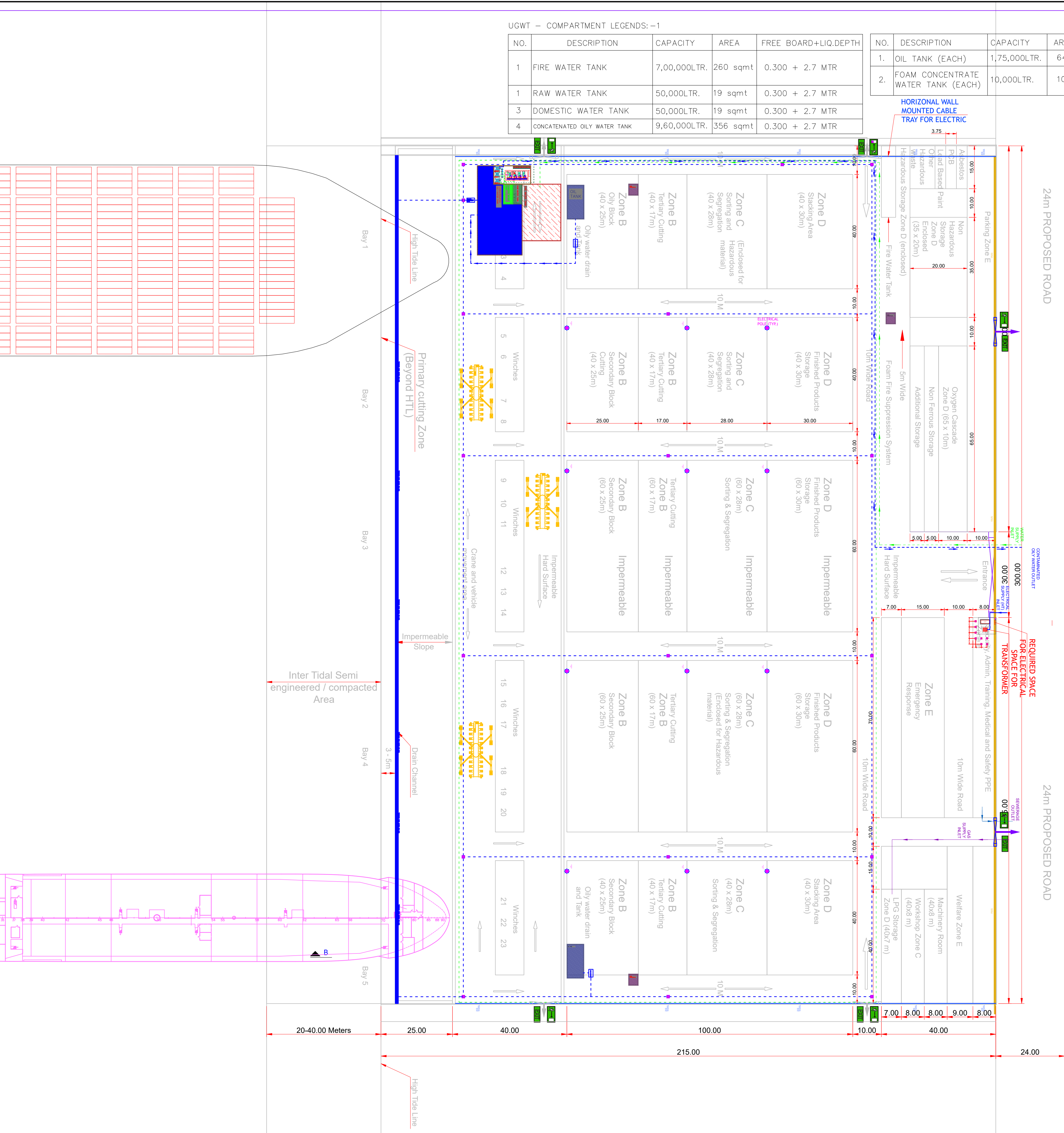
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-003

Rev

A0

This drawing is not to be used in whole or part other than for the intended purposes and project as defined on this drawing. Refer to the contract for full terms and conditions.



300m WATERFRONT WIDTH x 215m LENGTH PLOT

- NOTES :-
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 3. All levels are related to chart datum (+0.0m).
 4. Compliance verified with EU regulation.

LEGEND

WATER SUPPLY	
RAIN WATER	
FIRE FIGHTING	
MANHOLE	

- REFERENCE DRAWINGS :-
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-003
 - MERIZEN-1541-GMB-ALANG-FINAL-DWG-004
 - MERIZEN-1541-GMB-ALANG-FINAL-DWG-005

FOR FINAL REPORT

AD	24.11.2025	SUBMITTED WITH FINAL REPORT	APU	SK	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved

Client

Gujarat Maritime Board (GMB)

Project

Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard

Drawing title

PROPOSED PLOT LAYOUT-02
UTILITIES PLAN

Drawing status

Scale

1: 750 @A1

Do not scale

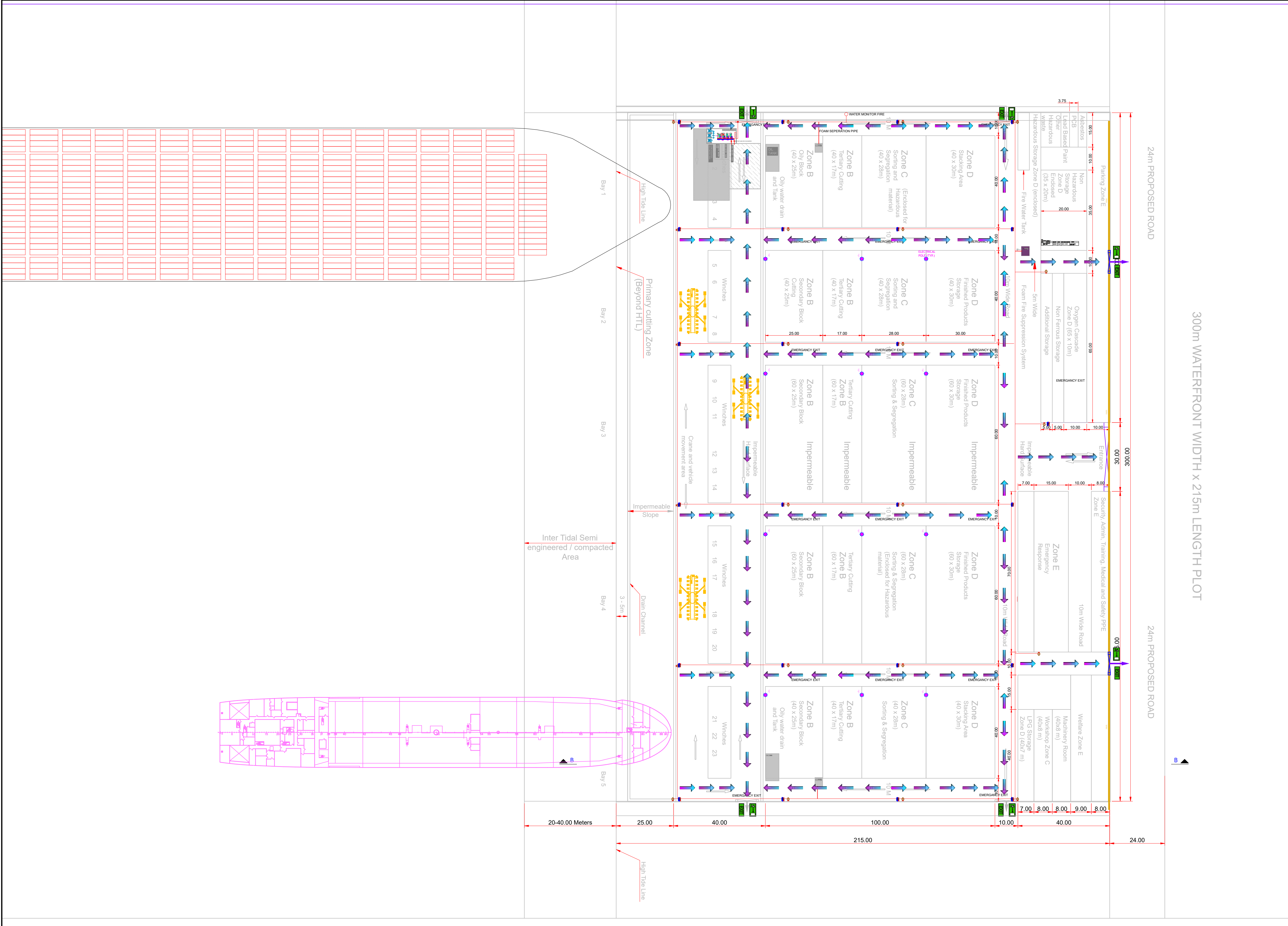
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-003A

Rev

A0

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LAYOUT-02
(SCALE 1 : 850) @ A1

- NOTES :-
1. All dimensions and levels are in meter unless noted otherwise.
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 3. All levels are related to chart datum (+0.0m).
 4. Compliance verified with EU regulation.

LEGEND

WATER SUPPLY	
RAIN WATER	
FIRE FIGHTING	
MANHOLE	

- REFERENCE DRAWINGS :-
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-003
 - MERIZEN-1541-GMB-ALANG-FINAL-DWG-004
 - MERIZEN-1541-GMB-ALANG-FINAL-DWG-005

FOR FINAL REPORT

Rev	20.11.2025	ISSUED WITH FINAL REPORT	APU	SK	TK
Rev	20.11.2025	Propose of revision	Drawn	Checked	Approved



Client
Gujarat Maritime Board (GMB)

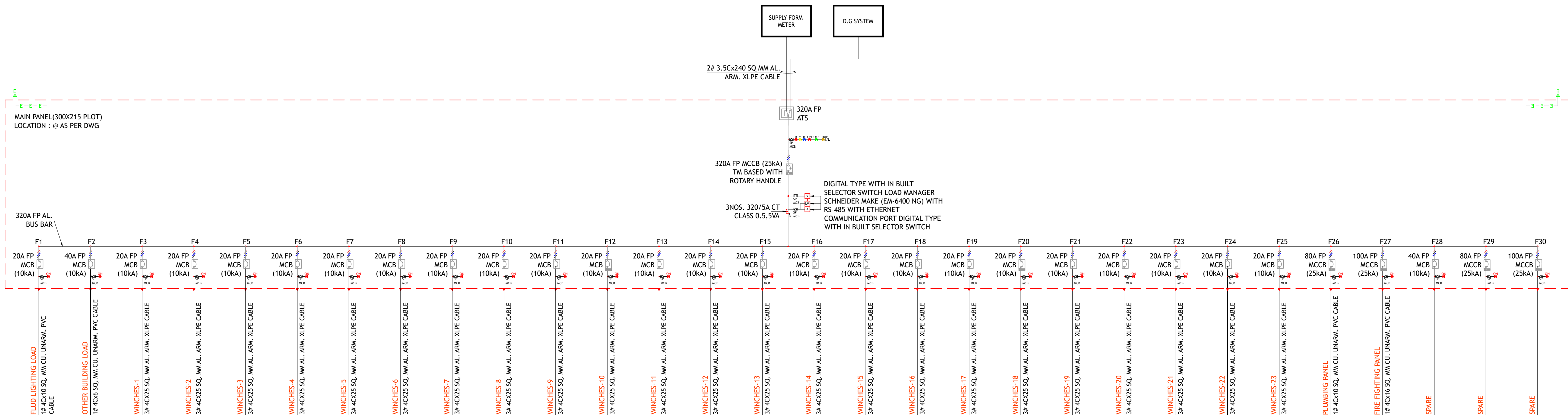
Project
Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

