# Draft Development Plan of Gujarat Petroleum, Chemical & Petrochemical Special Investment Regional Development Authority (GPCPSIRDA)

# Volume I

## Section 2 - Surveys and Studies

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* The above list is not an exhaustive list

# Content

## Tables



## Figures

# 1. Preamble

This Volume I, Section 2 of the Draft Development Plan report of Gujarat Petroleum Petrochemical Special Investment Regional Development Authority (GPCPSIRDA) contains the details of the surveys and studies carried out for the project. The Preliminary Flood Risk Assessment (FRA) activity for the GPCPSIR area has been carried out as one of the critical studies for the project. The Flood maps are an output of the preliminary flood risk assessment. The FRA outputs have provided preliminary assessment base for preparation of the drainage plan. Apart from that, suitable flood mitigation strategies and measures have also been suggested for the area on the basis of the FRA.

The Industrial sizing study has been done in order to derive a suitable indicative product value chain for GPCPSIR. Based on the required co-siting and the value chain the proposed industrial landuse has been suggested in synergy with the industrial infrastructure. Mott MacDonald study team has surveyed 100% existing operational industries in GPCPSIR area. Other chemical estates in the region have also been briefly studied. A benchmark study among parallel Petroleum, Chemical and Petrochemical Estates and desk research has been done on various chemical products. On the basis of all these, an indicative product range along with their area, infrastructure and employment related requirement has been identified.

# 2. Flood Risk Assessment

## 2.1 Introduction

Government of Gujarat has proposed to set up the GPCPSIR covering Dahej estate, Vagra and Bharuch Talukas of Gujarat. As a part of the DDP currently being undertaken by Mott MacDonald, detailed Flood Risk Assessment (FRA) and flood and water logging mitigation measures in the area has been undertaken as the project area has water logging issues as is bounded by Narmada River in the South and Sea in the West.

The following sections in this chapter elaborate the preliminary flood risk analysis of the GPCPSIR area. The primary output of this exercise is the generation of flood maps for the concerned area. In the next stage, the inputs from this analysis have been further used during the preparation of the drainage plan. Accordingly, suitable flood mitigation strategies and measures have also been suggested for the area.

Flooding is a natural phenomenon that has occurred throughout history. However, current pressures for development are increasingly causing the development of land which is susceptible to flooding. Development can exacerbate existing problems elsewhere within the same water catchment area; both in terms of surface water drainage and combined sewer storm overflow problems. Additionally, global climate change is predicted to increase the likelihood of both coastal and inland flooding.

The natural causes of flooding fall into 4 main categories:

- **Fluvial Flooding:** from rivers and streams, including that resulting from the restricted capacity and blockage of culverts conveying watercourses;
- **Coastal Flooding:** from high tides and/or storm surges;
- **Pluvial Flooding:** (known as ‘urban’ or surface water flooding) resulting from the sensitivity and limiting capacity of the existing or proposed surface water drainage network and combined drainage systems. (Pluvial flooding constitutes around 25% of flooding events.);
- **Groundwater Flooding:** Less likely, but more extreme, man-made situations can result in unexpected and catastrophic flooding. Indicative areas of concern include reservoirs and dams, flood defence failure and the inadequate capacity of culverts, particularly below embankments.

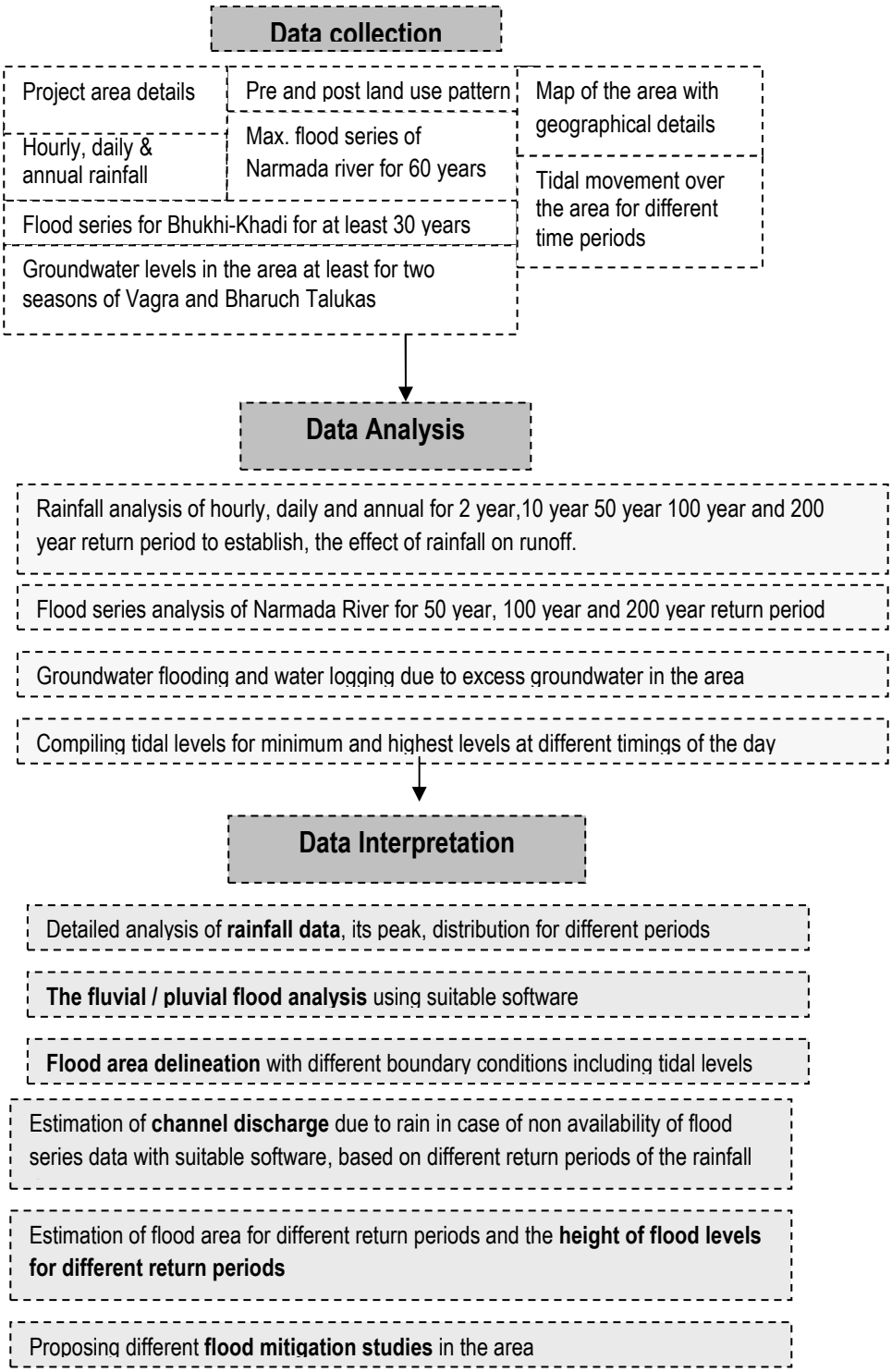
Measurement of Flood Risk: Flood risk is measured by its "return period". The return period of a flood is a measure of its rarity, defined as the average interval in years between occurrences of floods that exceed it, for example one in 200 year event. The degree of risk in probability is termed as the Annual Exceedance Probability (AEP). This is the probability associated with a return period.

Thus, an event of return period 200 years has an AEP of 0.5%.
Calculations of return period is based on-

- Assumptions from historical records of floods (reasonably unbiased sample).
- Conditions (e.g. climate and land use) have been basically constant during the period of the record.

It is a general practice to estimate the floods based on different return periods from 2 years to 200 years from local floods to high floods for analysing the risk and initiate flood mitigation measures.

### 2.1.1 FRA Study Methodology



**Software used for FRA**

- **ArcGIS** for interpreting the geographical content of the study
- **HEC_RAS** for estimating the flood levels and flood prone areas
- **HEC_HMM** for estimating the channel flood flow in case there were no flood series data is available and also small parts of the area where there are no designated streams.
- **Microsoft office** –Word and Excel for regular work.

