

# **Delineation of high tide line and seasonal beach profiling at Kalbadevi bay, Maharashtra, Central west coast of India**

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# **Delineation of high tide line and seasonal beach profiling at Kalbadevi bay, Maharashtra, Central west coast of India**

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## **ABSTRACT**

Seasonal morphological variations and effect of oceanographic processes such as erosion or accretion along beaches are important to understand the nature of the beach and the cyclic changes occurring during different seasons. These studies are more significant in the areas where rich beach placer deposits are occurring. This will help in understanding repletion of these heavy minerals in the area of interest. This report describes results of similar studies ( high tide line changes and beach profiling) carried out at Kalbadevi bay which is in Maharashtra along central west coast of India. Kalbadevi bay is one of the most important prospective area for the occurrence of heavy mineral placers rich in Ilmenite and Magnite. Several techniques are available for collecting these data using different instruments. The required data were collected by using highly sophisticated instruments like Laser Trak, DGPS (Differential Global Positioning System), Automatic level (Carl Zeiss make) and Wild T-2 Theodolite, following the standard survey techniques. The collected field data was processed using the software “ Conversion of Laser Trak raw data to obtain the final UTM co-ordinates” (Ganeshan, P. 2003). Beach profiles at three sites in Kalbadevi bay has clearly shown the specific zones of sand erosion and sand accumulation at various periods. Natural morphological beach features such as the erosional scarp and vegetation line accurately reflect the positions of maximum high water levels and the berm crust reflects the positions of frequent ordinary high water levels. This report analyses the field data collected at different seasons at Kalbadevi bay and presents the results of the field observations with

final processed high tide line maps and beach profiles. The report also highlights the method involved and the instruments used in collection of the field data.

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## 1.0 Introduction

Shoreline changes and beach profile studies of beaches give ample information on cyclic/seasonal changes of the study area. These studies are essential to understand the erosional, depositional features which in turn helps in understanding changes in oceanographic processes in the coastal areas. The areas store high concentrations and detrital minerals is present like placer sand and which is likely to be exploited in the near future. The above studies became more important to understand the replenishment of surficial mineral layers. Several techniques are available for collecting such data using different instruments. For scientists who are working along the coast, the most common shoreline is the one which was derived from aerial photographs or from remote sensing maps of that area, which has the instantaneous high water line separating the wet beach from the dry beach. However, more than two decades of beach surveys and field observations have demonstrated clearly that the high tide line shown on the aerial photography or on remote sensing maps, are highly dynamic and hence less reliable indicators of shoreline position (Robert A. Morton et al., 1999). The present report analyses the results of high tide line changes and beach profiles carried out at different seasons at Kalbadevi bay of Maharashtra. The data was collected using the following instruments:

1) Laser Trak, Make: MD Instruments,U.K.

Accuracy  $\pm$  20 cms. (High Accuracy option, + 1 cm.)

Resolution : 0.1 meter.

Range – Standard Class I :100 m. (non-reflective targets)

: 1500 m. (with single prism reflector)

:5000m.(withmulti-prism reflector) Range accuracy :  $\pm$  5 cms.

Horizontal and Vertical angles

Accuracy : 0.01 degs.

Resolution : 0 degs. to 360 degs.

2) DGPS : Make: Seeducer DGPS with RTCM corrections.

Accuracy : < 1 meter.

3) Automatic Level : Make: Carl Zeiss

Accuracy :  $\pm 5$  mm.

4) Wild T-2 Theodolite : Make:

Accuracy:  $\pm 0.02$  seconds.

The collected data was processed using the software “ Conversion of Laser Trak raw data to obtain the final UTM co-ordinates” (Ganeshan, P. 2003).

As a part of CSIR network project, “Capacity Building for Beach Placer mining”, the area along Kalbadevi bay of central west coast of India, is selected as a prospective zone for future exploitation. To study the environmental impact assessment (EIA) of this exploitation, three field seasons were undertaken along Kalbadevi beach.

## **2.0 Description and scope of the study**

Under the CSIR network project on “Beach placer mining capacity building”, NIO has identified Kalbadevi Bay in Maharashtra along central west coast of India, as a potential site for placer mining in future. Kalbadevi stretch is 5.5 kms. long and ~250 m. wide, with estuaries on both northern and southern ends of the bay. One of the main objectives of this project was to understand the environmental conditions in the areas of potential deposits and to prepare an environmental management plan. During the period from February 2004 to September 2004, to meet the requirements of the project, the following studies were conducted at Kalbadevi bay (from survey point of view) in three phases.

- i) Shoreline identification and demarcation of high tide line
- ii) Establishing permanent bench marks at three for carrying out beach profiles and
- iii) Beach profile studies with collection of raw data.

In order to improve the reliability and accuracy of data, the field survey procedures were adopted following the standard surveying techniques.

This study addresses the issue of short term fluctuations in shoreline position that currently is present in the data sets, even though by negligible measure.

The main need for preparation of this report is to compare the shorelines and beach profiles done at different periods. The report also highlights the method of survey and the technical aspects involved including final processed data output.

### **3.0 Methodology**

Comprehensive studies for a coastal development and management require the detailed information on the high tide line and low tide line. The first step in such a study is to collect the physical portion of high tide line and low tide line.

#### **3.1 Demarcation of high tide line**

**i) Horizontal control:** The horizontal location of the base line co-ordinates were fixed by Trimble DGPS (Differential Global Positioning System) and the extension of the base line co-ordinates, using DGPS, Wild T-2 Theodolite and Laser Trak. The horizontal control of all the HTL marks were then obtained using Laser Trak optical instrument, from the base line positions.

**ii) Vertical control:** The vertical control is essential to provide the height information for contours and spot heights in topographical mapping. For this purpose, the Tide pole, Automatic level with staff and leveling shoes, Marker line and Tide table can be used.

**.iii) Information :** The following information's were collected in the field: The basic data on morphological variations description, ground survey and sediment samples, wind driven water circulation, environmental cut and fill (current wave and long shore current), vegetation stabilization, berm crest, crest of wash over terraces and coastal structures.

The wet/dry boundary observed from the available base map of CRZ may be used for the first approximation of HTL position. However, for the final confirmation, the highest range of spring tide and its horizontal run up on the land should be identified by way of morphological features; permanent vegetation line and flotsam as per the existing guide lines of the Ministry of Environment. The seasonal cyclicality of beach changes could also result in a bias, in positioning of high tide line. The preferred approach would be to conduct the seasonal studies to confirm and re-describe the overall high tide line changes, estimation of the rates of changes and the shoreline stability in the future. As the high water line is ambulatory in nature, due to

environmental conditions, long time evolution is of prime importance for ascertaining the effect of level changes on erosion and erosion of beach material by short period seas versus accretion by longer period swells.

Demarcation of HTL was carried out by using Laser trak, an optical instrument which measures distance from base station to HTL marks, horizontal angle and vertical angle.

As a regular practice, the calibration of all the survey instruments has to be carried out before commencing the actual survey, to eliminate all types of errors, while collecting the raw data. The base line co-ordinates "A" and "B" were very precisely obtained using Trimble DGPS (Differential Global Positioning System), which forms the main base line co-ordinates, for the shoreline surveys. Using the base line positions, the extension of reference points were carried out throughout the survey stretch, using Wild T-2 Theodolite. Then the field data was collected systematically using LaserTrak (MK III model) by sighting the multi-prism kept over carefully identified HTL (High Tide Line) marks.

A Program "Conversion of LaserTrak raw data to obtain final UTM co-ordinates" which was individually generated by the author (Ganeshan, P., 2003) was used for obtaining the final corrected output values. The final corrected HTL positions were used for preparation of final charts (Fig :4) using HP Plotter.