Drawing title
PROPOSED PLOT LAYOUT-02
FIRE FIGHTING & EVACUATION PLAN

Drawing status	
Scale	1: 750 @ A1
Drawing number	

Merizen-1541-GMB-ALANG-FINAL-DWG-003B A0

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- GENERAL NOTES:
- 1) MCCB'S SHORT CIRCUIT RATING SHALL BE KCS-KCU-100% FOR 1SEC. ALL MCCB'S SHALL BE THERMAL MAGNETIC ADJUSTABLE RELEASE UP TO 400A & MICROPROCESSOR BASED 400A & ABOVE, UNLESS SPECIFIED OTHERWISE IN THE DRAWING/SLD.
 - 2) ALL MFAL, M, & KWH METER WITH RS 485 PORT METERS ARE APPROVED BY LOCAL SUPPLY ELECTRICITY BOARD AND WITH TESTING CERTIFICATES WHICH EVER APPLICABLE.
 - 3) CT/METER COMPARTMENT SHALL HAVE SEALING ARRANGEMENT.
 - 4) $MF = V/I \times F/KVA/KWH/KVARH/PF$
 - 5) $LW = V \times A/F/KVA/KWH/KVARH/THD$
 - 6) AS SOON AS D.G. SUPPLY IS START DG BREAKER AUTOMATICALLY 'ON' SEB BREAKER SHOWS 'OFF'.
 - 8) MOTOR STARTER FEEDER MCCB SHOULD BE MOTOR DUTY MOTOR STARTER FEEDER ON/OFF/TRIP INDICATION LAMP TO BE PROVIDED.
 - 9) MOTOR STARTER FEEDER HAVE POTENTIAL FREE CONTACT FOR BUS CONNECTIVITY.
 - 10) I/C, O/G, ACB 50KA / 65KA WITH LSGI MCCB - 35KA / 25KA WE PROPOSED SOFTWARE FOR READING OF METERS ONLINE ON COMPUTER SHOULD BE PROVIDE BY PANEL VENDOR.
 - 11) WIRING FOR RS485 PORT FOR METERS BREAKER SHOULD BE DONE BY PANEL VENDORS.
 - 12) IF ANY AMBIGUITY, SHOULD BE BROUGHT TO CLIENT/CONSULTANT'S NOTICE BEFORE PROCUREMENT, MANUFACTURING AND EXECUTION.
 - 13) ALL PANEL GA TO BE GOT APPROVED BY CONSULTANT BEFORE PROCUREMENT, MANUFACTURING AND EXECUTION.
 - 14) ALL TECHNICAL DETAILS AND DATA SHEETS OF ALL SWITCHGEARS, METERS, WIRES, ALL COMPONENTS ETC ALONG WITH MAKES AND MODEL NUMBERS MUST BE SUBMITTED TO CONSULTANTS AND GOT APPROVED BEFORE PROCUREMENT, MANUFACTURING AND EXECUTION.
 - 15) HVAC, AUTOMATION, PUMPS, EXTERNAL DEVELOPMENTS, FACADE, LANDSCAPES OR ANY OTHER SPECIAL REQUIREMENTS ARE VENDOR/CONTRACTOR/SUPPLIER/INTERIOR/CLIENT SPECIFIC, HENCE, THE RATING OF SWITCHGEAR AND WIRE OR CABLES MUST BE CONFIRMED WITH CONCERNED BEFORE PROCUREMENT, MANUFACTURING AND EXECUTION.
 - 16) THE SIZE/RATING OF THE SWITCHGEARS AND CABLES/WIRES MENTIONED IN THE SLD ARE SUBJECT TO CHANGE AS PER VENDOR/CONTRACTOR/SUPPLIER/INTERIOR/CLIENT SPECIFIC REQUIREMENTS, HENCE, THE RATING OF SWITCHGEAR AND WIRE OR CABLES MUST BE CONFIRMED WITH CONCERNED BEFORE PROCUREMENT, MANUFACTURING AND EXECUTION.
 - 17) THE CABLE SIZES ALSO MAY VARY AS PER THE FINAL LOCATION OF ANY ELECTRICAL EQUIPMENTS, HENCE, IF ANY CHANGES ARE DONE AT SITE BY ANY CONCERNED, IT MUST BE BROUGHT TO CONSULTANT'S NOTICE BEFORE PROCUREMENT, MANUFACTURING AND EXECUTION.
 - 18) THE LENGTH OF THE CABLES/WIRES MUST BE VERIFIED AT SITE BY THE CONTRACTOR/VENDOR/SUPPLIER/SITE TEAM BEFORE PROCUREMENT, MANUFACTURING AND EXECUTION.
 - 19) ALL PANEL TO BE AS MENTIONED IN SLD SUITABLE FOR INDOOR OR OUTDOOR INSTALLATION.
 - 20) ALL COMMITMENTS (INCLUDING INCOMING & OUTGOING) MUST HAVE NAME PLATE ACCORDING TO THE SLD (INCLUDING SWITCHGEAR RATING)

SYMBOL	DESCRIPTION
	ATs
	FP MCB
	FP MCCB
	INDICATION LAMP
	EARTHING
	EARTH STRIP
	METER

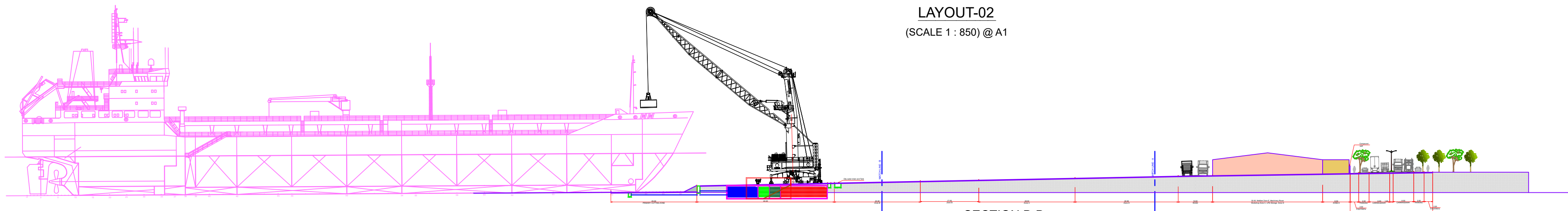
FOR FINAL REPORT

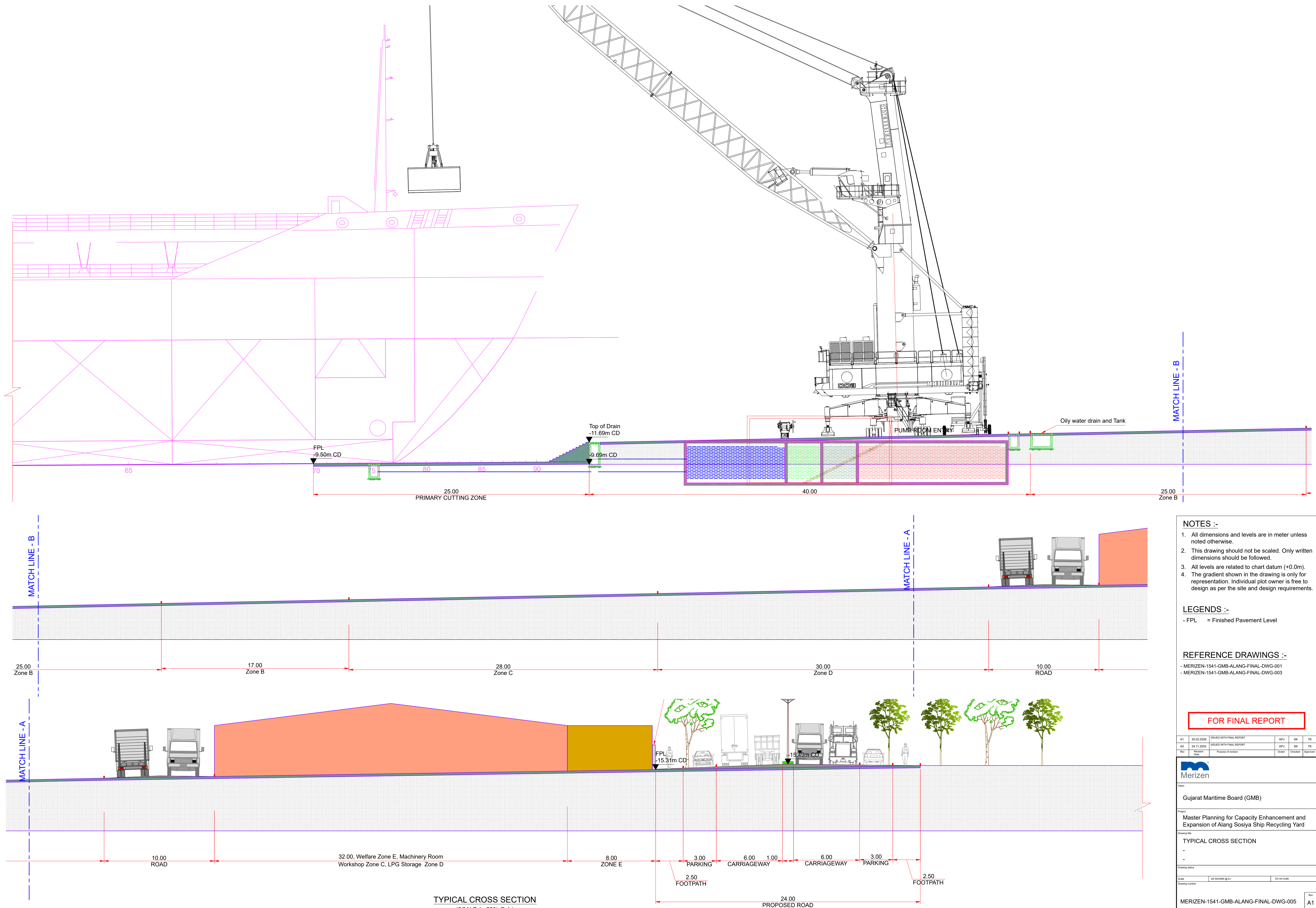
AD	24.11.2025	SUBMITTED WITH FINAL REPORT	APU	DR	TK
Rev	Revised Date	Purpose of revision	Drawn	Checked	Approved
					
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard					
Drawing title					
ELE MAIN PANEL LAYOUT-02					
Drawing status					
Scale					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-003C					
This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.					

- REFERENCE DRAWINGS :-**
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-003

FOR FINAL REPORT

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on this drawing. Refer to the contract for full terms and conditions.





- NOTES :-**
1. All dimensions and levels are in meter unless noted otherwise.
 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).
 4. The gradient shown in the drawing is only for representation. Individual plot owner is free to design as per the site and design requirements.