## 2.2 FRA Baseline Study

Baseline condition of the GPCPSIR is based on the following aspects-

- Soil
- Hydrology – Rainfall, Runoff
- Peak Flood Discharge
- Tanks
- Tidal Levels

These aspects and methods of its analysis are explained below-

### 2.2.1 Soils

The soil map of the study area is given as per the Soil Bureau of India, Nagpur. Types of soils in GPCPSIR are-

Table 2.1: Type of Soils in GPCPSIR

| Soils | Explanation |
|---|---|
| Very deep somewhat excessively drained, calcareous sandy soils | Soil is on sandy very gently sloping plains. Moderately eroded, associated with very deep, well drained coarse loamy, calcareous soils with loamy surface slightly eroded slightly saline. |
| Very deep well drained coarse loamy calcareous soils | These soils are found on sandy surface on very gently sloping plains, moderately eroded, associated with very deep, wee drained coarse loamy soils with loamy surfaces, slightly eroded. |
| Very deep well drained coarse loamy calcareous soils | On sandy surface on very gently sloping plains, moderately eroded, associated with very deep, wee drained coarse loamy soils with loamy surfaces, slightly eroded. |
| Very deep well drained coarse loamy soils | Soil with loamy surface on nearly level plains with sand dunes, slightly eroded, associated with very deep somewhat extensively drained, sandy soils with sandy surfaces, moderately eroded. |
| Very deep moderately well drained fine loamy calcareous soils | Soil with loamy surface on nearly level plain, slightly saline, slightly sodic, moderately flooded, associated with very deep moderately well drained, fine loamy soils with loamy surface, slightly eroded. |
| Very deep Well drained stratified, coarse loamy soils | Soil with loamy surface on mainly level plain, slightly eroded slightly sodic, subjected to slightly flooding associated with very deep well drained calcareous stratified coarse loamy soils with loamy surface moderately eroded. |
| Very deep, well drained calcareous, stratified coarse loamy soils | Soils with loamy surface on nearly level plain, slightly eroded associated with deep well drained, coarse loamy soils with loamy surface slightly eroded. |

| Soils | Explanation |
|---|---|
| Very deep, moderately well drained fine loamy calcareous soils | Soils with loamy surface on nearly level plain, slightly eroded slightly saline, slightly sodic, subjected moderate flooding, associated with very deep, moderately well drained, fine loamy soils with loamy surface slightly eroded. |

Source: Soil Bureau of India

A few soil analysis data collected by the study team is given below.

Table 2.2: Soil Typology

| Particle size distribution (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sr .No | Sample Location | Sand | Clay | Silt | Hydraulic Conductivity (Ks) (mm/hr) | Texture class | Bulk Density (gm/cm^3) | Porosity (%) | Water Holding capacity (%) |
| 1 | Project site | 84 | 6 | 10 | 11.70 | Loamy sand | 1.11 | 56 | 44 |
| 2 | Luvara | 62 | 8 | 30 | 11.43 | Sandy Loam | 1.34 | 62 | 48 |
| 3 | Jolva | 60 | 10 | 30 | 11.12 | Sandy Loam | 1.4 | 55 | 49 |
| 4 | Jageshwar | 42 | 18 | 40 | 9.31 | Loam | 1.28 | 43 | 36 |
| 5 | Ambheta | 86 | 4 | 10 | 11.92 | Loamy sand | 1.12 | 52 | 40 |
| 6 | Dahej | 42 | 12 | 40 | 10.75 | loam | 1.46 | 48 | 38 |
| 7 | Kaladara | 82 | 6 | 12 | 11.70 | Loamy sand | 1.12 | 44 | 36 |
| | Average | 65.4 | 9.1 | 24.6 | 11.26 | | | | |

## 2.2.2 Hydrology

### 2.2.2.1 Rainfall Data & Analysis

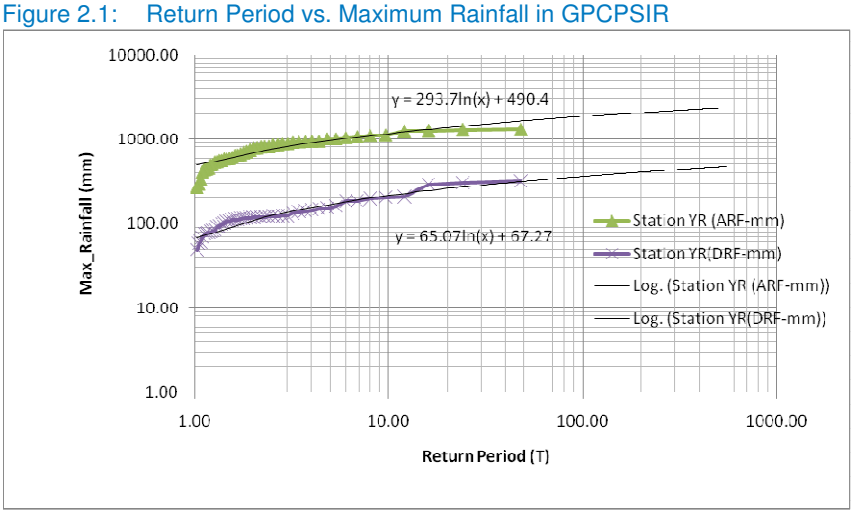
Data: The rainfall data of Bharuch, Hansot, Muller, Vagra and Dahej were collected from 1962 to 2008. In many stations, the data is not adequate and complete. Therefore, for flood analysis, data has been extrapolated. Method of extrapolation is given below.

Analysis:

**Step 1:** The average maximum daily rainfall and average annual rainfall of all the stations is compiled by **Station year method**. The basic data and yearly averages are given in Appendix A.1.

**Step 2:** Rainfall analysis done is for both **daily and annual rainfall** and estimated the **maximum rainfall** (daily rainfall maximum) for different return periods. The average annual rainfall is 772.55 mm and the average Daily rainfall is 129.77 mm. RP for respective years is given in Appendix A.2 table Rainfall analysis.

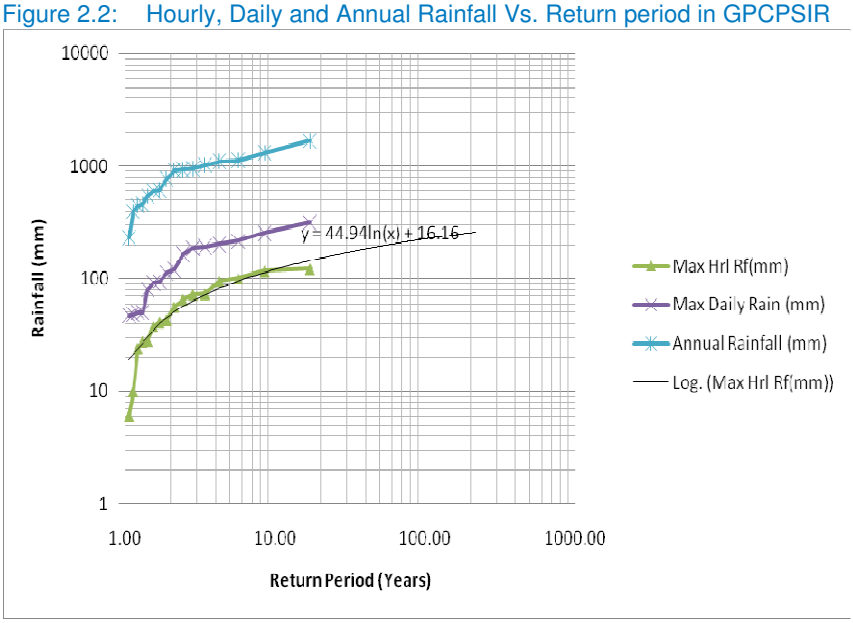
Figure 2.1: Return Period vs. Maximum Rainfall in GPCPSIR




Source: State Water Data Centre, Rainfall Analysis, Details shown in Appendix A.2

**Step 3:** A similar calculation is given in Appendix A.3 explaining the relation between Hourly, Daily and Annual Rainfall and Return period. Graph showing **Hourly, Daily and Annual Rainfall vs. Return period** is given below-

Figure 2.2: Hourly, Daily and Annual Rainfall Vs. Return period in GPCPSIR



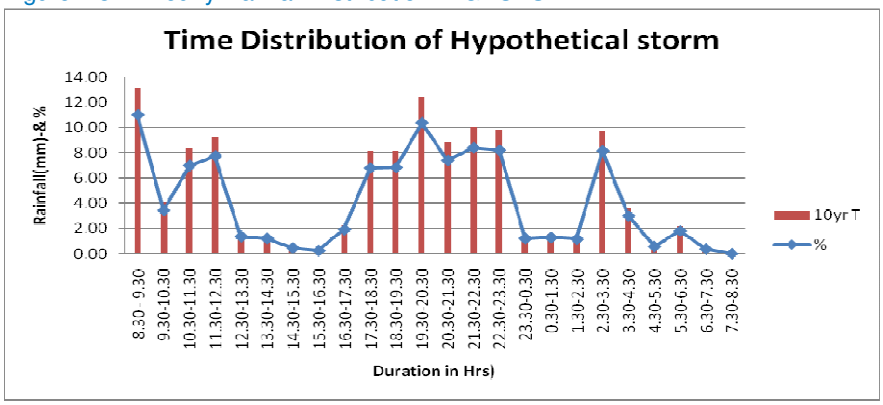

Source: State Water Data Centre, Hourly, Daily and Annual Rainfall Vs. Return period analysis, Appendix A.3

Output of step 3, forms the input for step 4 calculation.