### **3.2 Equipment used**

#### **Trimble DGPS (Differential Global Positioning System)**

A Trimble make DGPS, Series 4000 receiver was used for obtaining the geographical co-ordinates (Horizontal control) of the base stations, to extreme precision.. This instrument can perform the most precise static surveying and also, the slowest. After setting up the instrument on the base station, it requires observations of atleast four satellites for a period of about 60 minutes. There are two types of static surveys : single and dual frequency. Single-frequency static surveys are appropriate for surveys with base lines shorter than about 15 kms, under good atmospheric conditions. They yield base lines, that are precise to better than + 2cms + 2ppm. Dual-frequency static surveys are required to ensure accurate results in geodetic control surveys, with base lines upto 30 kms or more under good atmospheric conditions. They yield base lines, that are precise to better than + 5mm + 1ppm. The observation and simultaneous data logging time, recommended for

these surveys is atleast 45 minutes, during times when five or more satellites are available, or 60 minutes, during times when only four satellites are available.

### **Wild T-2 Universal Theodolite**

A wild T2 Universal theodolite with automatic index can be used for the extension survey. This instrument is extremely useful for extending the base stations from the main grid to convenient nearshore locations, by carrying out Triangulation surveys. The least count of this instrument (while measuring horizontal and vertical angles) is 0.2 second. For further clarifications on its Technical specification, refer Wild T-2 Universal Theodolite operation manual, which is being issued along with the instrument.

### **Laser Trak (Optical instrument)**

The tripod mounted Laser Trak instrument, located at fixed reference points, provides fast, accurate and logistically simple positioning of high tide line locations. This instrument can also be used to get the position of survey vessels and barges, from a fixed reference location. Other applications include hydrographic surveying of lakes, rivers and harbours and precision positioning of offshore structures and construction barges. LaserTrak is an electronic instrument which measures distance by timing the passage of a light pulse fired at a target and its return. The angles are measured by optical encoders and elevation by electrolytic liquid level sensors and / or optical encoders. LaserTrak has its own integral UHF data telemetry system and has facilities to interface a gyrocompass and computer system directly via cable.

Practically, it was found that LaserTrak is one of the most reliable and useful equipment, especially for carrying out surveys to delineate the high tide line. The speed with which a survey can be performed using this instrument, makes it, an ideal equipment for these type of surveys, where vast stretch of area can be covered in a short time. Also, this instrument can be used quite effectively for carrying out beach profile surveys and bathymetric surveys at inter tidal zones from well established permanent locations, on the shore.

**Ceeducer DGPS** : Ceeducer is a small, single unit, versatile survey measuring instrument that provides GPS position as well as digital echosounder (Dual frequency) depth. This instrument has the facility of about 7.2 hours of full data logging



of position and echosounding data. It has an integrated GPS receiver, an electronic processor and data logger. The instrument can be used as a Differential GPS position fixing system also, as it has integrated differential receiver (Optional), which can receive differential base station corrections from the nearest Marine Beacon receivers. The GPS positional accuracy of this system is 2 to 3 meters using 8 channel and less than 1 meter using 12 channel with DGPS. The accuracy of the echosounding depth varies from 20 cms. to 2 cms. (L1 channel) and 2 cms. (L2 channel). The data logging is normally every 2 seconds with full position and all echosounder depths. The system has a download utility, to transfer the logged data from CEEDUCER RAM to a file on a Personal Computer.

### **3.3 Establishing Permanent bench mark pillars**

Permanent bench mark pillars were established at three places along the Kalbadevi bay, one at the northern end (BP:1), second at the center (BP:2) and the third at the southern end (BP:3). First DGPS (Differential Global Positioning System) was used for obtaining the geographical co-ordinates of all three pillars. They form the horizontal control for carrying out high tide line surveys using Laser Trak instrument. The values were obtained first in WGS-1984 datum and later was converted to Indian datum (Indian-Everest 1975). The geographical co-ordinates thus obtained are given in ***Annexure : I***

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The method adopted for establishing vertical control of all the three pillars (BP:1, BP:2 and BP:3) with respect to M.S.L., using Laser Trak and automatic level was quite successful at Kalbadevi. Laser Trak was effectively used for giving alignment and distance between successive points, while carrying out beach profiles from all the three benchmark pillars.

### **3.4 Establishing high tide line**

Demarcation of high tide line of Kalbadevi bay was carried out using Laser Trak

optical instrument during Feb. 2004 and Seeducer DGPS during May and Sept. 2004.

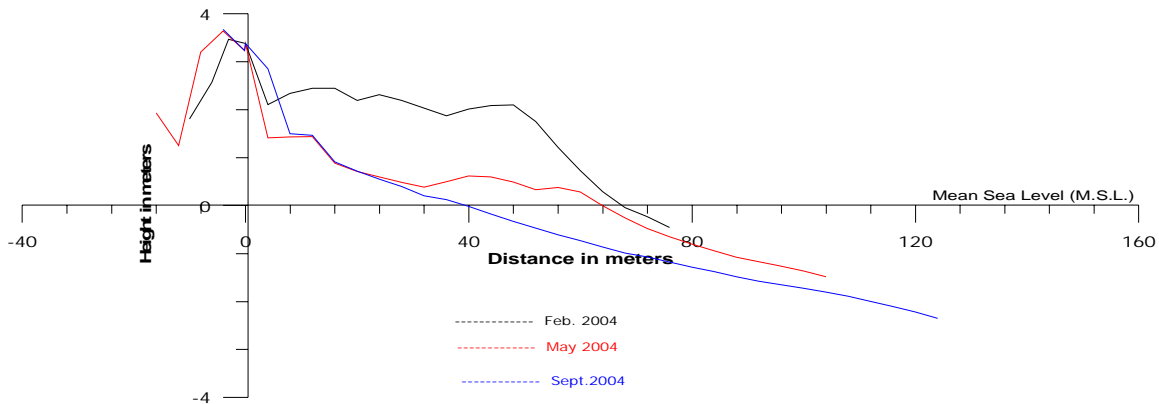
The field data thus obtained on the field is given as a sample for one period (Feb.2004)

in **Annexure : II** . High tide line was determined by physical appearance of the beach and not by vertical tidal datum technique. Vertical tidal datum technique adopted by Survey of India in 1993 in the Goa region did not yield satisfactory results as beach cyclicality (erosion and deposition) and wind driven wave data sets (specially during monsoon) were not available for the study. It was noticed that, at many places, the actual HTL was >20 meters landward from the demarcated HTL during monsoon season (Pathak, M.C., 2000 ). Therefore in such cases, what the demarcator actually delineated is the horizontal position of HTL, associated with wave run up at preceding high tides and forming geomorphic features like dune scarp, berm crest, tonal difference between wet and dry beach, below which the fore shore is smooth. In addition to above features boundary of perennial natural terrestrial vegetation, flotsam, drift wood was also considered. The identification of these markings enabled a reasonably accurate assessment of High Tide Line.

#### **4.0 Results and Discussions**

Variations in beach levels obtained represent the periodical changes occurred during pre monsoon and post monsoon periods. The beaches were found to be accreting during the survey period. Accumulation of sand or other beach material due to the natural action of waves, currents and wind Formation of prominent berm part at northern part of the Kalbadevi bay was observed. The beach width at different stations varied from 95 to 125 meters. At the middle transect, the beach had gradual slope from backshore zone upto midshore zones and later it takes a steep gradient upto low tide level.