LEGENDS :-

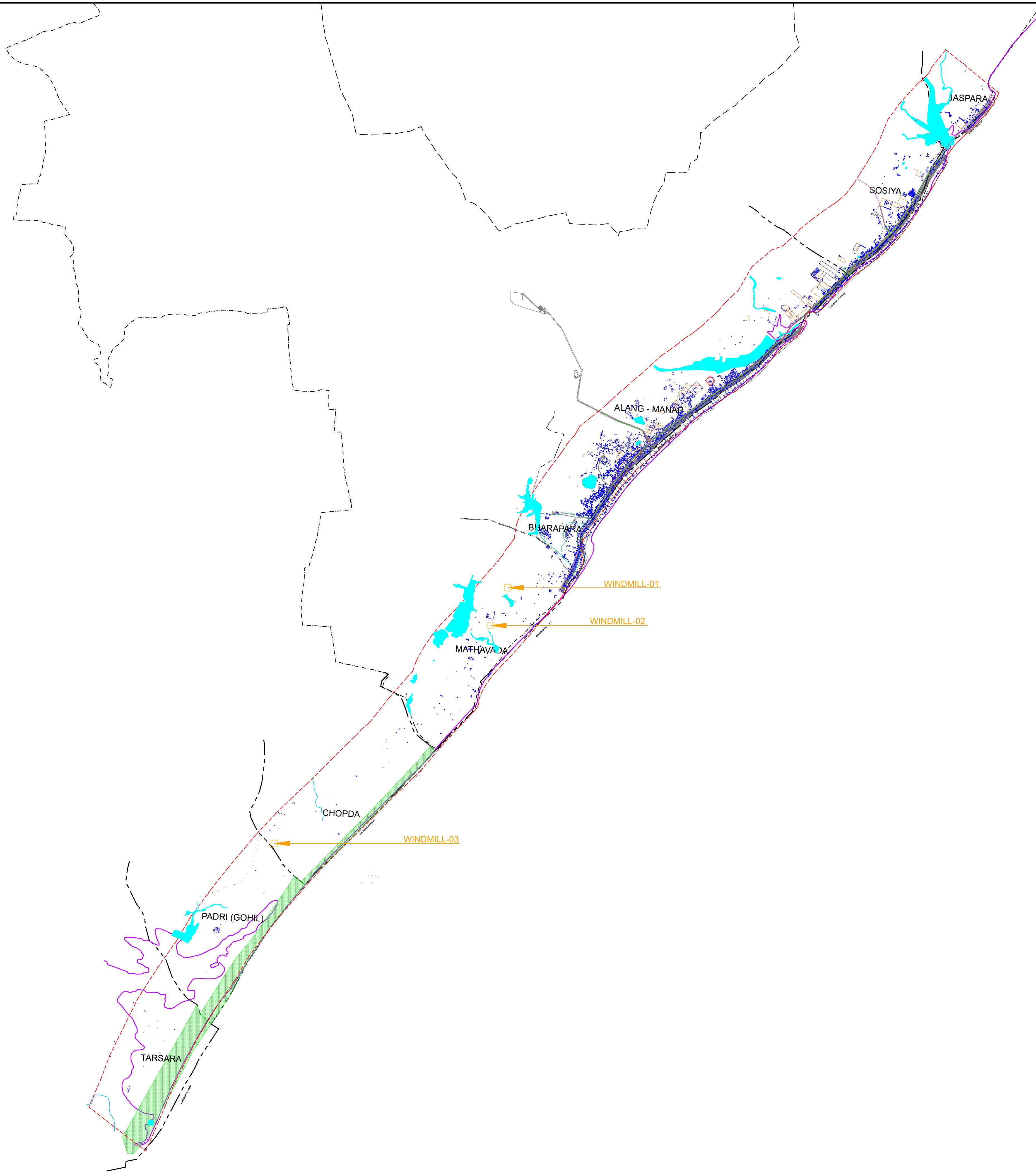
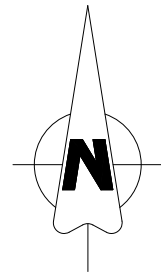
- FPL = Finished Pavement Level

REFERENCE DRAWINGS :-

- MERIZEN-1541-GMB-ALANG-FINAL-DWG-001
- MERIZEN-1541-GMB-ALANG-FINAL-DWG-003

FOR FINAL REPORT

A1	20.02.2026	ISSUED WITH FINAL REPORT	APJ	SK	TK
AD	24.11.2025	ISSUED WITH FINAL REPORT	APJ	SK	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard					
Drawing title					
TYPICAL CROSS SECTION					
-					
-					
Drawing status					
Scale					
AS SHOWN @ A1					
Do not scale					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-005					
This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.					
Rev					A1



NOTES :-

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2. This drawing should not be scaled. Only written dimensions should be followed.
3. All levels are related to chart datum (+0.0m).

LEGEND :-

	Study Area Boundary
	AADA Boundary
	Taluka Boundary
	Village Boundary
	River
	Natural Drain / Pond
	Canal
	High Tide Line (HTL)
	Highway / Main Road with bridge
	Buildings/Sheds
	Metalled Road
	Soil Road / Dirt Road
	Streams: Minor Canal
	Wells
	Water Body
	Divider
	Fencing
	Forest

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	24.11.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved



Client
Gujarat Maritime Board (GMB)

Project
Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

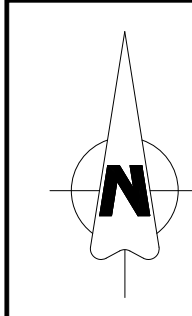
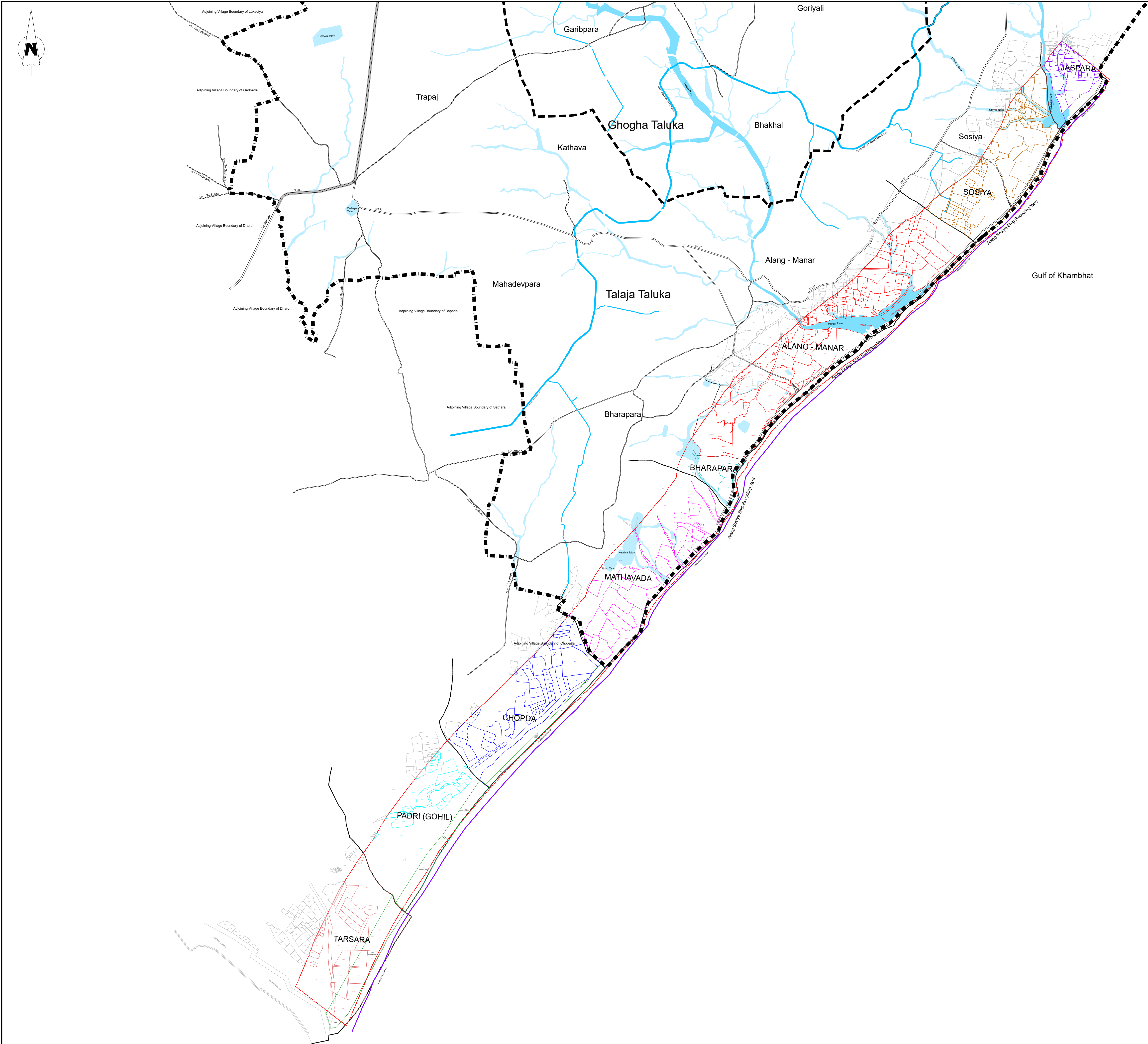
Drawing title
-
EXISTING SITUATION
-

Drawing status	
Scale	1:30,000 (S.A.)
Drawing number	

MERIZEN-1541-GMB-ALANG-FINAL-DWG-006

Rev
A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



- NOTES :-**
1. All dimensions and levels are in meter unless noted otherwise.
 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).

- LEGEND :-**
- Study Area Boundary
 - AADA Boundary
 - Taluka Boundary
 - Village Boundary
 - Existing Road
 - River
 - Natural Drain / Pond
 - Canal
 - High Tide Line

Reservation Proposal

- Reserved Forest Area

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	24.11.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved

Client

Gujarat Maritime Board (GMB)

Project

Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

Drawing title

-

BASE MAP SHOWING CADASTRAL DETAILS

-

Drawing status

Scale

1:30,000 (S.A1)

Do not scale

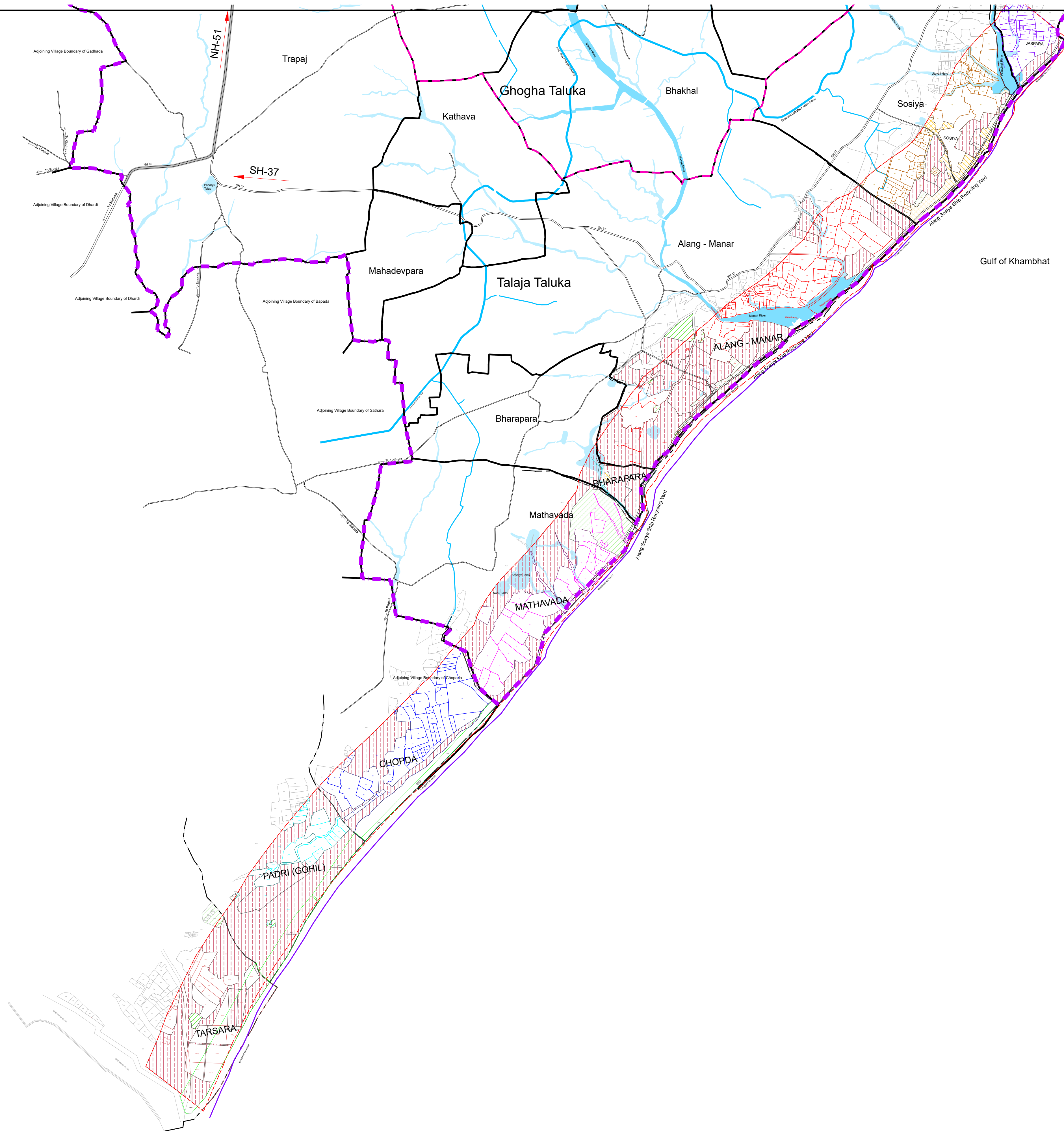
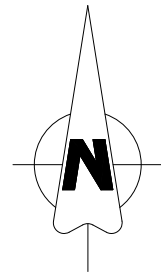
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-007

Rev

A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



NOTES :-

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3. All levels are related to chart datum (+0.0m).