**Step 4:** The hourly rainfall data is only available for 16 years in Bharuch Station and the same is used. The maximum hourly rainfall was selected for the year's data available and analysed in step 3. This data (Appendix A.4) has been adjusted to the different return periods for estimating the **maximum hourly rainfall** as it is required especially for pluvial floods. The graph below indicates the result.

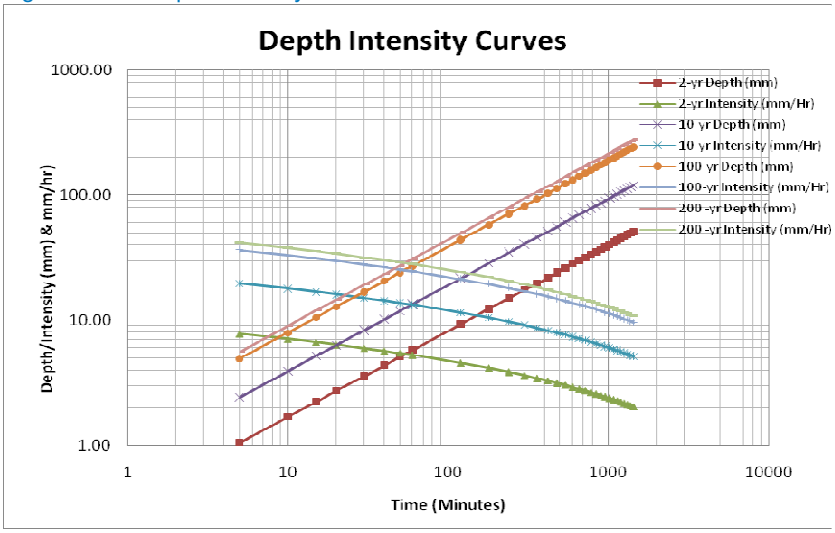
**Step 5:** The hourly rainfall distribution of hypothetical storm has been utilised to calculate depth intensity of floods for various return period. This analysis measures both depth and duration of flood.

Figure 2.3: Hourly Rainfall Distribution in GPCPSIR




Source: State Water Data Centre, Hourly Rainfall Distribution analysis in Appendix A.4

Figure 2.4: Depth Intensity Curve of Floods in GPCPSIR




Source: MM Analysis Depth intensity Curve, Appendix A.5

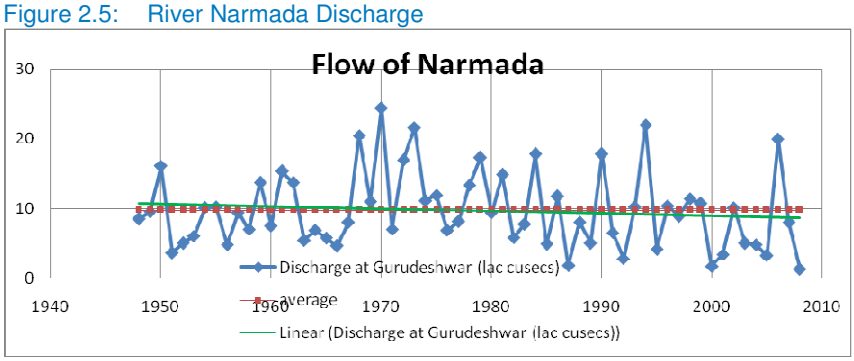
### 2.2.2.2 Runoff

The data of flood series is available for 60 years with Narmada Authorities. The nearest station is at Garudeswhar. The same is analyzed and the details are discussed below.

The flow in the Narmada varies from about 1.26 lakh cusecs to about 24.5 lakh cusecs with an average of 9.68 lakh cusecs. The standard deviation is about 5.52. The trend appears to be gradual reduction in the flow in the Narmada towards outfall area during the last 60 years.

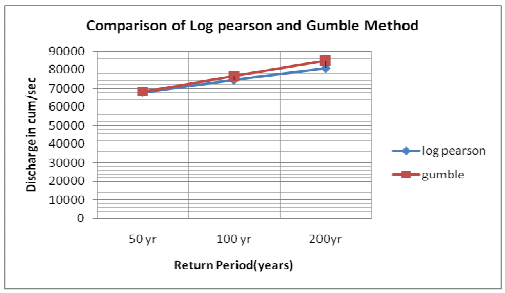
The flood frequency in the river has been estimated both by Log Pearson and Gumble method and the different flows are estimated for different return periods. Flood estimations from Log Pearson and Gamble method are compared and shown in Table 2.3 and Figure 2.6. Average of both the methods is taken further for analysis.

Figure 2.5: River Narmada Discharge




Source: Gujarat Water Supply & Sanitation Board, Flow in River Narmada, 1948-2008

Figure 2.6: Comparative Analysis




Source: MM Analysis

Table 2.3: Comparisons of Log Pearson and Gamble method

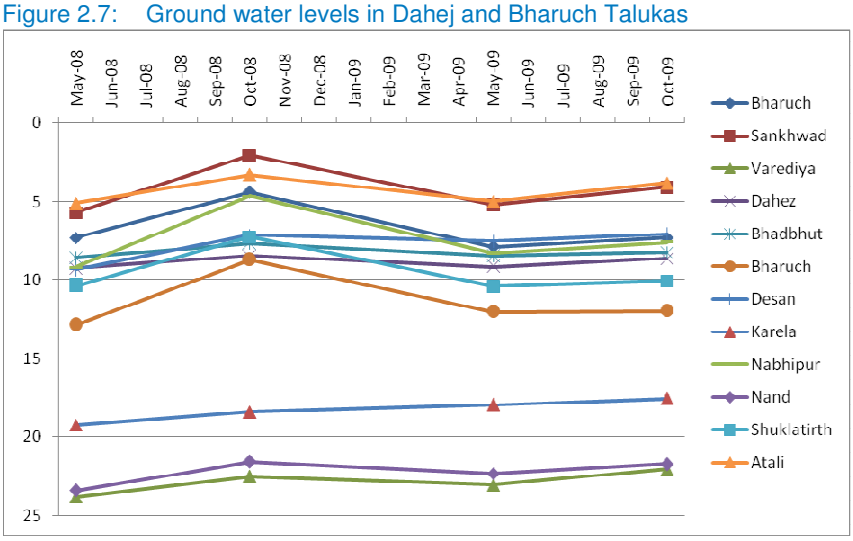
| T (Years) | xt=antilog of zt | Flood (lakh cusec)- Log Pearson | Flood (lakh cusec)- Gumble | Average of two methods (Lakh CFS) | Average of two methods (m^3/sec) |
|---|---|---|---|---|---|
| 2 | 8.7 | 8.7 | 10.18 | 9.44 | 26731 |
| 10 | 17.42 | 17.42 | 17.1 | 17.26 | 48874 |
| 25 | 21.31 | 21.31 | 21.05 | 21.18 | 59975 |
| 50 | 23.94 | 23.94 | 24.03 | 23.985 | 67917 |
| 100 | 26.34 | 26.34 | 27.01 | 26.675 | 75534 |
| 200 | 28.53 | 28.53 | 29.99 | 29.26 | 82854 |
| | | | Average | 9.68 | 27410 |

### 2.2.2.3 Ground water levels

The water levels are less than 10 m below ground level in all most all the study area. The quality of shallow groundwater is saline and is more than 3000 MicroSeimens /Cm while deep aquifers have more than 5500 MicroSeimens /Cm. As per the Central Groundwater Board, the area West of Vagra is saline ad not suitable from groundwater development.

Gujarat Water Resources Development Corporation (GWRDC) monitors the groundwater levels throughout Gujarat. The pre-monsoon and post monsoon groundwater levels for shallow aquifers for the year 2008 and 2009 collected by GWRDC is given in the graph below:

Figure 2.7: Ground water levels in Dahej and Bharuch Talukas




Source: GWRDC

The fluctuation is groundwater levels indicate that the fluctuation is about 0.04 m to about 1.14 m from May 09 to October 09 while it is higher from 0.77 to 4.53 during May 2008 to October 2008 indicating that larger declines during May 08 and higher withdrawal of water due to less rainfall in that period and subsequent rise of groundwater levels due to good monsoon.

### 2.2.2.4 Ground water potential

The groundwater potential of the area has been studied by Central Groundwater Board and the same is given below. As seen from the table, there is ample groundwater potential exists in the area and the same can be exploited by drilling tube wells at suitable locations.