**KALBADEVI BAY**  
**BEACH PROFILES AT BP: 1**



The comparison of beach profiles at northern transect (BP:1) clearly shows that continuous erosion is happening from Feb. 2004 to Sept. 2004 of the survey period. This erosion of land probably could be because of the action of natural forces. Comparison of pre-monsoon and post monsoon beach profiles at northern transect (at BP:1) reveal that large volume of sand had either been washed away or removed from the midshore and the foreshore areas. Volume of sand either removed or washed away per meter width of the beach at BP:1 is roughly estimated to be around 85 cu.mts., when compared from February 2004 to May 2004. And the volume of loss of sand is estimated to be around 25 cu.mts between mid tide to low tide areas when compared from May 2004 to Sept. 2004. At middle profile (at BP:2), the beach was found to be accreting from mid shore to low tide zone, when compared from Feb. 2004 to May 2004. But the surveys carried out during Sept. 2004 clearly indicate erosion at such places when compared from May 2004 to Sept. 2004. The volume of loss of sand was quite negligible, when compared from Feb.2004 to May and Sept.2004, especially from berm area to midshore area. Between midshore to foreshore area till the low tide zone, the volume of deposit of sand was roughly estimated to about 67 cu.mts when compared from Feb.2004 to May 2004. But post monsoon surveys done at Sept.2004 clearly reveals the loss of sand of about 40 cu.mts. midshore to foreshore area till low tide zone. Overall, at BP:2 no significant loss or deposit of sand was found from mid-shore area till the berm during all the three periods of observation. At southern transect (BP:3), accretion of sand was found when compared from Feb. 2004 to May 2004 between mid shore to low tide zone but there was huge erosion at this stretch between May 2004 to Sept. 2004. In general, at BP:3, only minor fluctuations were observed right from the berm to mid shore level during all the three periods of observation. About 20

cu.mts. of sand deposit was observed between mid-shore to low tide level when compared from Feb. to May period and from May to Sept., there was a sand loss of about 40 cu.mts. from mid-shore to low tide level with the beach taking an uniform gradient. The table below shows the details of sand deposit and loss at all the three study areas (BP:1, BP:2 and BP:3) of Kalbadevi bay during pre monsoon and post monsoon observations:

**Volume of sand computed for per meter width of the beach**

Name of Profile	Between Feb. And May '04. Deposit Loss (cu.mts)	Between May and Sept.'04. Deposit Loss (cu.mts)	Between Feb. to Sept.'04. Deposit Loss (cu.mts)	Slope/Gradient Berm mid- to Mid- shore to LTL	Remarks.
BP:1	Nil 85	Nil 25	Nil 110	Normal Steep	Northern Transect
BP:2	67 03	04 40	12 05	Gradual Steep	Middle Transect
BP:3	20 01	11 40	08 20	Steep Gradual	Southern Transect

The high tide line data collected at various seasons (Feb., May and Sept.2004) were carefully processed and the maps were prepared with geographical, as well with U.T.M. (Universal Transverse Mercator) grid. No significant variations were found when all the three maps were compared. The post monsoon surveys indicate that at most of the places (except a small stretch at the middle near middle transect), the high tide line was matching perfectly with the earlier surveyed maps. At middle stretch for about 30 meters length, the high tide line was shifted by 2.7 meters towards the landside between pre monsoon and post monsoon surveys. However, further studies which are likely to be taken up during Nov. 2004 and March 2005 would be of great use to confirm these minor shifts.

Laser Trak along with Automatic Level (Carl Zeiss make) instrument could be very effective for carrying out beach profile surveys. These instruments were used at Kalbadevi bay for collection of beach profiles field data, which was later processed for reducing the levels to M.S.L.. See (*Annexure: I*) for the profiles at BP:1, BP:2 and BP:3

at three seasons for the periods February, June and September 2004. Beach profiles were done near the time of low tide, to take advantage of maximum beach exposure. Further periodical observations are already underway. Interpretation of all these data can help us in investigating the complete Kalbadevi stretch for morphological changes, soil erosion, sediment transport, cyclicality, shift in high tide line if any, mineral deposits, etc.

Using the above method and instruments, valuable data collection from coastal areas can be made. This will enable scientific bodies and Coastal Zone Regulation Authorities, to carry out studies, involving management, environmental impact assessment, beach erosion, etc. so that the scientific community can come out with innovative ideas and results, thereby protecting our valuable coastal zone from all hazards, in the future.

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## **References**

1. Mascarenhas Antonio, 1999. The Coastal Regulation Zone of Goa: Oceanographic, environmental and societal perspectives, Current Science, Volume 77, No:12.

2. Pathak, M.C. , Ranjay Sinha, Nigam, R. , Gujar, A.R. and Kotnala, K.L. 2000. Concepts, Approaches and Applications of Integrated Coastal Zone Management In Planning and Management of Indian Coast : Proceedings for Marine GeoSciences in India.
3. Ganeshan, P. 2003. Delineation of high tide line using Laser Trak and DGPS Instruments: With special reference to mapping techniques. NIO / TR / 5 / 2003.
4. Robert A. Morton and F. Michael Speed, 1999. Evaluation of shorelines and legal boundaries controlled by water levels on sandy beaches, Journal of Coastal Research , Fall 1999.
5. Morton R.A., 1991. Accurate shoreline mapping: Past, present and future. Coastal Sediments, Volume I, 1991.

## DEFINITION OF IMPORTANT TERMS

**Accretion:**

Accumulation of sand or other beach material due to the natural action of waves, currents and wind; a build-up of sand or other beach material.

**Back beach:**

The section of beach extending landwards from the high water mark to the point where there is an abrupt change in slope or material; also referred to as the backshore.

**Backshore:** (1) The upper part of the active BEACH above the normal reach of the tides (high water), but affected by large waves occurring during a high. (2) The accretion or erosion zone, located landward of ordinary high tide, which is normally wetted only by storm tides.

**Backwash:** (1) The seaward return of the water following the uprush of the waves. Also called backrush or run down. (2) Water of waves thrown back by an obstruction such as a ship, BREAKWATER, CLIFF, etc.

**Backwash ripples:** Low amplitude ripple marks formed on fine sand beaches by the BACKWASH of the waves.

**Bank:** The rising ground bordering a lake, river or sea.

**Bar:** An offshore ridge or mound of sand, GRAVEL, or other unconsolidated material which is submerged (at least at high tide), especially at the mouth of a river or ESTUARY, or lying parallel to, and a short distance from, the BEACH.

**Barrier beach:** A BAR essentially parallel to the shore, which has been built up so that its crest rises above the normal high water level. Also called BARRIER ISLAND and OFFSHORE BARRIER.

**Barrier island:** A detached portion of a BARRIER BEACH between two inlets.

**Barrier spit:** Similar to a BARRIER ISLAND, only connected to the mainland.

**Basin:** A large submarine DEPRESSION of a generally circular, elliptical or oval shape.

**Bay:** A recess or INLET in the shore of a sea or lake between two capes or headlands, not as large as a GULF but larger than a COVE. See also BIGHT, EMBAYMENT.

**Baymouth bar:** A BAR extending partly or entirely across the mouth of a bay.

**Beach:** (1) A deposit of non-cohesive material (e.g. sand, GRAVEL) situated on the interface between dry land and the sea (or other large expanse of water) and actively "worked" by present-day hydrodynamics processes (i.e. waves, tides and CURRENTS) and sometimes by winds. (2) The zone of unconsolidated material that extends landward from the LOW WATER LINE to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation. The seaward limit of a BEACH – unless otherwise specified – is the MEAN LOW WATER LINE. A BEACH includes FORESHORE and BACKSHORE. (3) The zone of unconsolidated material that is moved by WAVES, wind and TIDAL CURRENTS, extending landward to the COASTLINE.

**Beach crest:** The point representing the limit of high tide storm wave run-up.

**Beach erosion:** The carrying away of beach materials by wave action, tidal CURRENTS, LITTORAL CURRENTS or wind.

**Beach face:** The section of the BEACH normally exposed to the action of wave UPBUSH. The FORESHORE of the BEACH.

**Beach head:** The CLIFF, dune or sea wall looming the landward limit of the active BEACH.

**Beach nourishment:** The process of replenishing a BEACH by artificial means; e.g., by the deposition of dredged materials, also called beach replenishment or beach feeding.

**Beach profile:** A cross-section taken perpendicular to a given beach contour; the profile may include the face of a dune or sea wall, extend over the BACKSHORE, across the foreshore, and seaward underwater into the nearshore zone.



**Beach Ridge:** A low extensive ridge of beach material piled up by storm waves landward of the BERM. Usually consists of very coarse sand, GRAVEL or shells. Occurs singly or as a series of more or less parallel ridges.

**Beach scarp:** (1) An almost perpendicular slope along the beach FORESHORE; an erosional feature due to wave action, it may vary in height from a few centimeters to several meters, depending on wave action and the nature and composition of the BEACH. See ESCARPMENT. See ESCARPMENT. (2) A steep slope produced by wave erosion.

Beach width: The horizontal dimension of the BEACH measured normal to the shoreline.

**Beach nourishment:**

Artificial process of replenishing a beach with material from another source that is located either inland or is dredged offshore.