LEGEND :-

- Study Area Boundary
- AADA Boundary
- Taluka Boundary
- Village Boundary
- Existing Road
- River
- Natural Drain / Pond
- Canal
- High Tide Line

Land Ownership

- Government Land
- GMB Land
- Mix of Government and Private Land
- Private Land

Reservation Proposal

- Reserved Forest Area

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	24.11.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved



Client
Gujarat Maritime Board (GMB)

Project
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard

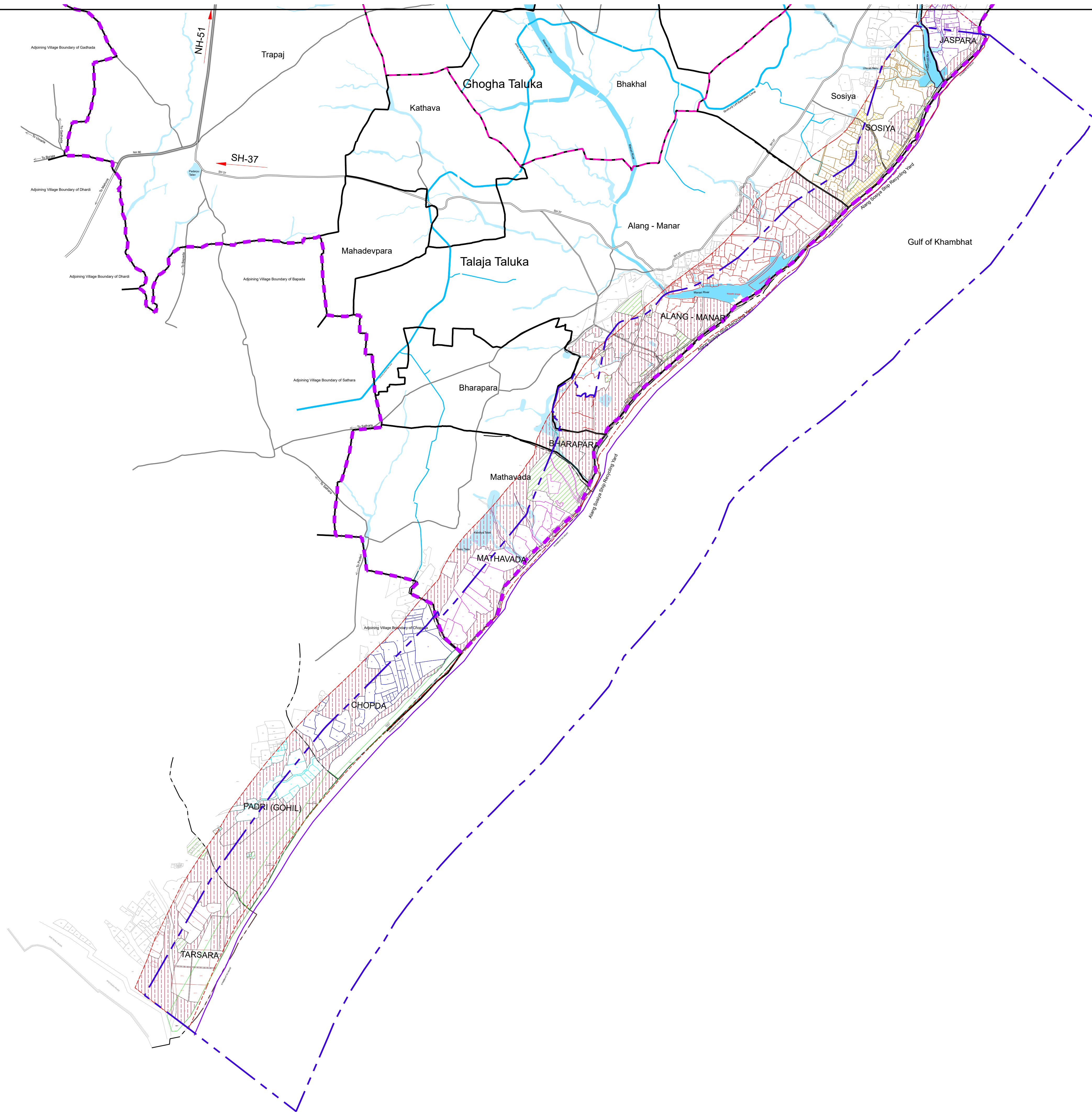
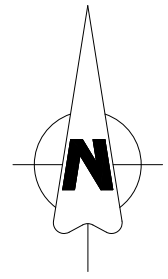
Drawing title
LAND OWNERSHIP MAP

Drawing status
Scale
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-008

A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



- NOTES :-
1. All dimensions and levels are in meter unless noted otherwise.
 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).

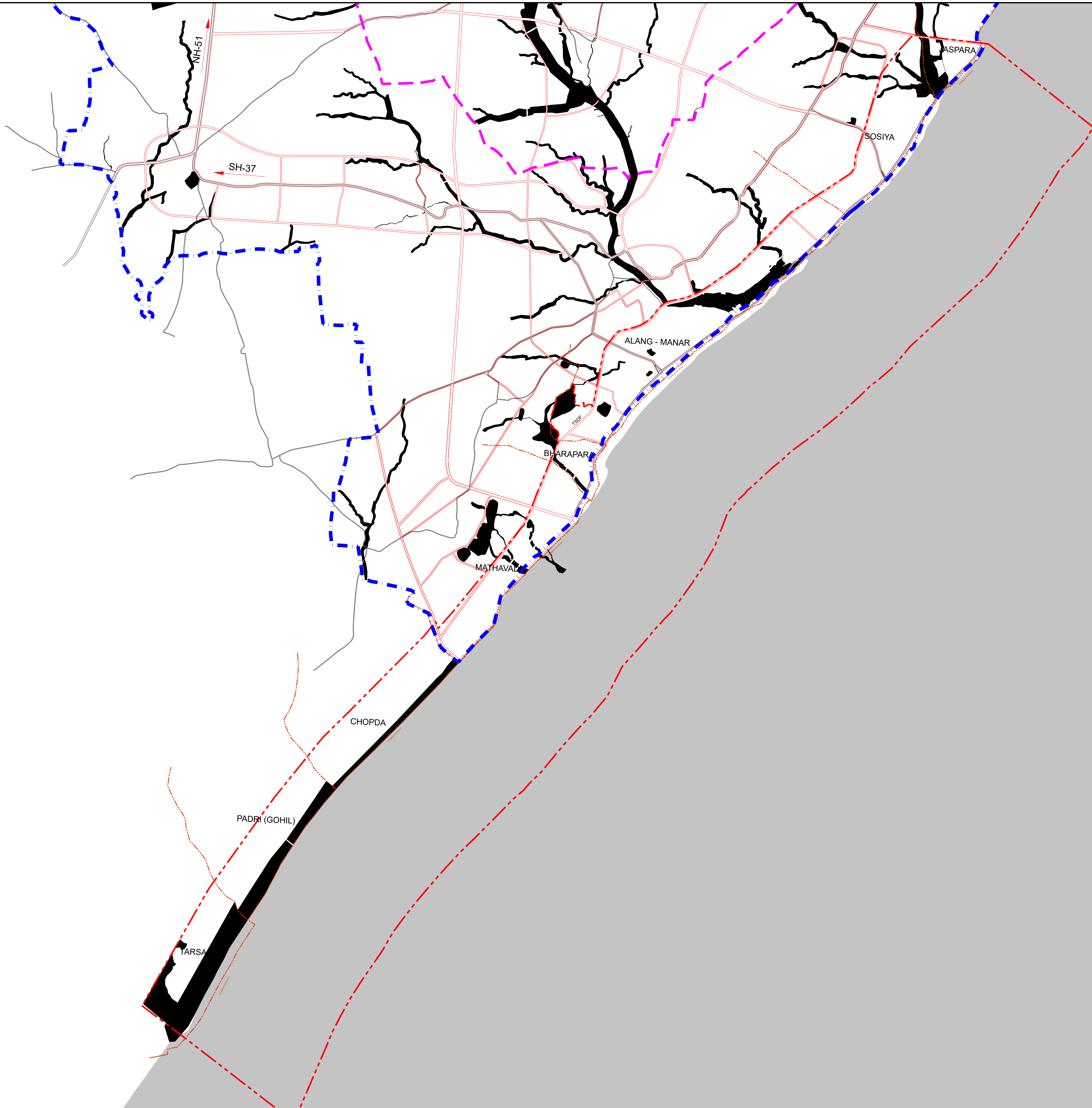
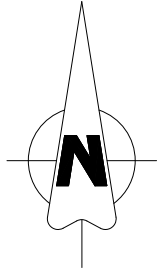
- LEGEND :-
- Masterplan Boundary
 - Study Area Boundary
 - AADA Boundary
 - Taluka Boundary
 - Village Boundary
 - Existing Road
 - River
 - Natural Drain / Pond
 - Canal
 - High Tide Line

- Land Ownership
- Government Land
 - GMB Land
 - Mix of Government and Private Land
 - Private Land

- Reservation Proposal
- Reserved Forest Area

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	26.11.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard					
Drawing title					
MASTERPLAN BOUNDARY (BASE MAP)					
Drawing status					
Scale					
1:30,000 (S.A1)					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-009					
This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.					
Rev					A1



NOTES :-

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3. All levels are related to chart datum (+0.0m).

LEGEND :-

- Masterplan Boundary
- Unsuitable Areas for Development
- Arabian Sea
- Existing Roads
- Proposed DP Roads
- AADA Boundary
- Taluka Boundary
- Village Boundary

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved



Client

Gujarat Maritime Board (GMB)

Project

Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

Drawing title

LAND SUITABILITY MAP

Drawing status

Scale 1:30,000 (g. A1)

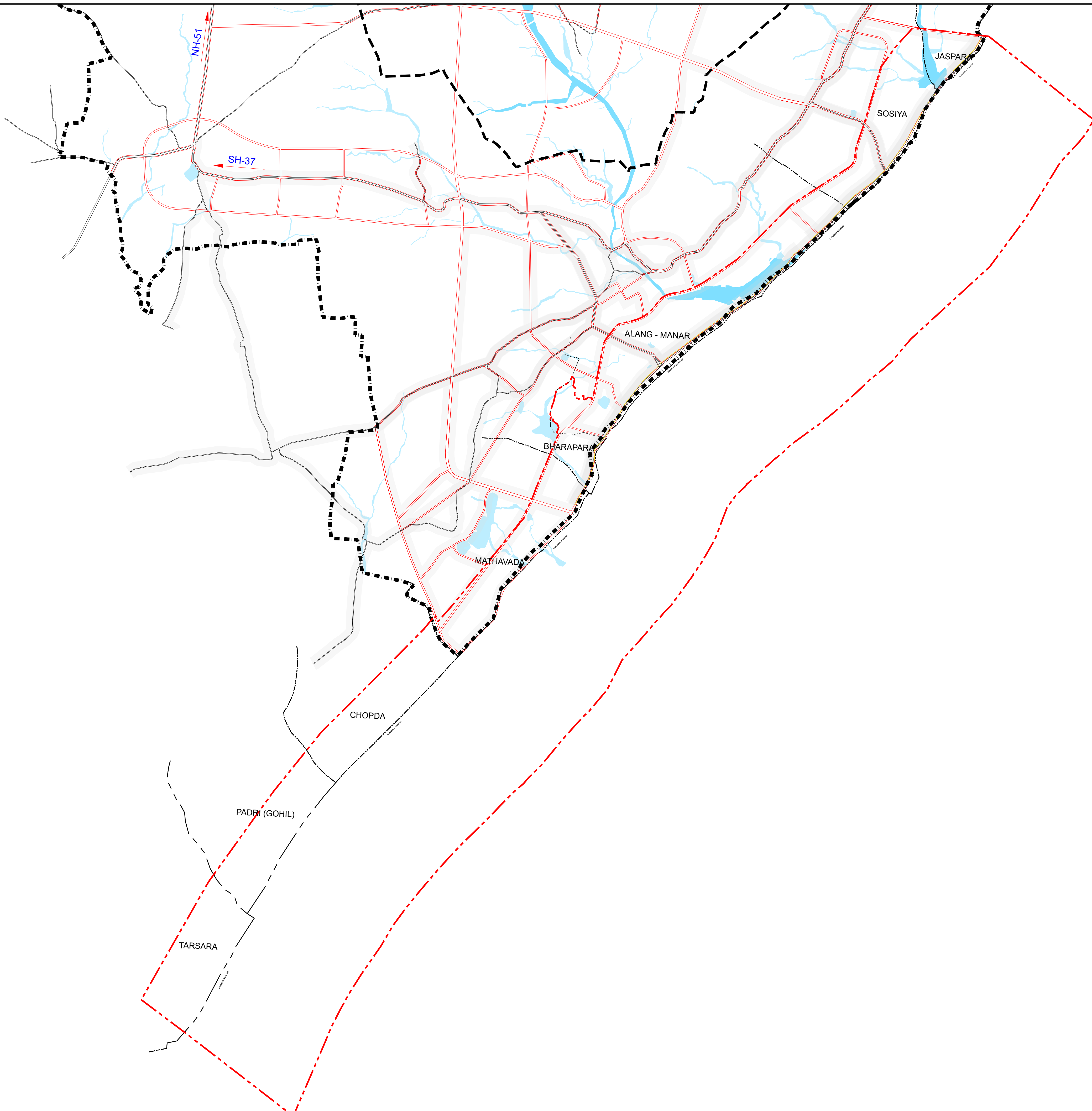
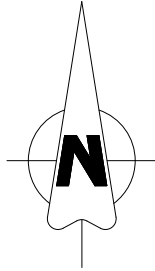
Do not scale

Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-009A

Rev A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



NOTES :-

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3. All levels are related to chart datum (+0.0m).

LEGEND :-

- AADA Boundary
- Taluka Boundary
- Village Boundary
- Blue River
- Light Blue Natural Drain / Pond
- Blue Canal
- Grey Existing Roads (100m buffer)
- Red Proposed DP Roads (100m buffer)
- Yellow Existing Ship Recycling Plots Stretch (150m buffer)
- Light Grey Development Suitability Boundary

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved



Client

Gujarat Maritime Board (GMB)

Project

Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

Drawing title

LAND POTENTIALITY MAP

Drawing status

Scale 1:30,000 (p. A1)

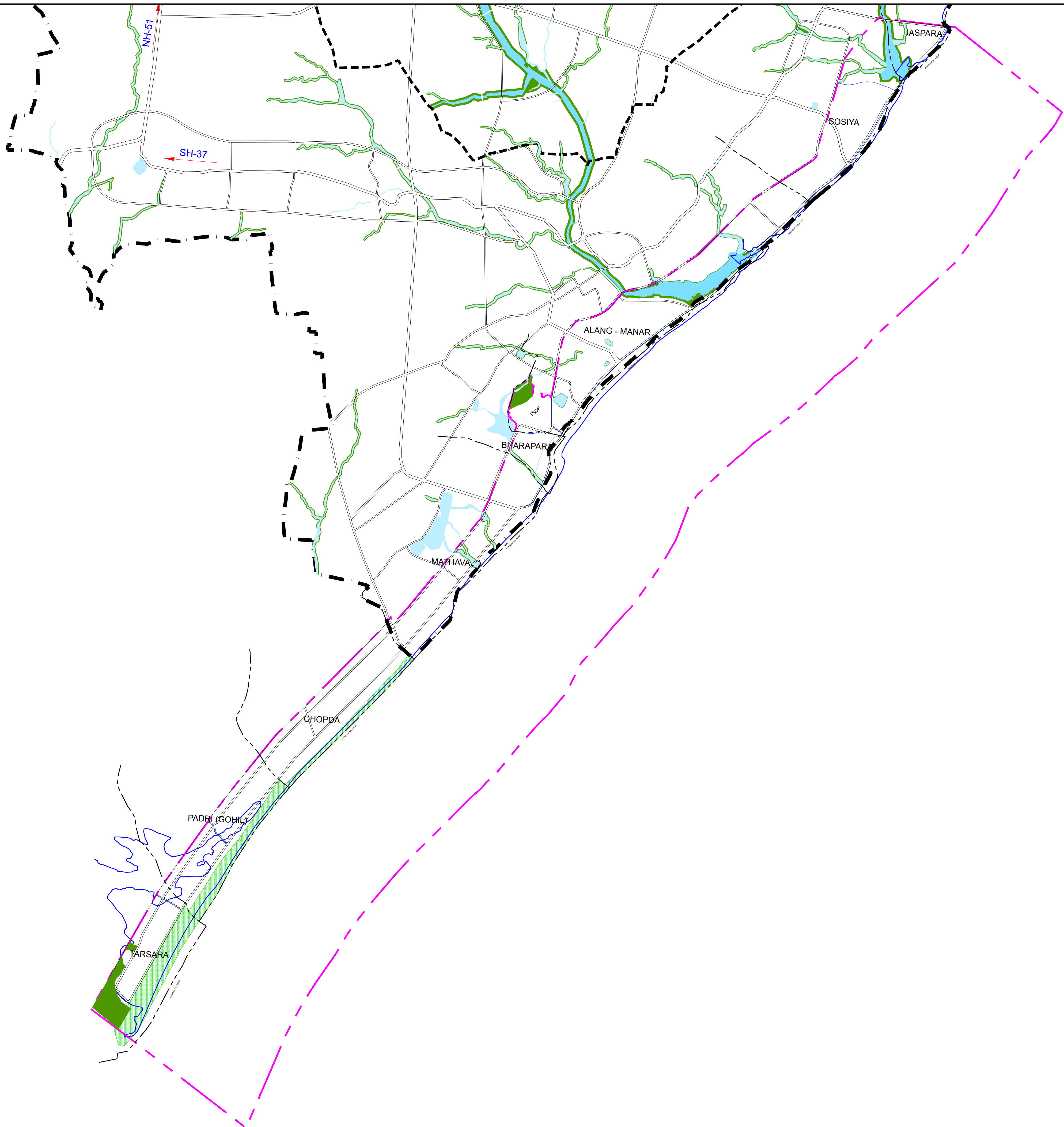
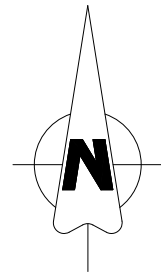
Do not scale

Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-009B

Rev
A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



NOTES :-

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3. All levels are related to chart datum (+0.0m).

LEGEND :-

- Masterplan Boundary
- AADA Boundary
- Taluka Boundary
- Village Boundary
- River
- Natural Drain / Pond
- Canal
- High Tide Line (HTL)

Reservation Proposal :-

- Reserved Forest Area
- Restricted Green Buffer

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved



Client

Gujarat Maritime Board (GMB)

Project

Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

Drawing title

ECO SENSITIVITY MAP

Drawing status

Scale 1:30,000 (g. A1)

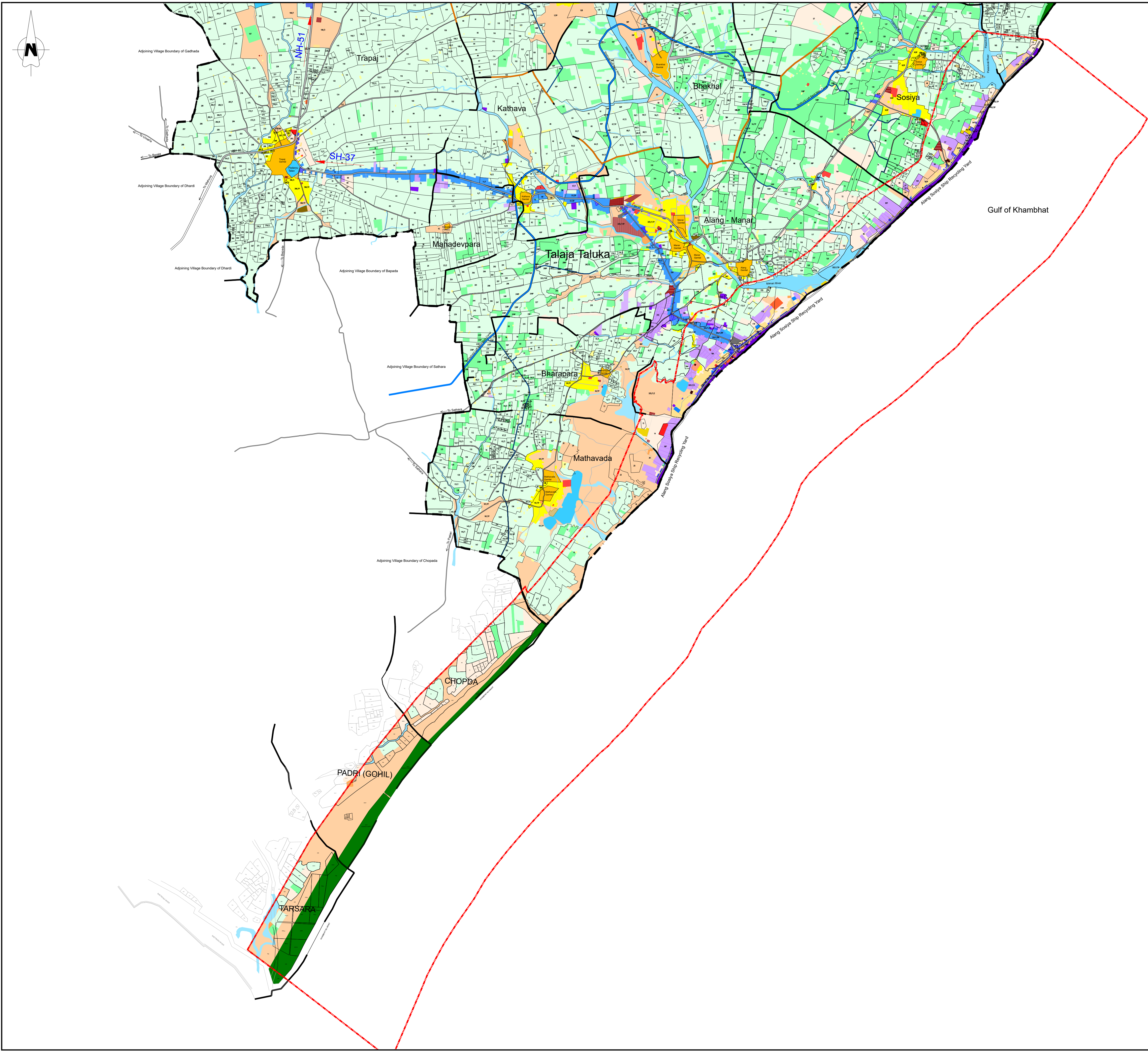
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-009C

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.

Rev

A1



- NOTES :-
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 3. All levels are related to chart datum (+0.0m).