Table 2.4: Ground water potential

| Sr.No | Details | Vagra | Bharuch |
|---|---|---|---|
| 1 | Gross Groundwater Recharge in MCM/Year | 16.35 | 80.33 |
| 2 | Available groundwater Recharge in MCM/year (95%) | 15.53 | 76.32 |
| 3 | Groundwater draft for irrigation MCM/year | 1.23 | 27.93 |
| 4 | Existing Domestic and industrial draft in MCM/year | 1.46 | 2.71 |
| 5 | Existing Gross groundwater draft for all users in MCM/year | 2.69 | 30.64 |
| 6 | Existing groundwater balance in MCM/year | 12.84 | 45.68 |
| 7 | Level of groundwater development (%) | 17.32 | 40.15 |
| | Category | Safe | Safe |

### 2.2.2.5 Peak discharge for local Nallah

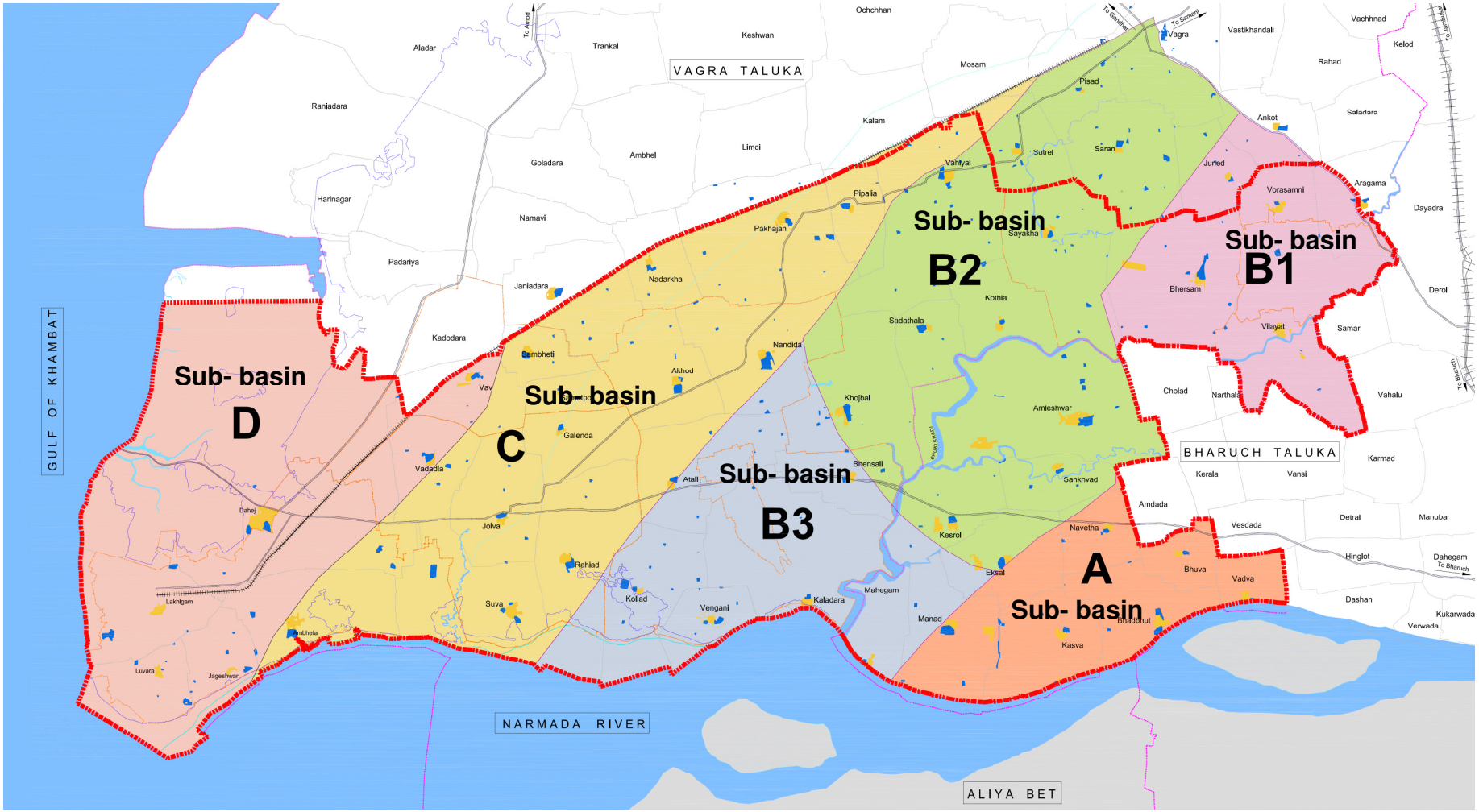
There is no flood discharge estimates from the local Nallah for estimating the pluvial floods. As such, the area has been divided into different sub basins based on the contours and the surface water movement and the maximum possible peak flood discharges has been estimated using HEC-HMS software.

The map of the sub areas is given in the figures after the following table. The peak discharges estimated with the help of HEC-HMS are given below. The detailed discussions are given separately.

Table 2.5: Peak Discharge

| Peak discharges for different sub basins-HEC-HMS calculations | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-YR Return Period | | | | | | | | | | | | |
| | A | A(J) | B1 | B1(J) | B2 | B1(J)+B2 (J) | B3 | B1(J)+ B2 (J)+B3 (J) | C | C(J) | D | D(J) |
| Area(sq.km) | 35 | 35 | 53 | 53 | 102 | 155 | 62 | 217 | 119 | 119 | 82 | 82 |
| peak disch)M^3/sec | 16.4 | 14.9 | 24.8 | 22.6 | 47.8 | 66 | 29.1 | 81.8 | 50.8 | 50.8 | 35 | 35 |
| Q(cum)*1000 | 1105.9 | 1105.8 | 1674.7 | 1674.6 | 322.8 | 4897.4 | 1958.9 | 6852.3 | 3759.8 | 3759.8 | 2590.8 | 2590.8 |
| 10-YR Return Period | | | | | | | | | | | | |
| peak disch)M^3/sec | 41.5 | 41.5 | 68 | 62.8 | 131 | 166.4 | 79.6 | 230.9 | 152.6 | 141 | 105.3 | 97.2 |
| Q(cum)*1000 | 3260.1 | 3260.1 | 4936.8 | 4936.8 | 9501.1 | 14438 | 5775.2 | 20201.6 | 11084.6 | 11084.4 | 7638.1 | 7638 |
| 100-YR Return Period | | | | | | | | | | | | |
| peak disch)M^3/sec | 96.1 | 89.1 | 145.6 | 135 | 280.2 | 394.1 | 170.3 | 498.9 | 326.9 | 303.1 | 225.2 | 208.8 |
| Q(cum)*1000 | 7165.1 | 7165.1 | 10850.7 | 10849.8 | 20881.1 | 31731.1 | 12692.4 | 44398.3 | 24361.2 | 24360.8 | 16787 | 16786.5 |

Figure 2.8: Peak Discharge map for Sub-Basins

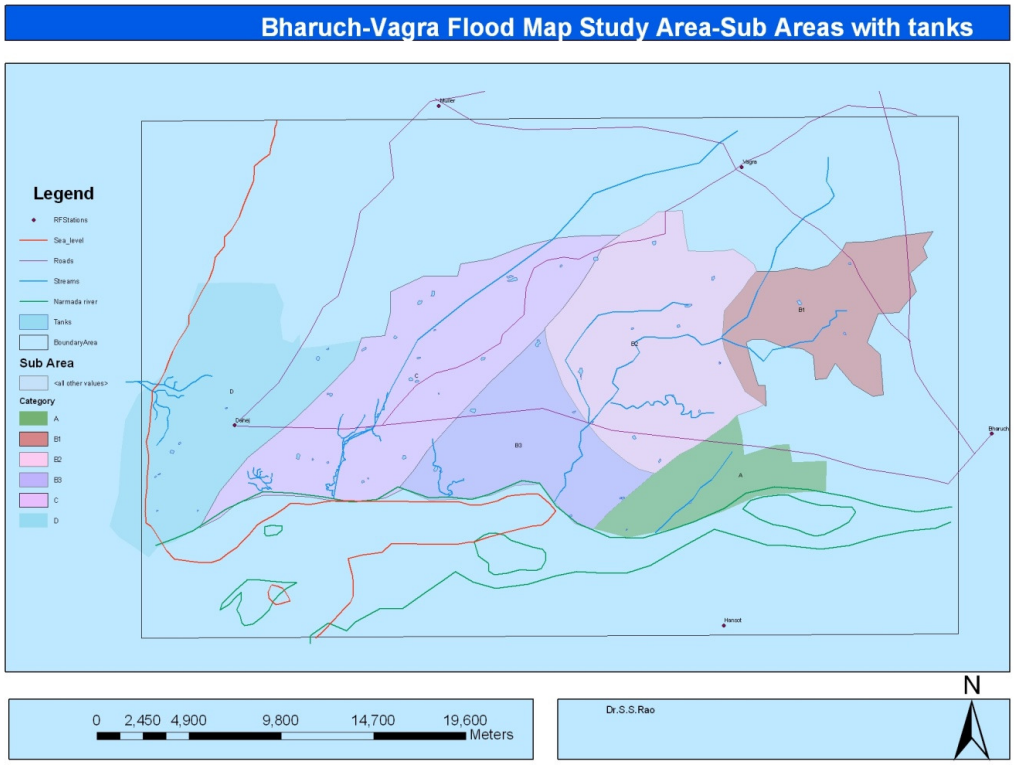



Source: MM

### 2.2.2.6 Tanks

About 56 major tanks could be identified from satellite map on one million sqm area with a total storage capacity of about 3 mcm in these tanks. There are much more tanks in the area, than identified from satellite map. These tanks work as stabilizing areas for flood protection and these should be preserved as far as possible even after development. The location of the tanks is given below.