**Beachrock:**

Ledges of rock formed within the body of the beach consisting of sand grains cemented by calcium carbonate and formed by chemical processes. Erosion of the sand leaves the beachrock exposed.

**Beach Segment:**

Any part of a stretch of beach.

**Berm crest:**

Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.

**Dune:**

Accumulations of wind-blown sand in ridges or mounds that lies landward of the beach and usually parallel to the shoreline. Dunes shift periodically.

**Ecosystem:**

Organization of the biological community and the physical environment in a specific geographical area.

***Erosion:***

Wearing away of the land, usually by the action of natural forces.

***Foreshore:***

Zone between the high water and low water marks.

***Groyne:***

Shore protection structure built perpendicular to the shore; designed to trap sediment. Also, groin.

***High water mark:***

The highest reach of the water at high tide. It is sometimes marked by a line of debris, e.g. sea grass, pieces of wood, etc,

***Hurricane:***

Intense, low-pressure, tropical weather system with maximum surface wind speeds that exceed 118 km/hr (74 mph).

***Leeward coast:***

Coast sheltered from the waves.

***Longshore current:***

A movement of water parallel to the shore, caused mainly by waves.

***Longshore drift:***

Movement of material parallel to the shore also referred to as longshore transport. This results from the action of longshore currents.

***Low water mark:***

The highest reach of the water at low tide.

***Monitoring:***

Systematic measurement and recording over time.

***Profile Area:***

Cross-sectional area under the beach profile.

***Profile Width:***

Horizontal distance across the beach profile, measured from the base of the fixed reference point to the first offshore step.

***Revetment:***

Shore protection structure made with stones laid on a sloping face.

***Seasonal deposition:***

Accumulation of sand or other beach material, usually layered, resulting from seasonal variations in coastal processes.

***Seasonal erosion:***

Loss of sand or other beach material resulting from seasonal variations in coastal processes.

***Setback:***

Prescribed distance landward of a coastal feature from a standard feature (e.g. the line of permanent vegetation), within which all or certain types of development are prohibited.

***Shore:***

Narrow strip of land in immediate contact with the sea.

***Shoreline:***

Intersection of a specific water height with the shore or beach, e.g. the high water shoreline is the intersection of the high water mark with the shore or beach.

***Swell:***

Waves that have traveled out of the area in which they were generated.

***Topography:***

Configuration of a surface including its relief and the position of its natural and man-made features.

***Wave breakpoint:***

The point where the waves break.

***Wetlands:***

Low-lying areas that are frequently flooded and which support vegetation adapted to saturated soils e.g. mangrove swamps.

***Windward:***

Side facing the prevailing wind.

***Windward coast:***

Coast exposed to wave action as a result of facing the prevailing wind.

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**Annexure : I (i)**

**Horizontal control of all the benchmark pillars established**

The geographical co-ordinates obtained for B.P. 1, B.P. 2 and B.P. 3 are given Below:

Bench mark Pillar No	Position in WGS-1984		Position in Indian -1975		Remarks
	Latitude (N)	Longitude (E)	Latitude (N)	Longitude (E)	
<b>BP - 1</b>	<b>17 04 03.994</b>	<b>73 17 19.439</b>	<b>17 03 59.681</b>	<b>73 17 18.325</b>	at Northern end
<b>BP - 2</b>	<b>17 03 24.694</b>	<b>73 17 17.557</b>	<b>17 03 20.378</b>	<b>73 17 16.443</b>	at Middle
<b>BP - 3</b>	<b>17 02 40.967</b>	<b>73 16 56.129</b>	<b>17 02 36.647</b>	<b>73 16 55.012</b>	at Southern end

The converted U.T.M. (Universal Transverse Mercator ) of B.P. 1, B.P. 2 and B.P. 3 are given below:

Bench mark Pillar No	Position in WGS-1984		Position in Indian -1975		Remarks
	Northing (N)	Easting (E)	Northing (N)	Easting (E)	
<b>BP - 1</b>	1887851.160	317890.244	1887566.880	317881.160	at Northern end
<b>BP - 2</b>	1886643.535	317824.004	1886359.250	317814.920	at Middle
<b>BP - 3</b>	1885304.895	317178.564	1885020.600	317169.480	at Southern end

**The following positions are a couple of most prominent landmarks, whose geographical positions were obtained using DGPS instrument.**

Position in WGS-1984		Position in Indian -1975		Remarks
Northing (N)	Easting (E)	Northing (N)	Easting (E)	
1888882.480	318125.920	1888598.210	318116.440	Above a concrete pillar at Are Creek near new bridge site
1885233.468	317330.213	1884949.172	317321.129	Rameshwar Mandir (South)

**Annexure : I (ii)**

**(Vertical control of all the benchmark pillars established)**

Three permanent benchmark pillars were established along the shore of the study area; one at the northern end (BP:1), the second at the middle (BP:2) and the third at the southern end (BP:3). All values are reduced to M.S.L. (Mean sea level) and are shown below:

Northern Pillar	<b>BP : 1</b>	<b>+ 3.375 meters above M.S.L.</b>
Middle Pillar	<b>BP : 2</b>	<b>+ 3.160 meters above M.S.L.</b>
Southern Pillar	<b>BP : 3</b>	<b>+ 3.570 meters above M.S.L.</b>

As per the Maharashtra Tide Tables, **the chart datum is + 1.520 meters below M.S.L.** at Ratnagiri and the same has been used for Kalbadevi bay.

## ANNEXURE : II

### Raw field data for HTL surveys collected at Kalbadevi bay using Laser Trak

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Period of survey : February 2004

The raw data obtained on the field, while doing high tide line surveys, is given as a sample for one period.

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Fix No.	Hori. angle	Vert. angle	Distance in mts.	Remarks.
1	149.26	0.41	350.65	
2	150.6	0.47	307.65	
3	151.91	0.51	257.6	
4	152.47	0.68	181.4	
5	148.67	0.97	123.4	
6	129.39	1.75	67.6	
7	62.78	2.55	47.7	
8	22.44	1.44	87.3	
9	13.76	1.15	123.15	
10	8.48	0.84	159.15	
11	3.85	0.57	215.85	
12	1.47	0.49	270.15	
13	0.08	0.41	322.9	
14	359.62	0.39	364.6	
15	358.96	0.35	421.6	
16	358.26	0.33	455.3	
17	359.03	0.29	468.25	
18	359.07	0.22	476.95	
19	358.29	0.29	470.25	
20	358.06	0.26	484.55	
21	357.8	0.26	502.9	
22	357.27	0.26	520.25	
23	357.28	0.25	554.55	
24	357.2	0.25	564.55	
25	356.23	0.26	604.8	
26	355.41	0.21	659.5	
27	354.85	0.18	708.1	
28	316.67	1.74	39.25	
29	277.57	1.71	41.6	
30	267.14	1.48	43.95	
31	256.13	2.06	36.65	
32	212.82	1.37	61.9	
33	203.42	0.76	102.35	

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34	199.37	0.53	155.35
35	200.63	0.37	210
36	200.25	0.68	238.3
37	198.1	0.33	244.2
38	197.5	0.32	266.6
39	196.5	0.4	294.4
40	195.86	0.25	345.45
41	195.98	0.22	382.65
42	195.95	0.18	424.6
43	194.31	0.17	471.65
44	194.73	0.14	515.75
45	194.94	0.14	523.8
46	194.91	0.08	545.55
47	359.98	0.38	233.05
48	359.95	0.45	204.35
49	356.05	0.51	184.65
50	355.28	0.53	171.95
51	354.64	0.61	153.0
52	348.96	0.91	141.9
53	350.12	0.73	134.55
54	351.42	0.81	113.55
55	337.63	0.95	98.45
56	334.11	1.05	88.25
57	328.03	1.64	51.2
58	295.28	2.61	36.3
59	267.78	2.07	47.0
60	259.46	2.06	47.85
61	234.85	1.7	50.40
62	217.39	1.3	73.95
63	219.59	1.02	97.5
64	220.05	0.94	88.25
65	208.85	0.81	117.6
66	195.36	0.72	137.85
67	188.41	0.69	177.85
68	186.74	0.5	206.45
69	187.07	0.4	248.3
70	187.16	0.41	251.65
71	345.9	1.39	74.75
72	343.11	1.55	105.1
73	343.73	1.89	47.7
74	324.84	2.45	38.0
75	303.47	3.05	30.95
76	251.78	3.19	26.2
77	234.41	1.5	52.75
78	237.98	1.71	66.05
79	234.43	1.17	69.75
80	224.18	1.26	71.0
81	209.09	1.04	84.3
82	207.45	0.88	107.05
83	205.44	0.83	111.45
84	199.92	0.77	124.25