Land Use

- Residential**
- Gamtal
 - Residential General
 - Residential Agriculture
 - Residential Labour Housing
 - Slum

- Commercial**
- Commercial General
 - Commercial Khadas
 - Godown / Storage
 - Garage
 - Petrol Pumps / Gas Station
 - Hotels / Lodges
 - Cinema Hall
 - Aashram / Trust
 - Brick Kiln

- Public Offices**
- Government and Semi Government Offices

- Industrial**
- Ship Recycling Unit
 - Scrap Processing Unit
 - Oxygen Plant
 - Oil Processing Unit
 - Steel Re-rolling Unit
 - Agro Industries

- Education**
- Anganwadi
 - Primary School
 - Secondary School
 - Professional Training College

- Health**
- Primary Health Centre
 - Hospitals
 - Dispensary / Clinic

- Religious**
- Temple
 - Mosque / Dargah

- Utilities and Services**
- Electric Main / Sub Station
 - Telephone Exchange / Tower
 - Water Pumping Station / OHT / Sump
 - Water Stands, Washing / Bathing Platform
 - Police Station/ Chowki
 - Fire Station
 - Post office
 - Landfill Site
 - Public Toilets

Cremation and Burial Ground

- Cremation Ground
- Graveyard

Legend

- ADA Boundary
- Taluka Boundary
- Village Boundary
- Existing Road

Transport

- Roads
- Cart Track / Kutchra road
- Bus Stop
- Truck Parking

Agriculture

- Agriculture
- Plantation

Water Bodies

- River
- Rivelutes / natural drains / vorka
- Pond / Tank
- Canal

Waste Land

-

Vacant Land

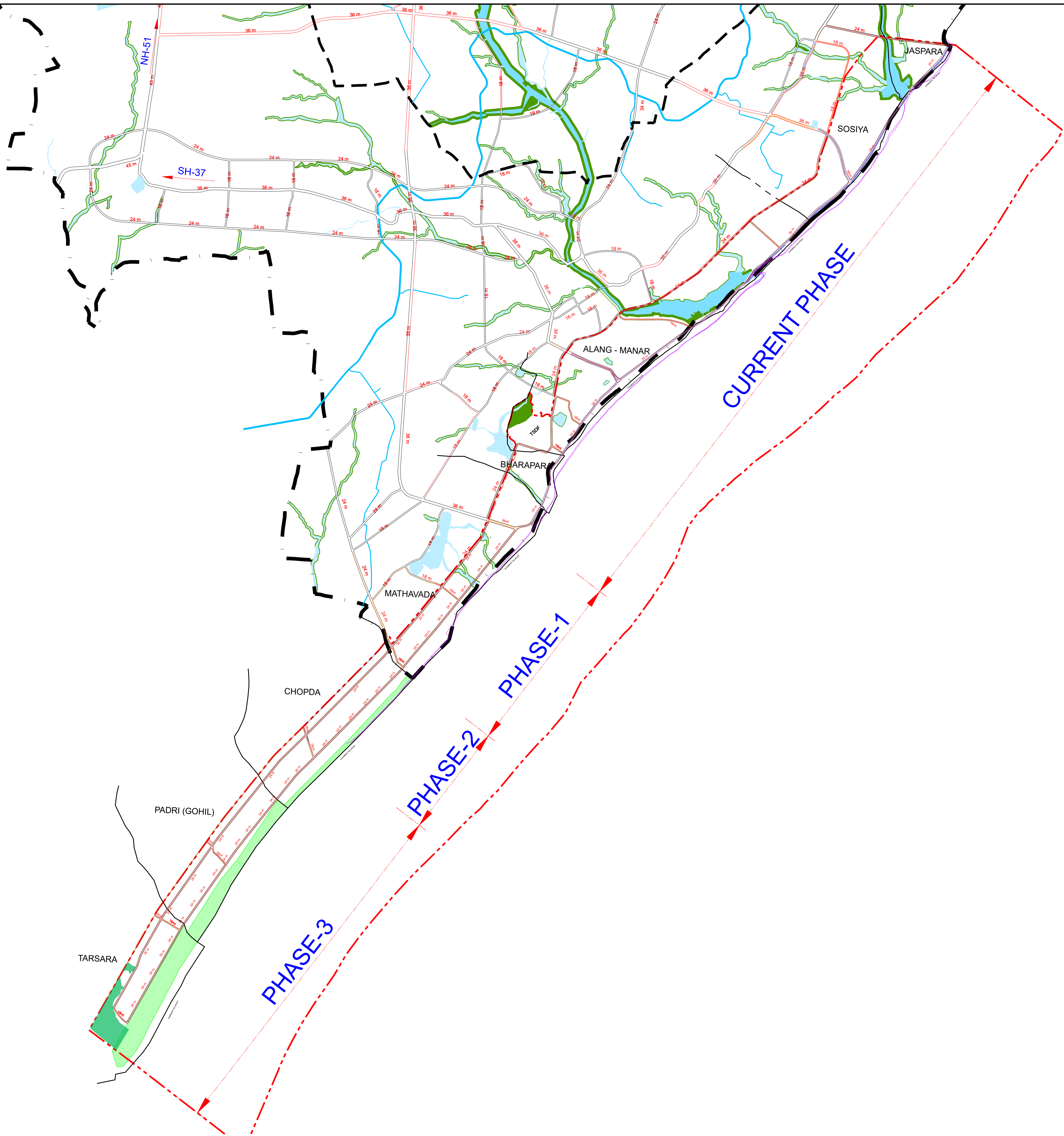
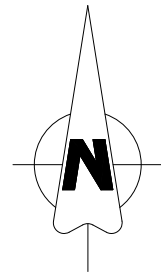
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Forest

-

FOR FINAL REPORT

AD	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved
Merizen					
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard					
Drawing title					
EXISTING LANDUSE MAP					
Drawing status					
Scale					
1:30,000 (S.A.)					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-009D					
This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.					



NOTES :-

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3. All levels are related to chart datum (+0.0m).

LEGEND :-

- Masterplan Boundary
- AADA Boundary
- Taluka Boundary
- Village Boundary
- River
- Natural Drain / Pond
- Canal

Reservation Proposal :-

- Reserved Forest Area
- Restricted Green Buffer

Road Proposal :-

- Existing Road
- Proposed Master Plan Road
- Proposed 18 M Road Center Line
- Proposed 24 M Road Center Line
- Proposed 36 M Road Center Line

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
AD	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved



Client
Gujarat Maritime Board (GMB)

Project
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard

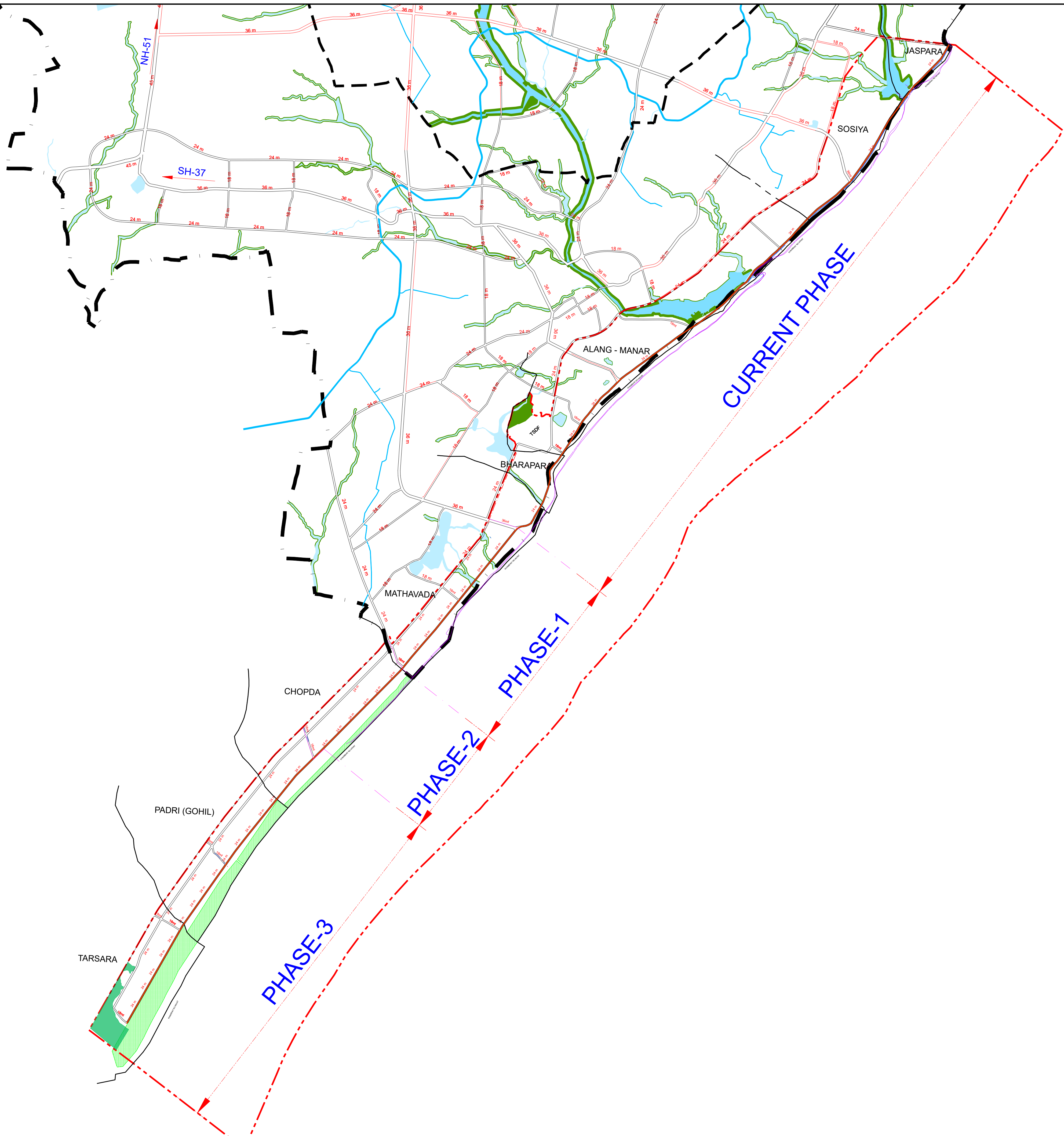
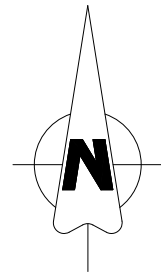
Drawing title
-
PROPOSED ROAD NETWORK
-

Drawing status
Scale
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-010

A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



NOTES :-

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3. All levels are related to chart datum (+0.0m).

LEGEND :-

- Masterplan Boundary
- AADA Boundary
- Taluka Boundary
- Village Boundary
- River
- Natural Drain / Pond
- Canal

Reservation Proposal :-

- Reserved Forest Area
- Restricted Green Buffer

Network Proposal :-

- Proposed Road Network
- Proposed Public Transport Network

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Propose of revision	Drawn	Checked	Approved



Client
Gujarat Maritime Board (GMB)