Figure 2.9: Tanks in GPCPSIR




Source: Storage of tank, Appendix A.7

Details of the tanks are given in the Appendix A.7, table: Storage of Tanks. The impact of presence of tanks is discussed further with pluvial floods.

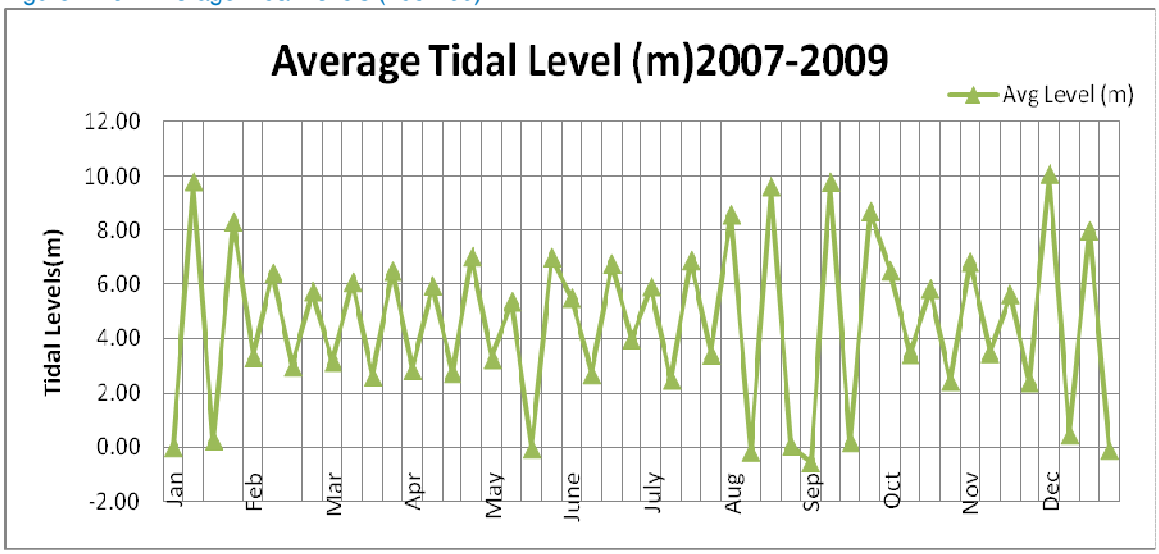
### 2.2.2.7 Tidal levels

The tidal information has been collected from 2007 to 2009 data given in Annexure and the same has been analysed the month wise, time wise rise and fall of the levels to study the effect of the same along with fluvial and pluvial floods.

Monthly: The month wise effect of the tidal levels have been studied and given below. The maximum is observed in the month of December and the minimum in the month of September. It is

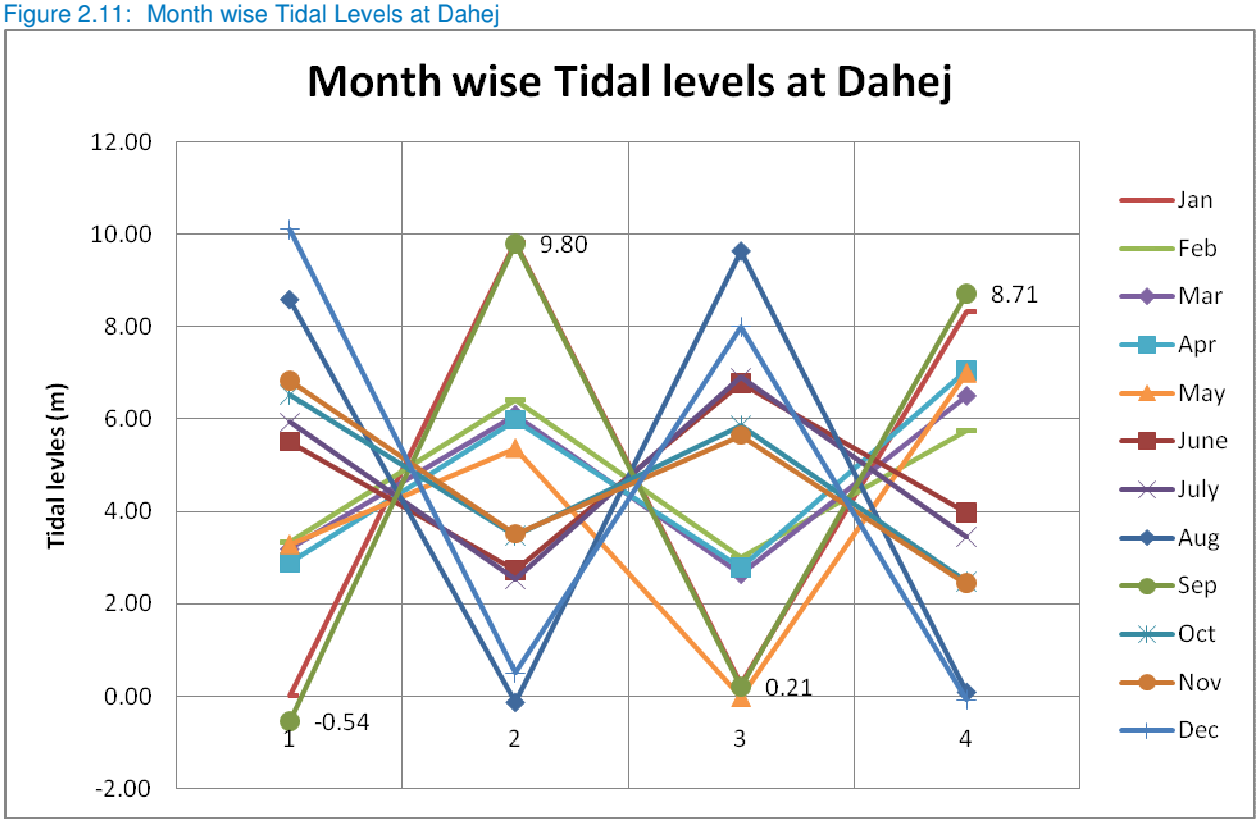
also noticed that the maximum and minimum floods broadly occur near full moon day or No-Moon day “Amavas”. Even though, the maximum appears on the month of December, the month of September is very important mainly due to concurrent maximum and minimum along with high rainfall and peak floods. Accordingly, the tidal levels of month of September were considered for estimating the tidal effect along with floods while analyzing the same with HEC-RAS software.

Figure 2.10: Average Tidal Levels (2007-09)




Source: Tidal Data from Gujarat Maritime Board shown in Appendix A.8

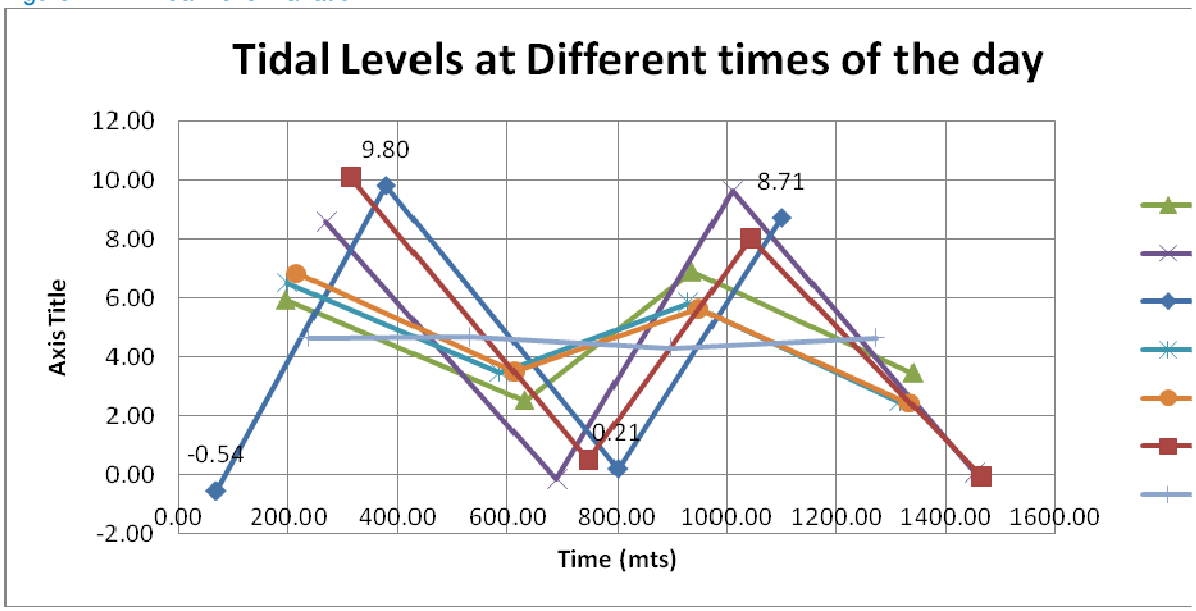
Figure 2.11: Month wise Tidal Levels at Dahej