85	194.33	0.18	156.9
86	196.0	0.58	202.1
87	348.82	1.98	84.65
88	340.59	2.05	82.85
89	337.95	2.19	75.85
90	342.7	2.79	62.6
91	341.79	3.44	45.7
92	289.86	14.96	11.7
93	202.81	2.53	78.65
94	199.44	1.11	187.40
95	200.14	0.81	239.40
96	353.43	1.46	170.00
97	352.0	1.38	181.1
98	349.38	1.3	179.55
99	349.36	1.68	146.45
100	343.81	3.25	92.3
101	304.39	4.14	62.55
102	273.96	3.58	71.0
103	268.24	3.01	83.9
104	267.15	2.96	87.9
105	236.39	2.85	98.4
106	225.93	1.4	160.90
107	227.15	1.3	176.30

End of data.

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### ANNEXURE : III (i)

#### Final output of HTL surveys derived from field data collected in Feb. 2004 )

The program "**Program to compute U.T.M. co-ordinates using Laser Trak raw data**" (Ganeshan, P., 2003) was effectively used to obtain final corrected co-ordinates and are given below:

( Note: All position co-ordinates are computed based on INDIAN –1975 SPHEROID )

#### FINAL OUTPUT OF THE SURVEYS IN UTM VALUES

FIX	H.DIST (Mts.)	EASTING (Mts.)	NORTHING (Mts.)	AZI (Degrees)	AZAC
1	350.64	374068.426	1196660.770	83.69	232.94
2	307.64	374098.474	1196692.475	83.69	234.28
3	257.59	374135.727	1196726.514	83.69	235.59
4	181.39	374197.603	1196771.041	83.69	236.15
5	123.38	374250.557	1196796.709	83.69	232.35
6	67.57	374311.377	1196815.449	83.69	213.07
7	47.65	374374.577	1196832.350	83.69	146.46
8	87.27	374432.090	1196847.834	83.69	106.12
9	123.13	374470.338	1196856.120	83.69	97.44
10	159.13	374507.270	1196866.064	83.69	92.16
11	215.84	374563.889	1196881.361	83.69	87.53
12	270.14	374617.424	1196894.896	83.69	85.15
13	322.89	374669.231	1196907.149	83.69	83.76
14	364.59	374710.354	1196914.588	83.69	83.30
15	421.59	374766.371	1196926.055	83.69	82.64
16	455.29	374799.048	1196935.883	83.69	81.94
17	468.24	374812.712	1196931.462	83.69	82.71
18	476.95	374821.386	1196932.235	83.69	82.75

19	470.24	374813.887	1196937.735	83.69	81.97
20	484.55	374827.772	1196941.657	83.69	81.74
21	502.89	374845.599	1196946.550	83.69	81.48
22	520.24	374862.023	1196953.876	83.69	80.95
23	554.54	374895.911	1196959.174	83.69	80.96
24	564.54	374905.663	1196961.523	83.69	80.88
25	604.79	374943.695	1196977.996	83.69	79.91
26	659.50	374995.832	1196996.857	83.69	79.09
27	708.10	375042.212	1197012.842	83.69	78.53
28	39.23	374373.652	1196901.967	83.69	40.35
29	41.58	374349.159	1196913.642	83.69	1.25
30	43.94	374341.243	1196915.443	83.69	350.82
31	36.63	374335.611	1196906.446	83.69	339.81
32	61.88	374292.871	1196899.685	83.69	296.50
33	102.34	374250.435	1196902.167	83.69	287.10
34	155.34	374196.920	1196907.155	83.69	283.05
35	210.00	374144.773	1196923.985	83.69	284.31
36	238.28	374116.978	1196929.445	83.69	283.93
37	244.20	375812.856	1196777.042	271.11	109.21
38	266.60	375834.914	1196772.315	271.11	108.61
39	294.39	375862.855	1196768.330	271.11	107.61
40	345.45	375912.664	1196756.573	271.11	106.97
41	382.65	375948.011	1196744.952	271.11	107.09
42	424.60	375988.176	1196732.839	271.11	107.06
43	471.65	376036.931	1196732.002	271.11	105.42
44	515.75	376078.427	1196716.639	271.11	105.84
45	523.80	376085.644	1196712.596	271.11	106.05
46	545.55	376106.626	1196706.859	271.11	106.02

47	233.04	375349.247	1196861.783	271.11	271.09
48	204.34	375377.941	1196861.133	271.11	271.06
49	184.64	375397.835	1196848.205	271.11	267.16
50	171.94	375410.649	1196846.529	271.11	266.39
51	152.99	375429.680	1196846.019	271.11	265.75
52	141.88	375442.496	1196832.891	271.11	260.07
53	134.54	375449.282	1196836.869	271.11	261.24
54	113.54	375469.674	1196842.619	271.11	262.54
55	98.44	375490.510	1196821.685	271.11	248.75
56	88.24	375502.136	1196820.395	271.11	245.23
57	51.18	375538.314	1196831.122	271.11	239.15
58	36.26	375566.129	1196824.888	271.11	206.40
59	46.97	375583.156	1196810.409	271.11	178.90
60	47.82	375590.081	1196810.196	271.11	170.58
61	50.38	375610.446	1196815.622	271.11	145.97
62	73.93	375640.105	1196811.342	271.11	128.51
63	97.48	375656.151	1196793.794	271.11	130.71
64	88.24	375648.677	1196799.289	271.11	131.17
65	117.59	375684.120	1196798.638	271.11	119.97
66	137.84	375714.430	1196818.279	271.11	106.48
67	177.84	375757.635	1196827.942	271.11	99.53
68	206.44	375786.755	1196829.156	271.11	97.86
69	248.29	375828.015	1196822.020	271.11	98.19
70	251.64	375831.274	1196821.152	271.11	98.28
71	74.73	375509.433	1196840.579	271.11	257.02
72	105.06	375481.145	1196828.808	271.11	254.23
73	47.67	375536.234	1196844.907	271.11	254.85
74	37.97	375550.792	1196836.115	271.11	235.96
75	30.91	375564.707	1196831.925	271.11	214.59

76	26.16	375589.944	1196832.368	271.11	162.90
77	52.73	375612.099	1196813.899	271.11	145.53
78	66.02	375616.159	1196800.723	271.11	149.10
79	69.74	375621.703	1196799.868	271.11	145.55
80	70.98	375632.183	1196806.920	271.11	135.30
81	84.29	375655.093	1196814.966	271.11	120.21
82	107.04	375676.258	1196806.189	271.11	118.57
83	111.44	375681.932	1196807.551	271.11	116.56
84	124.24	375698.210	1196812.776	271.11	111.04
85	156.90	375733.483	1196815.586	271.11	105.45
86	202.09	375775.390	1196797.897	271.11	107.12
87	84.60	375498.953	1196842.585	271.11	259.94
88	82.80	375503.638	1196831.379	271.11	251.71
89	75.79	375511.459	1196830.288	271.11	249.07
90	62.53	375522.202	1196839.942	271.11	253.82
91	45.62	375538.648	1196843.960	271.11	252.91
92	11.30	375578.204	1196846.816	271.11	200.98
93	78.57	375654.072	1196825.505	271.11	113.93
94	187.36	375757.686	1196791.585	271.11	110.56
95	239.38	375805.343	1196770.591	271.11	111.26
96	169.94	375413.075	1196841.214	271.11	264.55
97	181.05	375402.508	1196835.667	271.11	263.12
98	179.50	375405.211	1196827.728	271.11	260.50
99	146.39	375437.881	1196833.146	271.11	260.48
100	92.15	375493.270	1196833.403	271.11	254.93
101	62.39	375546.017	1196806.583	271.11	215.51
102	70.86	375575.982	1196786.786	271.11	185.08
103	83.78	375583.193	1196773.591	271.11	179.36

104	87.78	375584.908	1196769.628	271.11	178.27
105	94.28	375632.901	1196777.848	271.11	147.51
106	160.85	375691.858	1196739.644	271.11	137.05
107	176.25	375699.580	1196725.843	271.11	138.27

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The final UTM co-ordinates thus obtained were used as input file for preparation of the final maps (showing the high tide line) using HYDRO PRO post processing software. (See Annexure for final maps showing the high tide line with shore features).