Project
Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard

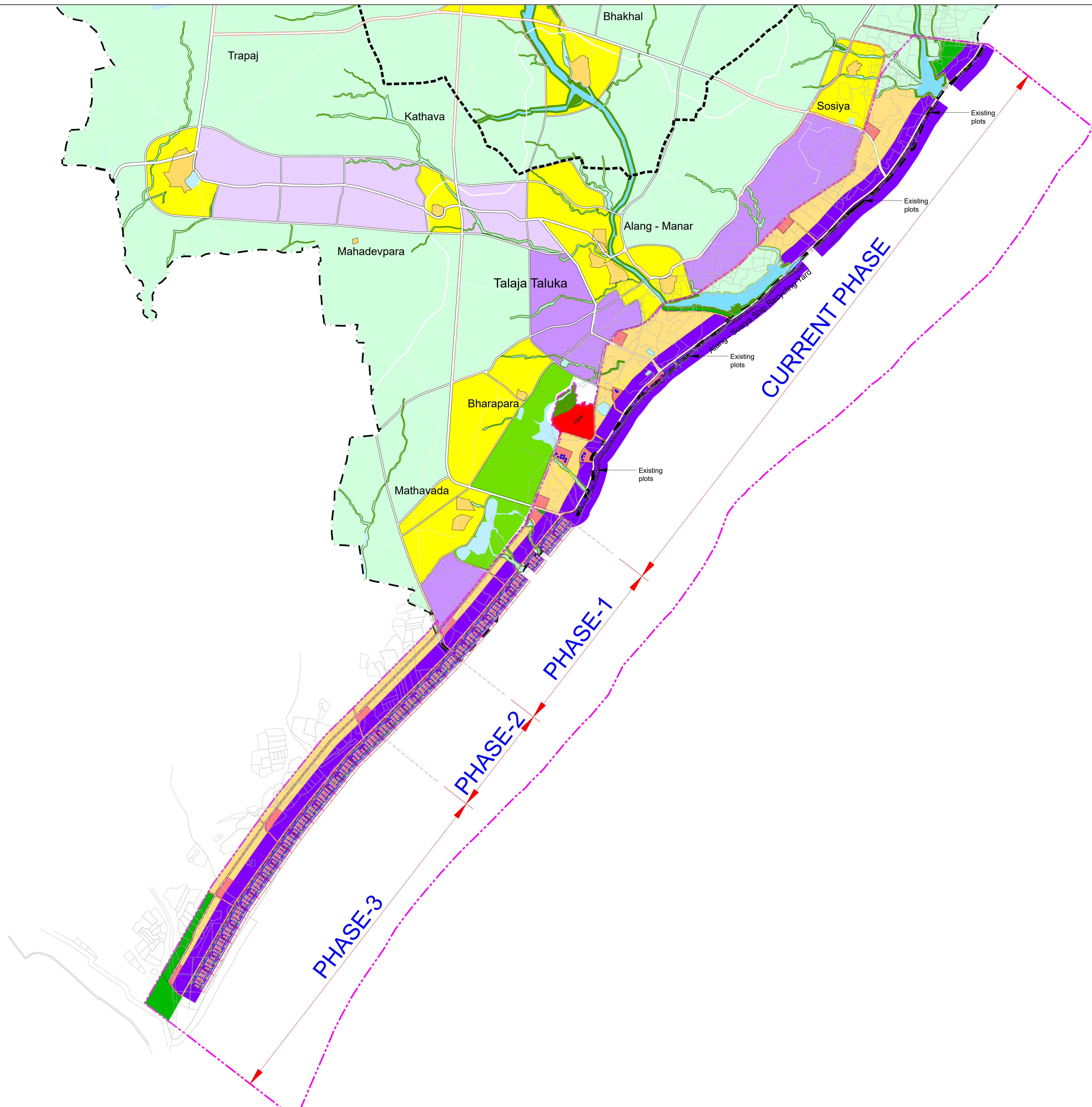
Drawing title
PUBLIC TRANSPORT NETWORK

Drawing status
Scale
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-011

A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



- NOTES :-
1. All dimensions and levels are in meter unless noted otherwise.
 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).

- LEGEND :-
- Masterplan Boundary
 - AADA Boundary
 - Taluka Boundary
 - Village Boundary
 - River
 - Natural Drain / Pond
 - Canal

- Reservation Proposal :-
- Reserved Forest Area
 - Restricted Green Buffer

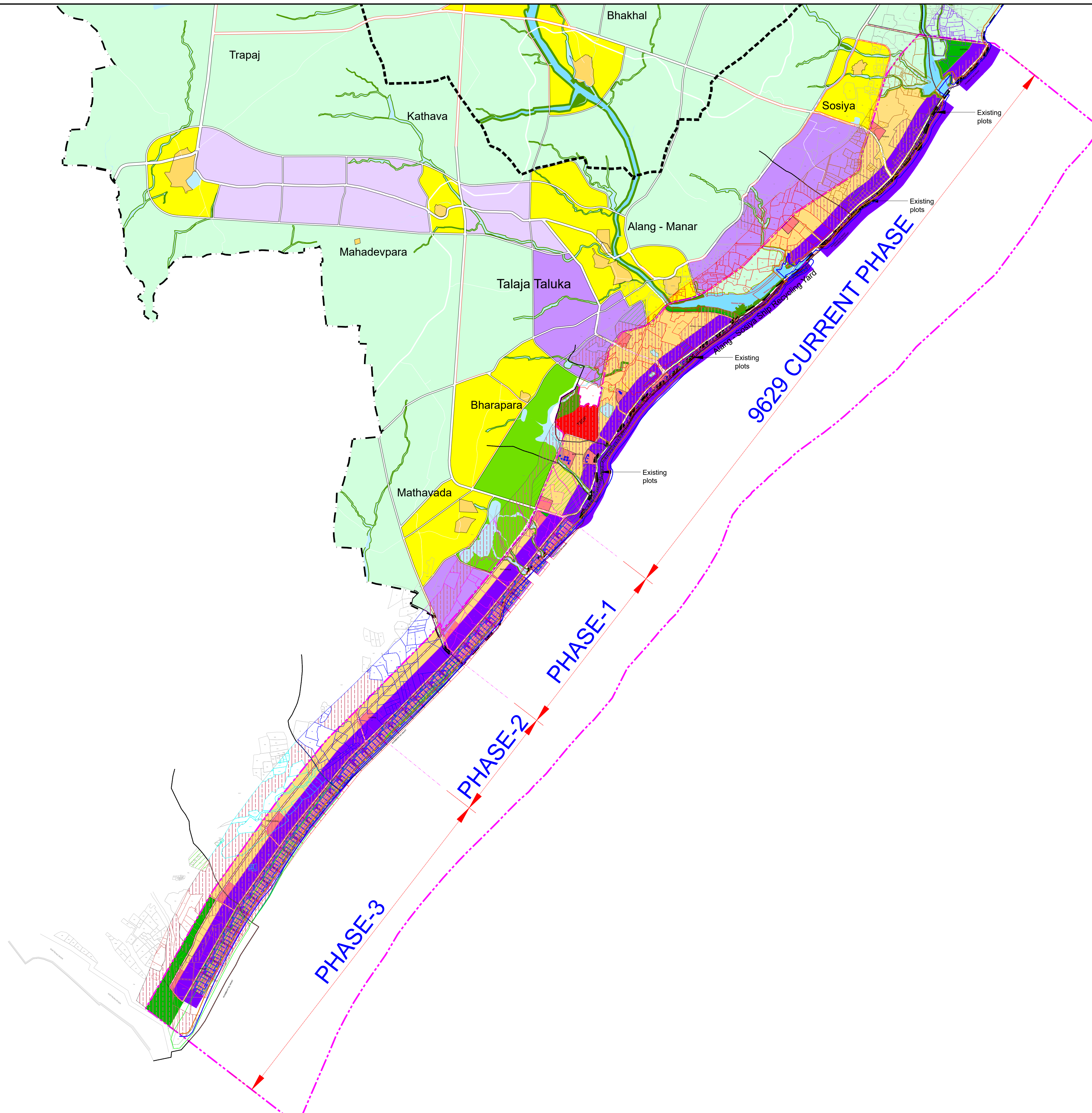
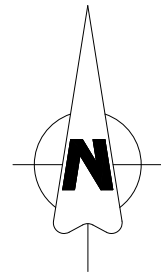
- Road Proposal :-
- Proposed Master Plan Road

- DP Proposed Zones :-
- Residential - A
 - Residential - B
 - Industrial - A
 - Industrial - B
 - Mixed Industrial
 - Recreational
 - Agriculture

- Masterplan Proposed Zones :-
- Industrial - A / Ship Recycling Zone
 - Industrial - B (IZ6) / Scrap Market
 - Mixed Industrial Use (IZ7)

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard					
Drawing title					
PROPOSED ZONING WITH ROAD NETWORK					
Drawing status					
Scale					
1:30,000 (S.A.)					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-012					
This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.					



NOTES :-

1. All dimensions and levels are in meter unless noted otherwise.
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3. All levels are related to chart datum (+0.0m).

LEGEND :-

- Masterplan Boundary
- AADA Boundary
- Taluka Boundary
- Village Boundary
- River
- Natural Drain / Pond
- Canal
- High Tide Line (HTL)
- 50 Yards from High Tide Line (HTL)

Reservation Proposal :-

- Reserved Forest Area
- Restricted Green Buffer

Road Proposal :-

- Proposed Master Plan Road

DP Proposed Zones :-

- Residential - A
- Residential - B
- Industrial - A
- Industrial - B
- Mixed Industrial
- Recreational
- Agriculture

Masterplan Proposed Zones :-

- Industrial - A / Ship Recycling Zone
- Industrial - B (IZ6) / Scrap Market
- Mixed Industrial Use (IZ7)

Land Ownership :-

- Government Land
- GMB Land
- Mix of Government and Private Land
- Private Land

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	APJ	UP	TK
	Date		Drawn	Checked	Approved

Client

Gujarat Maritime Board (GMB)

Project

Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard

Drawing title

IMPLEMENTATION PLAN

Drawing status

Scale

1:10,000 (G.A1)

Do not scale

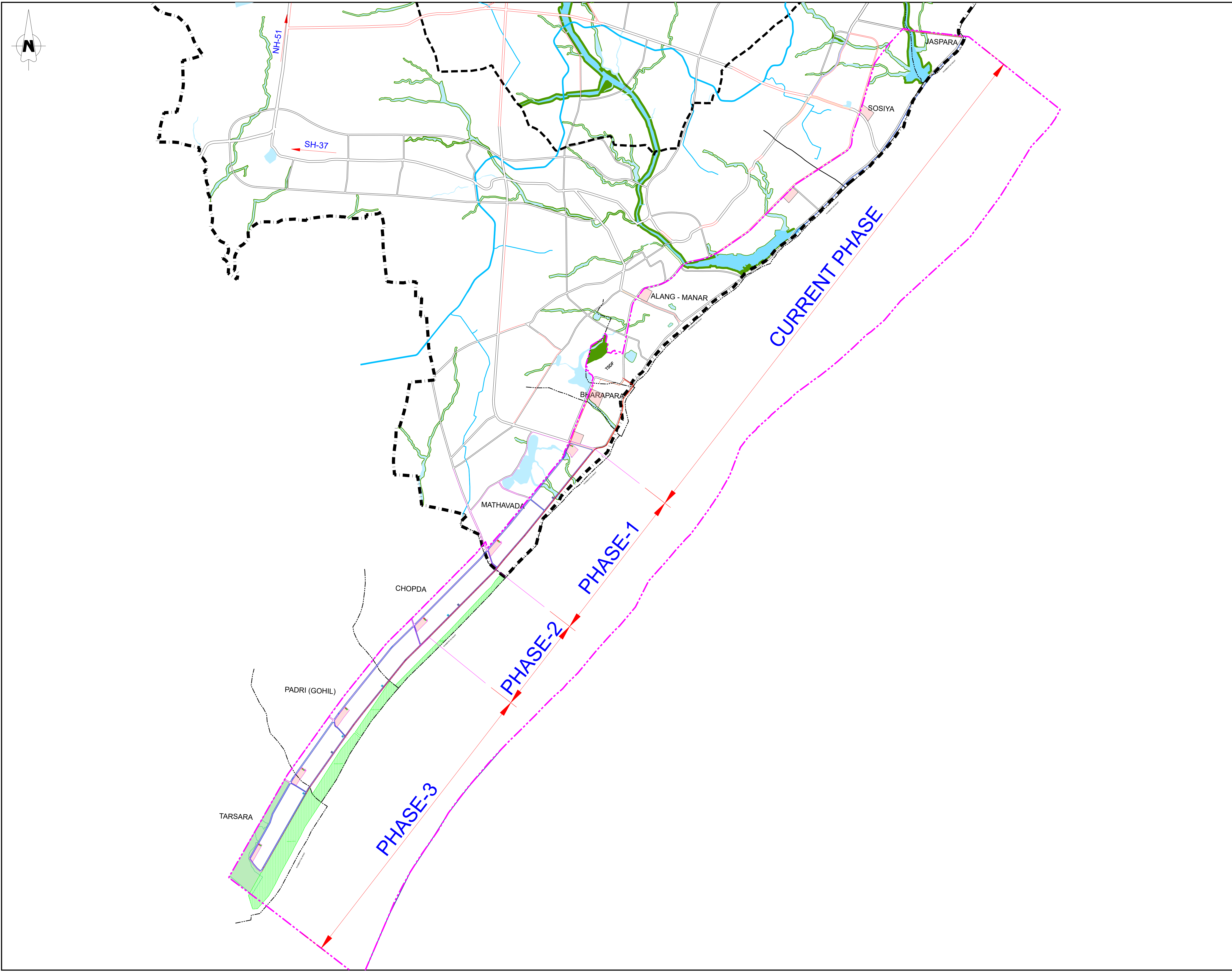
Drawing number

MERIZEN-1541-GMB-ALANG-FINAL-DWG-013

Rev

A1

This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.