Source: Tidal Data from Gujarat Maritime Board shown in Appendix A.7

Daily: The daily change of tidal levels has been studied. It is observed that there are at least two highs and two lows in a day. The maximum tidal levels have been observed mainly during full moon or full dark days of the month. The same is given below mainly for the rainy season.

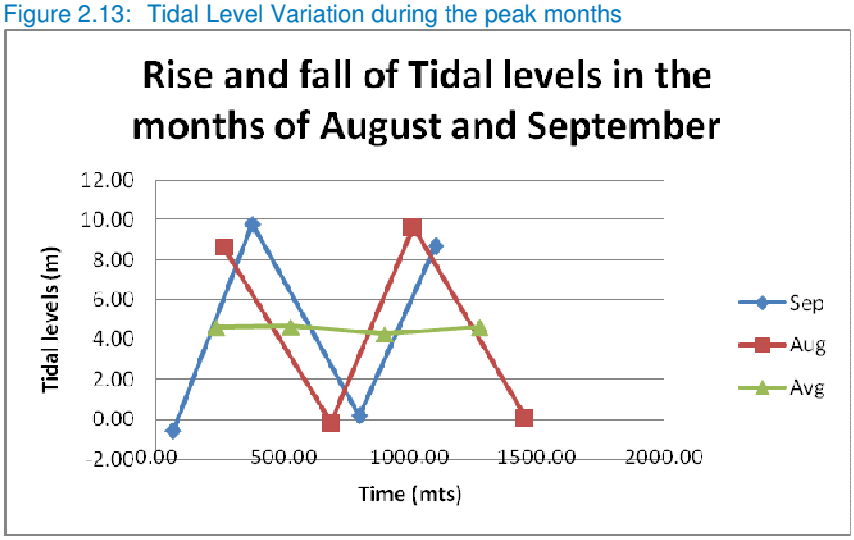
Figure 2.12: Tidal Level Variation




Source: Tidal Data from Gujarat Maritime Board shown in Appendix A.7

As seen from the above graph, the high tide occurs in the month of September. The rainfall is also normally highest in this month and the flood in the river is also highest in this month.

Figure 2.13: Tidal Level Variation during the peak months




Source: Tidal Data from Gujarat Maritime Board shown in Appendix A.7

### 2.2.3 Flood Risk Analysis for GPCPSIR area

Flood analysis involve assessment of levels of floods, analysis of flood plains, extent of floods for 2yr peak, 10 yr peak and 200 yr peak fluvial and pluvial flood area.

#### 2.2.3.1 Fluvial Floods with Tidal effect

Fluvial and tidal floods in River Narmada can not be separated as the study area is the outfall of the area is Cambay basin.

The floods are caused due to fluvial, pluvial, tidal and groundwater flooding. The fluvial floods in the region are caused mainly due to Narmada River along with the tidal effect. It is not possible to separate the fluvial and tidal as the study area is the outfall of the area is Cambay basin. Accordingly, the tidal effects as well as high flood effect has been studied with HEC-RAS. Data considered were:

Table 2.6: Flood Data

| Return Period (T )(Years) | Flood (lakh cusec)- Log Pearson | Flood (lakh cusec)- Gumble | Average of two methods (Lakh CFS) | Average of two methods (m^3/sec) |
|---|---|---|---|---|
| 2 | 8.7 | 10.18 | 9.44 | 26731 |
| 10 | 17.42 | 17.1 | 17.26 | 48874 |
| 25 | 21.31 | 21.05 | 21.18 | 59975 |
| 50 | 23.94 | 24.03 | 23.985 | 67917 |
| 100 | 26.34 | 27.01 | 26.675 | 75534 |
| 200 | 28.53 | 29.99 | 29.26 | 82854 |
| | | Average | 9.68 | 27410 |

Table 2.7: Tidal Data

| Important Tidal levels | | | | | |
|---|---|---|---|---|---|
| Sep | Time (mt) | 66.00 | 377.33 | 800.00 | 1099.67 |
| | Level (m) | -0.54 | 9.80 | 0.21 | 8.71 |
| Avg | Time (mts) | 236.47 | 529.61 | 897.75 | 1271.97 |
| Avg | Level (m) | 4.64 | 4.68 | 4.31 | 4.64 |

#### 2.2.3.2 HEC-RAS/ HEC-GEORAS Analysis

##### Hydrologic and Hydraulic Models:

Representation of flooding is accomplished using two types of models: hydrologic and hydraulic.

- Hydrologic modeling simulates the hydrologic response (flow) of a basin to a given input of rainfall. HEC-1 and HEC-HMS are two types of hydrologic models used.
- Hydraulic modeling simulates the hydraulic response (water surface profiles) of a stream to a given input of flows. HEC-2 and HEC-RAS are the hydraulic models used.

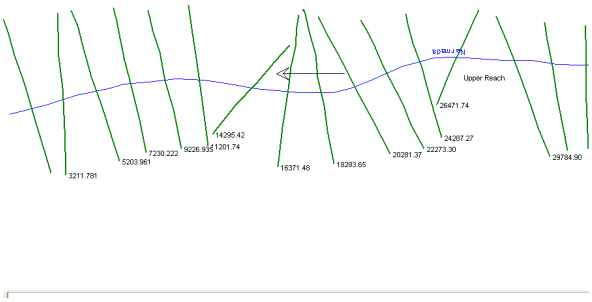
Both hydrologic and hydraulic models are needed for an in-depth flood analysis of any watershed system. HEC-RAS is used in estimating the fluvial floods caused by R. Narmada, as the flood series data of Narmada is available.

##### Geometric Data

Geometric data includes the map of the area, river channel and flood plain and the cross sections across the river. The geometric calculations were exported to ARCGIS and the spatial distribution of

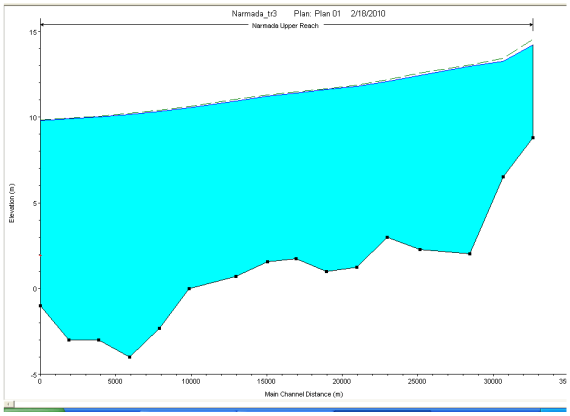
the floods was estimated. The more number of cross sections, more realistic are the results. The number of cross sections on the river and longitudinal (Figure 2.14& Figure 2.15) as well cross sections for different profiles of average flow(Profile 1), 100 year (Profile 2)and 200 year (Profile 3) flow are given in Appendix B.1 for comparison purposes.