**ANNEXURE : III ( ii )**

**Final output of HTL surveys derived from field data collected in May 2004 )**

(Note: All position co-ordinates are computed based on INDIAN –1975 SPHEROID)

FINAL OUTPUT OF THE SURVEYS IN UTM VALUES

-----  
FIX EASTING      NORTHING                      REMARKS  
No. (Mts.)      (Mts.)  
-----

1	318114.430	1888597.910	0.0
2	317914.380	1888436.900	0.0
3	317944.960	1888491.250	0.0
4	317980.780	1888532.820	0.0
5	318051.230	1888572.010	0.0
6	318047.640	1888603.330	0.0
7	318084.620	1888618.220	0.0
8	317999.638	1888494.480	0.0
9	317988.800	1888467.175	0.0
10	317992.199	1888419.521	0.0
11	317967.792	1888338.441	0.0
12	317955.204	1888245.632	0.0
13	317951.029	1888185.039	0.0
14	317938.735	1888113.618	0.0
15	317933.721	1888042.649	0.0
16	317924.898	1887980.995	0.0
17	317913.016	1887912.252	0.0
18	317904.657	1887839.125	0.0
19	317916.004	1887804.987	0.0
20	317910.272	1887789.012	0.0
21	317905.368	1887777.578	0.0

22 317886.587 1887731.844 0.0

23 317893.564 1887702.859 0.0

-----  
FIX EASTING NORTHING REMARKS  
No. (Mts.) (Mts.)  
-----

24 317886.995 1887672.005 0.0

25 317859.899 1887591.989 0.0

26 317875.203 1887592.020 0.0

27 317870.520 1887563.778 0.0

28 317866.580 1887519.234 0.0

29 317868.469 1887498.619 0.0

30 317851.224 1887420.375 0.0

31 317856.448 1887375.448 0.0

32 317856.631 1887362.530 0.0

33 317843.312 1887259.964 0.0

34 317863.074 1887220.439 0.0

35 317851.082 1887201.791 0.0

36 317843.322 1887126.231 0.0

37 317857.291 1887100.591 0.0

38 317853.205 1887072.957 0.0

39 317845.574 1886978.335 0.0

40 317869.739 1886935.082 0.0

41 317867.088 1886902.518 0.0

42 317837.915 1886846.820 0.0

43 317831.753 1886818.590 0.0

44 317823.677 1886774.391 0.0

45 317822.550 1886747.039 0.0

46 317824.289 1886709.209 0.0

47 317822.866 1886681.861 0.0

48 317818.742 1886649.923 0.0

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FIX No.	EASTING (Mts.)	NORTHING (Mts.)	REMARKS
49	317816.464	1886626.271	0.0
50	317814.012	1886616.148	0.0
51	317829.775	1886559.134	0.0
52	317838.299	1886553.218	0.0
53	317842.946	1886543.647	0.0
54	317854.097	1886533.712	0.0
55	317826.911	1886502.284	0.0
56	317806.418	1886458.501	0.0
57	317804.294	1886452.371	0.0
58	317812.221	1886412.028	0.0
59	317811.293	1886407.424	0.0
60	317808.307	1886404.069	0.0
61	317801.925	1886384.449	0.0
62	317800.812	1886392.452	0.0
63	317809.843	1886343.183	0.0
64	317803.256	1886334.018	0.0
65	317787.501	1886324.625	0.0
66	317771.949	1886304.779	0.0
67	317770.971	1886294.335	0.0
68	317763.913	1886265.190	0.0
69	317748.718	1884396.129	0.0
70	317721.690	1884349.329	0.0
71	317712.995	1884302.060	0.0



72 317712.093 1884199.078 0.0

73 317705.533 1885981.326 0.0

---

FIX No.	EASTING (Mts.)	NORTHING (Mts.)	REMARKS
74	317682.057	1885900.985	0.0
75	317679.969	1885898.851	0.0
76	317647.258	1885878.232	0.0
77	317644.085	1885853.665	0.0
78	317641.407	1885851.844	0.0
79	317607.507	1885796.804	0.0
80	317593.422	1885741.896	0.0
81	317591.884	1885735.146	0.0
82	317548.776	1885675.575	0.0
83	317511.477	1885603.963	0.0
84	317486.418	1885545.463	0.0
85	317463.471	1885491.864	0.0
86	317416.158	1885424.951	0.0
87	317395.414	1885386.396	0.0
88	317374.379	1885348.459	0.0
89	317352.739	1885308.990	0.0
90	317351.639	1885284.713	0.0
91	317358.932	1885273.274	0.0
92	317340.511	1885263.598	0.0
93	317337.194	1885256.248	0.0
94	317310.100	1885235.581	0.0
95	317278.645	1885189.742	0.0
96	317257.731	1885165.639	0.0

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97 317244.775 1885138.391 0.0

98 317226.821 1885114.569 0.0

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FIX No.	EASTING (Mts.)	NORTHING (Mts.)	REMARKS
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99 317202.061 1885090.192 0.0

100 317058.026 1885055.488 0.0

101 317153.875 1885025.132 0.0

102 317158.567 1885024.989 0.0

103 317137.842 1885001.554 0.0

104 317098.639 1884956.598 0.0

105 317069.021 1884927.852 0.0

106 317033.001 1884887.996 0.0

107 316998.545 1884845.225 0.0

108 316960.223 1884800.991 0.0

109 316936.014 1884771.968 0.0

110 316910.008 1884742.872 0.0

111 316872.114 1884699.058 0.0

112 316829.899 1884649.959 0.0

113 316789.966 1884594.663 0.0

114 316763.055 1884544.258 0.0

115 316738.633 1884472.899 0.0

116 316727.959 1884422.221 0.0

117 316721.556 1884378.269 0.0

END OF HTL DATA.

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### ANNEXURE : III ( iii )

**Final output of HTL surveys derived from field data collected in Sept. 2004 )**

(Note: All position co-ordinates are computed based on INDIAN –1975 SPHEROID)

FINAL OUTPUT OF THE SURVEYS IN UTM VALUES

FIX No.	EASTING (Mts.)	NORTHING (Mts.)	REMARKS
1	318039.489	1888590.047	0.0
2	318002.052	1888569.470	0.0
3	317947.600	1888530.596	0.0
4	317929.617	1888503.084	0.0
5	317910.308	1888425.473	0.0
6	317902.847	1888350.217	0.0
7	317900.114	1888274.612	0.0
8	317899.369	1888199.767	0.0
9	317893.092	1888148.319	0.0
10	317897.973	1888131.674	0.0
11	317893.496	1888059.467	0.0
12	317888.784	1887960.514	0.0
13	317883.978	1887850.803	0.0
14	317896.108	1887817.801	0.0
15	317895.895	1887793.516	0.0
16	317878.163	1887727.265	0.0
17	317892.745	1887704.080	0.0
18	317895.887	1887691.448	0.0
19	317868.476	1887634.198	0.0
20	317879.431	1887602.129	0.0
21	317878.756	1887592.604	0.0
22	317862.649	1887542.941	0.0
23	317870.924	1887508.743	0.0
24	317868.467	1887498.312	0.0
25	317850.305	1887416.694	0.0
26	317848.982	1887400.719	0.0
27	317853.812	1887378.234	0.0
28	317863.717	1887361.238	0.0