- NOTES :-
1. All dimensions and levels are in meter unless noted otherwise.
 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).

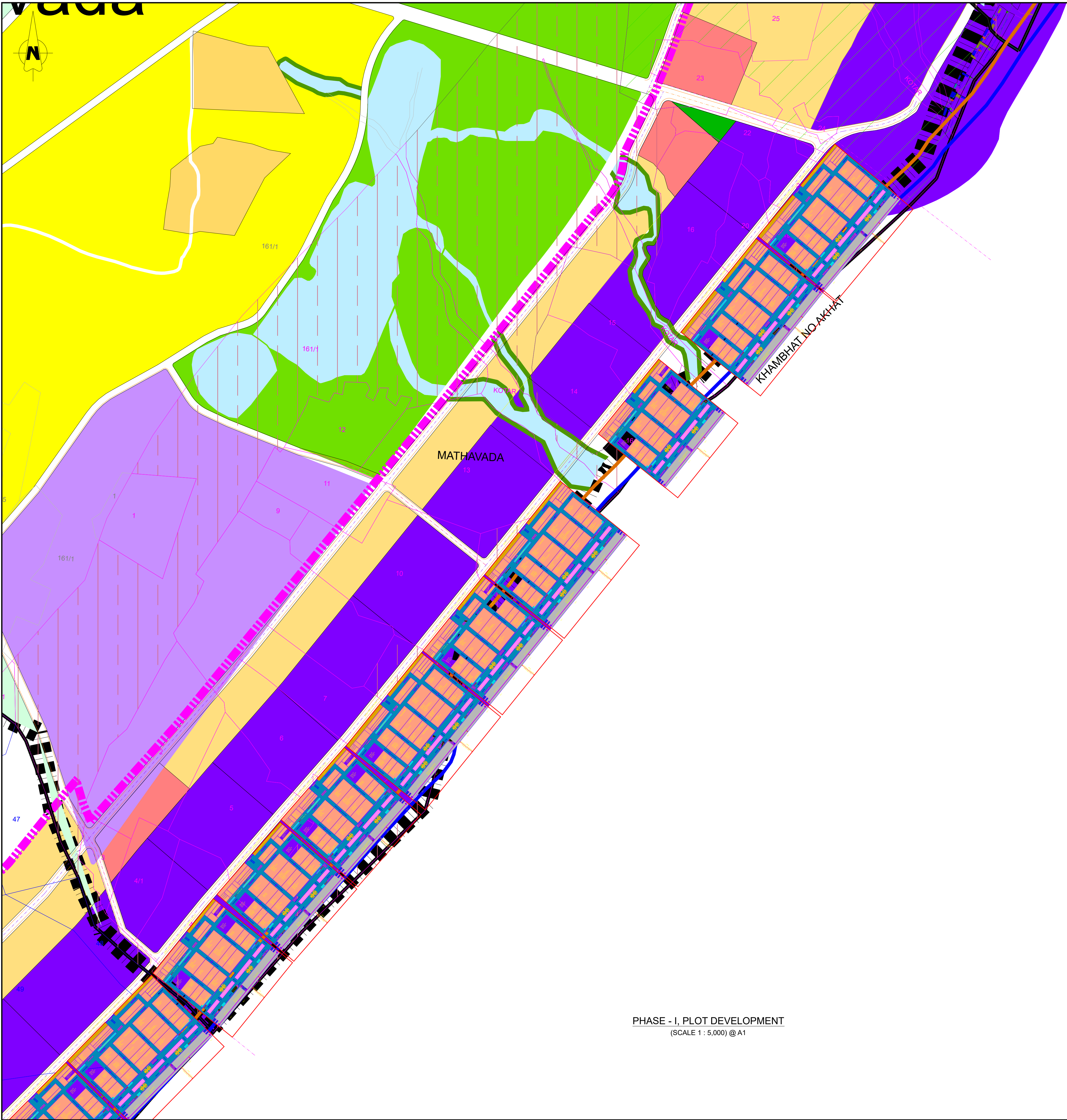
- LEGEND :-
- Masterplan Boundary
 - AADA Boundary
 - Taluka Boundary
 - Village Boundary
 - River
 - Natural Drain / Pond
 - Canal

- Reservation Proposal :-
- Reserved Forest Area
 - Restricted Green Buffer

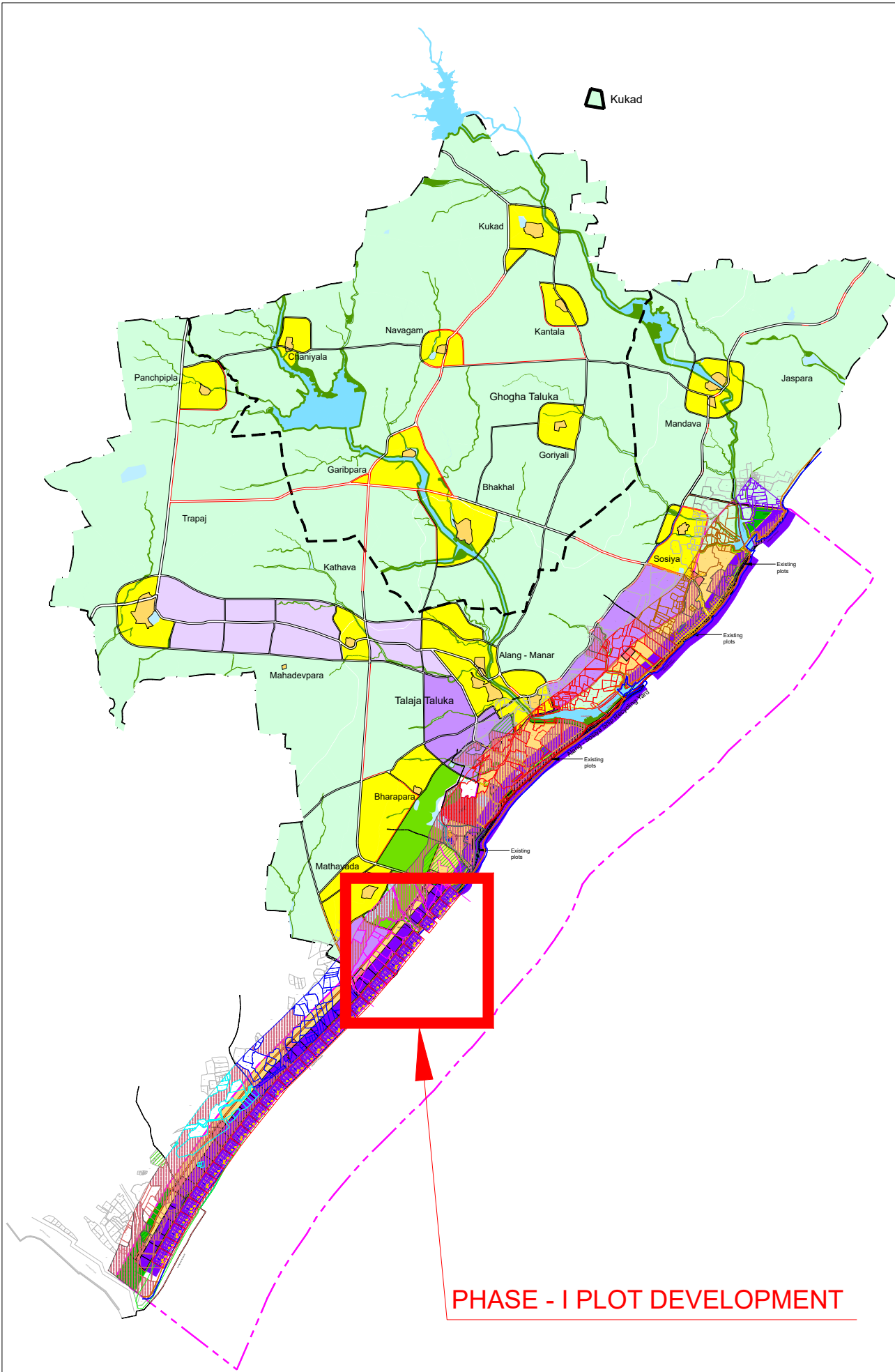
- Proposed Infrastructure :-
- STP PLANT
 - WATER SUPPLY TANK
 - WATER SUPPLY TANK
 - SUB-STATION
 - MANHOLE
 - CONTAMINATED OIL STORAGE TANK
 - ELE. CABLE DUCT
 - SEWERAGE LINE
 - STORM WATER DRAIN
 - WATER SUPPLY LINE
 - CONTAMINATED WATER TRANSFER LINE
 - GAS SUPPLY LINE

FOR FINAL REPORT

A1	20.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
AD	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Sosiya Ship Recycling Yard					
Drawing title					
WATER SUPPLY, SEWERAGE, STORMWATER AND ELECTRICAL NETWORK MAP					
Drawing status					
-					
Scale					
1:30,000 (S.A1)					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-014					
This drawing is not to be used in whole or part other than for the intended purpose and project as defined on the drawing. Refer to the contract for full terms and conditions.					



PHASE - I, PLOT DEVELOPMENT
(SCALE 1 : 5,000) @ A1



KEY PLAN
(SCALE 1 : 1,00,000) @ A1

- NOTES :-
1. All dimensions and levels are in meter unless noted otherwise.
 2. This drawing should not be scaled. Only written dimensions should be followed.
 3. All levels are related to chart datum (+0.0m).

- LEGEND :-
- Masterplan Boundary
 - AADA Boundary
 - Taluka Boundary
 - Village Boundary
 - River
 - Natural Drain / Pond
 - Canal
 - High Tide Line (HTL)
 - 50 Yards from High Tide Line (HTL)

- Reservation Proposal :-
- Reserved Forest Area
 - Restricted Green Buffer

- Road Proposal :-
- Proposed Master Plan Road

- DP Proposed Zones :-
- Residential - A
 - Residential - B
 - Industrial - A
 - Industrial - B
 - Mixed Industrial
 - Recreational
 - Agriculture

- Masterplan Proposed Zones :-
- Industrial - A / Ship Recycling Zone
 - Industrial - B (IZ6) / Scrap Market
 - Mixed Industrial Use (IZ7)

- Land Ownership :-
- Government Land
 - GMB Land
 - Mix of Government and Private Land
 - Private Land

FOR FINAL REPORT

A1	06.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
AD	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision	Purpose of revision	Drawn	Checked	Approved
Client					
Gujarat Maritime Board (GMB)					
Project					
Master Planning for Capacity Enhancement and Expansion of Alang Soshiya Ship Recycling Yard					
Drawing title					
PROPOSED PLOT DEVELOPMENT					
PHASE - I					
Drawing status					
Scale					
Drawing number					
MERIZEN-1541-GMB-ALANG-FINAL-DWG-015					
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1. All dimensions and levels are in meter unless noted otherwise.
2. This drawing should not be scaled. Only written dimensions should be followed.
3. All levels are related to chart datum (+0.0m).

	Masterplan Boundary
	AADA Boundary
	Taluka Boundary
	Village Boundary
	River
	Natural Drain / Pond
	Canal

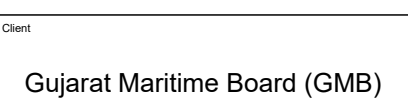
Proposed Master Plan Road

	Residential - A
	Residential - B
	Industrial - A
	Industrial - B
	Mixed Industrial
	Recreational
	Agriculture

- Scrap Yard Zone
- Backup Yard Zone
- Ship Recycling Plot
- Dredging Area

FOR FINAL REPORT

A1	08.02.2026	ISSUED WITH FINAL REPORT	APJ	UP	TK
A0	01.12.2025	ISSUED WITH FINAL REPORT	APJ	UP	TK
Rev	Revision Date	Purpose of revision	Drawn	Checked	Approved



Project
Master Planning for Capacity Enhancement and
Expansion of Alang Sosiya Ship Recycling Yard

CONTOURS FOR EARTHWORK EXCAVATION AND DREDGING MAP

Drawing status

Scale	1: 17,000 (B.A.1)	Do not scale
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Drawing number		
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MERIZEN-1541-GMB-ALANG-FINAL-DWG-016

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