Figure 2.14: No. of Cross Sections observed on R. Narmada



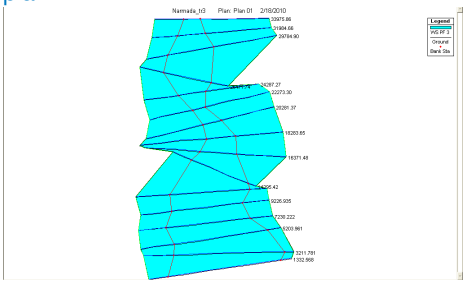

Source: MM Analysis

Figure 2.15: Longitudinal profile of River Narmada




Source: MM Analysis

Figure 2.16: X-Y-Z Perspective of the flood plain



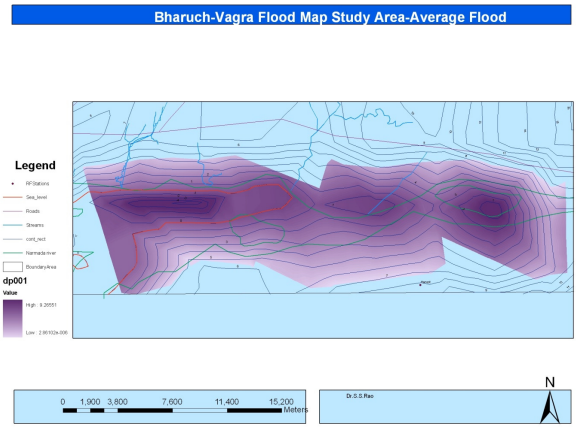
Source: MM Analysis, Geometric Analysis (Appendix:B.2 )

shown below.

### 2.2.3.3 Flood plain analysis

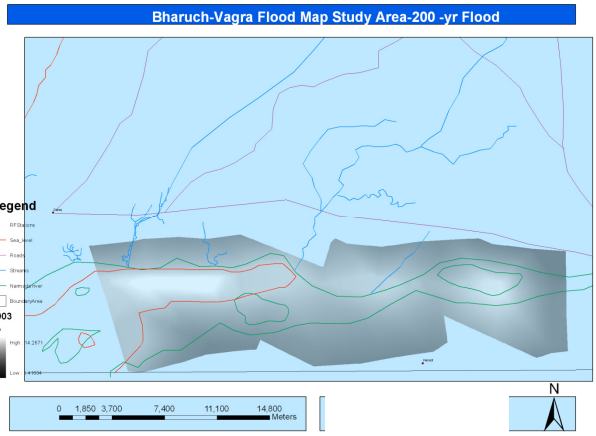
Arial Extent of flood affected area: About 57 sq.km in North of the normal flood plain area would be effected if the average flood of 9.66 lakh cusecs flow in the river along with an average tidal effect of 4.5 m. In case of profile 3 of 200 year flood about 74 sq.km of area would be effected along with the high tidal of 9.8 m. The same is shown below. **Approximately about 1 km north of the present flood plain may be affected due to high floods which require protection in low lying areas.** There is not much difference between 100 yr and 200 yr flood profile. As such, only average profile and maximum profile is

Figure 2.17: Extent of Avg. Flood




Source: MM Analysis, Geometric Analysis (Appendix:B.2 )

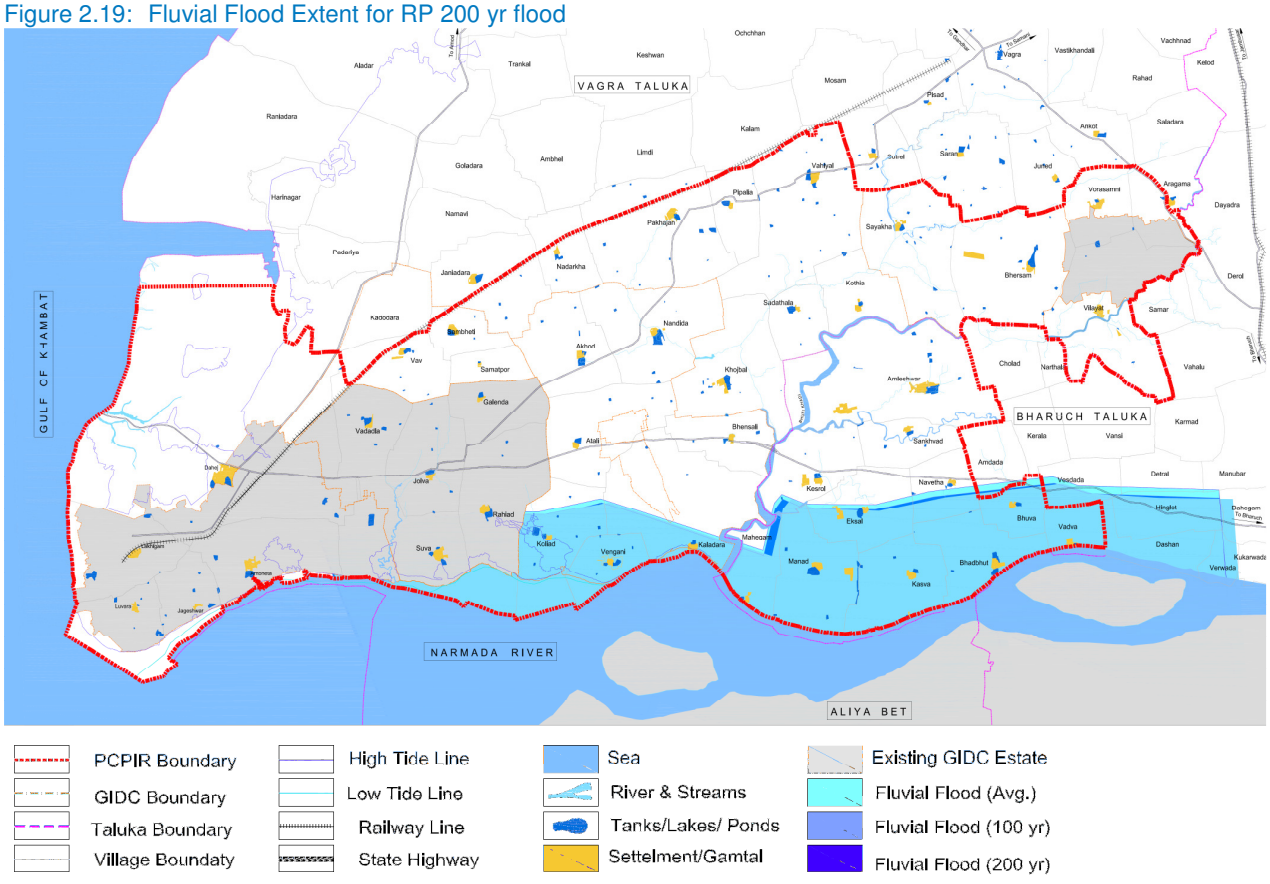
Figure 2.18: Extent of RP 200yrs flood




Source: MM Analysis, Geometric Analysis (Appendix:B.2)

Arial Extent of flood affected area (Combination of average and 200 yr flood).

Figure 2.19: Fluvial Flood Extent for RP 200 yr flood




Source: MM Fluvial Flood Risk analysis, Appendix: B.2

### 2.2.3.4 Effects of tidal waves on the fluvial floods

The effects of tidal waves have been included in the boundary conditions in the above flood analysis. For average flow conditions, the average high flood of 4.5 m included while, the highest of 9.8 m tidal level for the month of September is considered for the 100 year and 200 year floods. The results are shown in the earlier Figure 2.19.

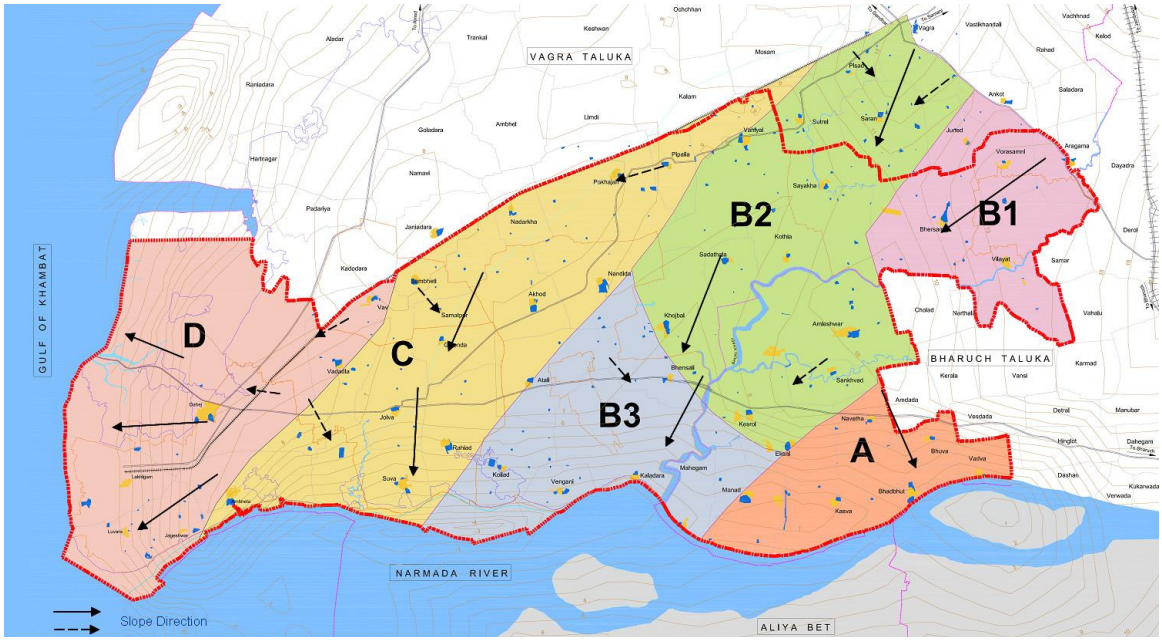
### 2.2.3.5 Pluvial Floods

Pluvial floods are caused due to the constraints in the drainage system during heavy rains. The drainage system cannot carry the excess rainfall and results into heavy temporary floods. This is normally difficult to estimate. There are mainly two aspects of pluvial floods.1) Prediction of heavy rainfall 2) the effect of heavy rainfall on the drainage basin.