FIX No.	EASTING (Mts.)	NORTHING (Mts.)	REMARKS
29	317855.997	1887357.617	0.0
30	317840.683	1887263.677	0.0
31	317864.826	1887217.965	0.0
32	317859.095	1887205.103	0.0
33	317843.032	1887126.848	0.0
34	317861.331	1887089.181	0.0
35	317867.457	1887079.596	0.0
36	317858.855	1887076.598	0.0
37	317853.748	1887067.419	0.0
38	317843.493	1886977.124	0.0
39	317868.438	1886921.567	0.0
40	317868.529	1886898.201	0.0
41	317833.848	1886821.339	0.0
42	317824.781	1886731.648	0.0
43	317815.784	1886616.132	0.0
44	317821.681	1886580.418	0.0
45	317836.823	1886553.539	0.0
46	317840.250	1886539.674	0.0
47	317840.419	1886525.223	0.0
48	317805.431	1886447.135	0.0
49	317814.223	1886404.324	0.0
50	317806.013	1886378.572	0.0
51	317813.031	1886335.777	0.0
52	317807.714	1886336.439	0.0
53	317790.203	1886329.214	0.0
54	317777.603	1886308.726	0.0
55	317777.078	1886282.599	0.0
56	317766.844	1886262.090	0.0
57	317767.545	1886240.871	0.0
58	317761.610	1886238.464	0.0
59	317745.386	1886209.400	0.0
60	317726.172	1886142.855	0.0
61	317724.708	1886110.895	0.0
62	317740.259	1886063.107	0.0

FIX No.	EASTING (Mts.)	NORTHING (Mts.)	REMARKS
63	317738.363	1886049.289	0.0
64	317711.859	1886028.308	0.0
65	317703.124	1885976.429	0.0
66	317698.646	1885971.549	0.0
67	317674.497	1885949.318	0.0
68	317673.969	1885922.883	0.0
69	317677.318	1885900.104	0.0
70	317673.740	1885896.754	0.0
71	317651.992	1885878.498	0.0
72	317650.550	1885848.997	0.0
73	317642.512	1885842.919	0.0
74	317631.764	1885831.331	0.0
75	317632.718	1885805.191	0.0
76	317626.734	1885797.250	0.0
77	317607.733	1885788.808	0.0
78	317605.396	1885758.393	0.0
79	317585.919	1885729.358	0.0
80	317548.117	1885667.895	0.0
81	317533.315	1885632.363	0.0
82	317517.722	1885607.905	0.0
83	317502.433	1885584.367	0.0
84	317481.028	1885537.825	0.0
85	317481.479	1885521.834	0.0
86	317517.319	1885470.497	0.0
87	317463.447	1885489.097	0.0
88	317457.447	1885479.312	0.0
89	317442.494	1885460.382	0.0
90	317433.243	1885450.933	0.0
91	317400.820	1885395.880	0.0
92	317365.343	1885329.785	0.0
93	317352.116	1885305.307	0.0
94	317351.018	1885281.337	0.0
95	317352.106	1885270.567	0.0
96	317310.710	1885237.728	0.0

FIX No.	EASTING (Mts.)	NORTHING (Mts.)		REMARKS
97	317245.359	1885137.463	0.0	
98	317232.244	1885125.896	0.0	
99	317181.932	1885054.399	0.0	
100	317163.386	1885030.582	0.0	
101	317155.660	1885026.346	0.0	
102	317090.235	1884951.600	0.0	
103	317049.031	1884907.077	0.0	
104	316999.995	1884846.329	0.0	
105	316952.760	1884788.639	0.0	
106	316894.217	1884723.056	0.0	
107	316847.629	1884671.817	0.0	
108	316819.216	1884635.790	0.0	
201	318016.563	1888538.292	0.0	DGPS position of NIO BM BP: 1A
202	317836.897	1886730.620	0.0	DGPS position of NIO BM BP: 2A
203	317658.121	1885869.222	0.0	DGPS position of NIO BM Ref.Stn.
204	317490.257	1885477.487	0.0	DGPS position of NIO BM BP: 3A
205	316909.833	1884615.624	0.0	DGPS position of NIO BM BP: 4A
END OF HTL DATA.				

## ANNEXURE : IV

### GEOGRAPHICAL POSITIONS OF BEACH PROFILE LIMITS AND LANDMARKS

( Note: All position co-ordinates are computed based on INDIAN –1975 SPHEROID )

FIX No.	EASTING (Mts.)	NORTHING (Mts.)		REMARKS
201	317881.160	1887566.880	0.0	BEGINNING OF <b>B.P. 1</b> (Northern end)
202	317795.160	1887566.880	0.0	END OF <b>B.P. 1</b>
301	317814.920	1886359.250	0.0	BEGINNING OF <b>B.P. 2</b> (Middle bay)
302	317742.920	1886359.250	0.0	END OF <b>B.P. 2</b>
401	317169.480	1885020.600	0.0	BEGINNING OF <b>B.P. 3</b> (Southern end)
402	317070.480	1885020.600	0.0	END OF <b>B.P. 3</b>
500	318116.440	1888598.210	0.0	PWD Concrete Pillar near Are bridge
600	317321.129	1884949.172	0.0	Location of Rameshwar Mandir

The final UTM co-ordinates thus obtained were used as input file for preparation of the final maps (showing the high tide line) using HYDRO PRO post processing software. (See Annexure for final maps showing the high tide line with shore features).

## Annexure – V (i)

### BEACH PROFILE LEVELS

The final corrected levels (reduced to M.S.L.) along profiles BP:1, BP:2 and BP:3 are given below :

Levels along BP : 1 Surveyed on 25.02.2004 ( Northern Profile )

S.No.	Distances in meters	Levels in Meters	Remarks
1	-- 10	+ 1.803	Along profile, behind B.P. : 1
2	-- 6	+ 2.568	----- do -----
3	-- 3	+ 3.463	----- do -----
4	0	+ 3.375	Along profile over B.M. Pillar B.P. : 1
5	4	+ 2.098	
6	8	+ 2.334	
7	12	+ 2.442	
8	16	+ 2.443	
9	20	+ 2.189	
10	24	+ 2.305	
11	28	+ 2.191	
12	32	+ 2.027	
13	36	+ 1.868	
14	40	+ 2.008	
15	44	+ 2.081	
16	48	+ 2.096	
17	52	+ 1.749	
18	56	+ 1.208	
19	60	+ 0.726	
20	64	+ 0.286	
21	68	-- 0.049	
22	72	-- 0.236	
23	76	-- 0.459	First point on sea side near LWL



### Annexure – V (ii)

Levels along BP : 2 Surveyed on 25.02.2004 (Middle Profile)

S.No.	Dist. In meters	Levels in Meters	Remarks
1	0	+ 3.036	Along profile, behind B.P. 2
2	4	+ 3.716	Along profile, behind B.P. 2
3	8	+ 3.160	Along profile over B.M. Pillar B.P. 2
4	12	+ 2.922	
5	16	+ 2.550	
6	20	+ 2.092	
7	24	+ 1.862	
8	28	+ 1.702	
9	32	+ 1.479	
10	36	+ 1.424	
11	39	+ 1.598	
12	42	+ 1.704	
13	46	+ 1.520	
14	49	+ 1.277	
15	54	+ 0.790	
16	57	+ 0.620	
17	60	+ 0.310	
18	63	-- 0.135	
19	66	-- 0.153	
20	69	-- 0.118	
21	73	-- 0.358	
22	77	-- 0.318	Last point on seaside near LWL

### Annexure – V (iii)

Levels along BP : 3      Surveyed on 25.02.2004      ( Southern Profile )

S.No.	Dist. In meters	Levels in meters	Remarks
1	0	+ 3.570	Along profile on B.P. 3 Pillar
2	0.15	+ 3.063	Just below B.P. 3 on ground
3	4	+ 2.570	
4	8	+ 2.065	
5	12	+ 2.150	
6	16	+ 2.200	
7	20	+ 2.140	
8	24	+ 1.965	
9	28	+ 1.620	
10	32	+ 1.635	
11	36	+ 1.562	
12	40	+ 1.400	
13	44	+ 1.175	
14	48	+ 0.950	
15	52	+ 0.730	
16	56	+ 0.585	
17	60	+ 0.480	
18	64	+ 0.325	
19	68	+ 0.185	
20	72	+ 0.095	
21	76	+ 0.015	
22	80	-- 0.095	
23	84	-- 0.232	
24	88	-- 0.505	
25	92	-- 0.665	
26	95	-- 0.930	Last point along profile on waterline.

### Annexure – V (iv)

Levels along BP : 1 Surveyed on 03.05.2004 ( Northern end )

S.No.	Dist. In meters	Levels in Meters	Remarks
1	0	+ 3.375	Along profile on B.P. 1 Pillar
2	-- 0.15	+ 3.230	Just below B.P. 1 on ground
3	-- 4.0	+ 3.640	
4	-- 8.0	+ 3.195	
5	-- 12	+ 1.245	
6	-- 16	+ 1.930	
7	+ 4	+ 1.405	
8	8	+ 1.430	
9	12	+ 1.435	
10	16	+ 0.880	
11	20	+ 0.705	
12	24	+ 0.593	
13	28	+ 0.480	
14	32	+ 0.382	
15	36	+ 0.495	
16	40	+ 0.615	
17	44	+ 0.595	
18	48	+ 0.485	
19	52	+ 0.330	
20	56	+ 0.375	
21	60	+ 0.280	
22	64	-- 0.005	
23	68	-- 0.260	
24	72	-- 0.478	
25	76	-- 0.655	
26	80	-- 0.807	
27	84	-- 0.945	
28	88	-- 1.078	( Cont...)

Cont..	From last	Page.	
S.No.	Dist. In meters	Levels in Meters	Remarks
29	92	-- 1.175	
30	96	-- 1.270	
31	100	-- 1.365	Along the profile at waterline
32	104	-- 1.485	Last point of the profile.

### Annexure – V (v)

Levels along BP : 2      Surveyed on 03.05.2004      ( Middle end )

S.No.	Dist. In meters	Levels in meters	Remarks
1	--11	+ 3.028	Along profile behind BP: 2
2	-- 7	+ 3.139	----- do -----
3	-- 3	+ 3.866	----- do -----
4	+ 0	+ 3.160	Along profile on B.P. 2 Pillar
5	0.3	+ 3.033	Just below B.P. 2 on ground
6	4	+ 2.055	Frontside of BP:2
7	8	+ 1.937	
8	12	+ 1.862	
9	16	+ 1.750	
10	20	+ 1.630	
11	24	+ 1.530	
12	28	+ 1.470	
13	32	+ 1.395	
14	36	+ 1.393	
15	40	+ 1.598	
16	44	+ 1.630	
17	48	+ 1.633	
18	52	+ 1.453	
19	56	+ 1.418	
20	60	+ 1.308	
21	64	+ 1.358	
22	68	+ 1.441	
23	72	+ 1.193	
24	76	+ 0.793	
25	80	+ 0.538	
26	84	+ 0.350	
27	88	+ 0.220	

28	92	+ 0.098	( Cont... )
(Cont.	From last	Page....)	
S.No.	Dist. In meters	Levels in meters	Remarks
29	96	+ 0.018	
30	100	-- 0.032	
31	104	-- 0.129	
32	108	-- 0.357	Along the profile on waterline.
33	111	-- 0.797	Last point along the profile.

### Annexure – V (vi)

Levels along BP : 3    Surveyed on 04.05.2004    ( Southern end )

S.No.	Dist. In meters	Levels in meters	Remarks
1	0	+ 3.570	Along profile on B.P. 3 Pillar
2	4	+ 2.937	
3	8	+ 2.270	
5	12	+ 2.070	
6	16	+ 2.170	
7	20	+ 2.042	
8	24	+ 1.772	
9	28	+ 1.607	
10	32	+ 1.625	
11	36	+ 1.495	
12	40	+ 1.360	
13	44	+ 1.470	
14	48	+ 1.280	
15	52	+ 1.235	
16	56	+ 0.973	
17	60	+ 0.812	
18	64	+ 0.665	
19	68	+ 0.585	Along the profile on waterline.
20	72	+ 0.455	
21	76	+ 0.380	Last point along the profile.

### Annexure – V (vii)

Levels along BP : 1 Surveyed on 01.09.2004 ( Northern end )

S.No.	Dist. In Meters	Levels in Meters	Remarks
1	- 4	+ 3.670	----- do -----
2	- 0.15	+ 3.230	Just below B.P. 1 on ground
3	+ 0	+ 3.375	Along profile on B.P. 1 Pillar
4	4	+ 2.845	
5	8	+ 1.495	
6	12	+ 1.465	
7	16	+ 0.905	
8	20	+ 0.715	
9	24	+ 0.545	
10	28	+ 0.390	
11	32	+ 0.200	
12	36	+ 0.123	
13	40	-- 0.017	
14	44	-- 0.182	
15	48	-- 0.335	
16	52	-- 0.477	
17	56	-- 0.614	
18	60	-- 0.737	
19	64	-- 0.867	
20	68	-- 0.992	
21	72	-- 1.072	
22	76	-- 1.182	
23	80	-- 1.287	
24	84	-- 1.384	
25	88	-- 1.487	
26	92	-- 1.577	
27	96	-- 1.652	
28	100	-- 1.726	
29	104	-- 1.807	Along the profile at waterline
30	108	-- 1.894	Last point of the profile.



S.No.	Dist. In Meters	Levels in Meters	Remarks
31	112	-- 2.004	
32	116	-- 2.107	
33	120	-- 2.222	
34	124	-- 2.352	

### Annexure – V (viii)

Levels along BP : 2      Surveyed on 31.08.2004      ( Middle end )

S.No.	Dist. In meters	Levels in meters	Remarks
1	-- 15	+ 2.927	
2	-- 12	+ 3.022	
3	-- 9	+ 3.237	
4	-- 6	+ 3.642	Along profile on B.P. 2 Pillar
5	-- 3	+ 3.662	Just below B.P. 2 on ground
6	-- 0.15	+ 2.862	
7	+ 0	+ 3.160	
8	4	+ 1.927	
9	8	+ 2.382	
10	12	+ 1.892	
11	16	+ 1.817	
12	20	+ 1.662	
13	24	+ 1.567	
14	28	+ 1.442	
15	32	+ 1.312	
16	36	+ 1.172	
17	40	+ 1.022	
18	44	+ 0.867	
19	48	+ 0.722	
20	52	+ 0.527	
21	56	+ 0.357	
22	60	+ 0.187	
23	64	+ 0.017	
24	68	-- 0.158	
25	72	-- 0.403	
26	76	-- 0.643	
27	80	-- 0.848	

### Annexure – V (ix)

Levels along BP : 3    Surveyed on 01.09.2004    ( Southern end )

S.No.	Dist. In meters	Levels in meters	Remarks
1	-- 8	+ 3.423	Along profile on B.P. 3 Pillar
2	-- 4	+ 3.363	
3	-- 0.15	+ 3.523	
4	+ 0	+ 3.570	
5	4	+ 3.248	
6	8	+ 2.763	
7	12	+ 2.448	
8	16	+ 2.060	
9	20	+ 2.188	
10	24	+ 2.098	
11	28	+ 1.908	
12	32	+ 1.403	
13	36	+ 1.130	
14	40	+ 0.903	
15	44	+ 0.728	
16	48	+ 0.583	
17	52	+ 0.459	
18	56	+ 0.319	
19	60	+ 0.209	
20	64	+ 0.094	
21	68	-- 0.011	Along the profile on waterline.
22	72	-- 0.089	
23	76	-- 0.179	Last point along the profile.
24	80	-- 0.266	
25	84	-- 0.336	
26	88	-- 0.406	
27	92	-- 0.476	
28	96	-- 0.561	
29	100	-- 0.651	
30	104	-- 0.741	

S.No.	Dist. In meters	Levels in Meters	Remarks
31	108	-- 0.831	
32	112	-- 0.936	
33	116	-- 1.036	
34	120	-- 1.126	