#### Local Streams

In the present case, there are numbers of small local streams which carry the excess water through their natural stream/ channels to the main river Narmada or sea. Broadly they are shown in the following table.

Figure 2.20: Drainage Sub basins




Source: MM

In addition the project area has been divided into sub areas based on the contours and the drainage pattern of the area. Pluvial floods mainly depend on slope and drainage pattern. The sub areas have been divided as A, B, C, and D. Based on the stream pattern, the B sub area has been further divided as B1, B2, and B3 for calculating the discharge capacity of the drainage based on the rainfall with different return periods.

The peak hourly rainfall area was available only for 16 years and the same is attuned for the peak daily and peak annual rainfall years for different return periods from Figure. Hourly Rainfall Distribution & Peak Discharge for local Nallah is given earlier in section 2.2.2. The detailed analysis is given in the section on hydrology, which is summarized below-

Table 2.8: Maximum Depth as per the return period

| Return Period | Daily Depth of Rainfall (mm) |
|---|---|
| 02-yr | 51.2 |
| 10-Yr | 119.38 |
| 100-yr | 241.51 |
| 200-yr | 275.24 |

There is a great difference between 2-yr return period and 10 yr return period where the major pluvial floods occur, which have to be taken care of while 100 yr and 200 yr daily rainfall even though very high, cannot be taken care of as no drainage system is efficient to drain excess water during a specific high rainfall period. Generally 2 yr and 10 yr daily rainfall events are considered to be associated with the pluvial floods.

#### 2.2.3.6 HEC-HMS analysis

##### Hydrologic and Hydraulic Models:

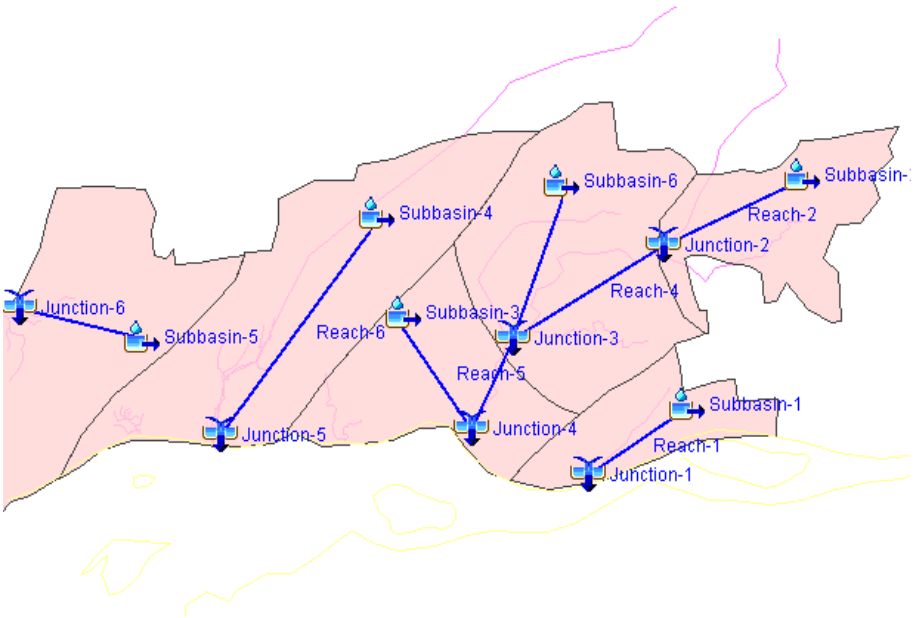
Representation of flooding is accomplished using two types of models; hydrologic and hydraulic. HEC-RAS was used in estimating pluvial floods as the flood series data of Narmada is available.

##### HEC-HMS:

Hydrologic Modelling System (HEC-HMS) allows manipulation of hydrologic elements such as basin and river reaches and the easy input of basin characteristics. The model broadly consists of Sub basin, Reach and Junction where the peak discharge is calculated which is crucial.

The peak floods estimate analysed for local nallah and sub basins of the Study area, discussed in the section 2.2.2, are inputs for Pluvial hydrological & hydraulic modelling. The schematic diagram of the study area is given below.

Figure 2.21: HMS of Sub Basin

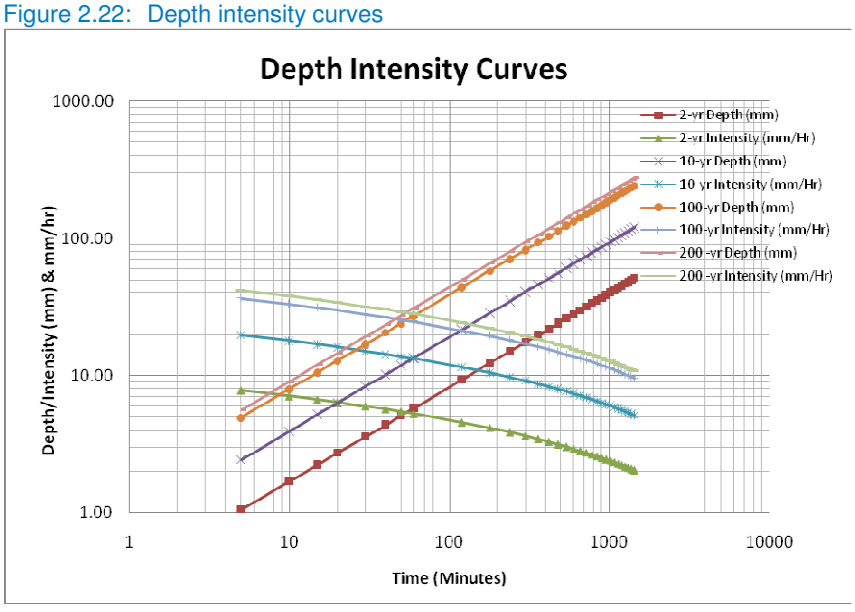



Source: MM analysis

The main results of the modelling are indicated below, while the calculations are given in the Appendix C.1.

The results are calculated for 2 yr-10 yr and 100- yr and 200-yr return period of the daily peak rainfall. The depth intensity curves are shown below for different return periods.

Figure 2.22: Depth intensity curves




Source: MM analysis, Details in Appendix C.1.

### 2.2.3.7 Estimation of pluvial floods

The estimation of pluvial floods in different sub basins are calculated using HEC-RAS with the peak floods generated from HEC-HMS for different sub basins. Various calculations for reference are given in Appendix C.2.

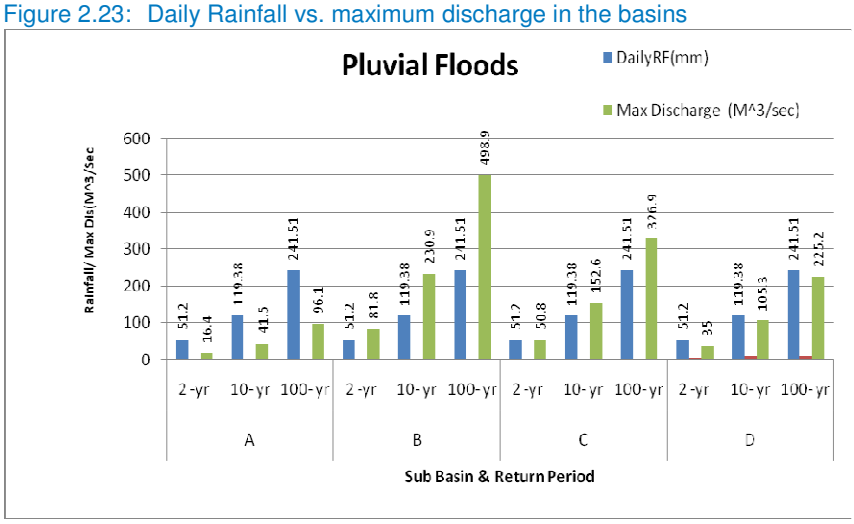
The table and graph given below depict likely pluvial flood affected area.

Table 2.9: Estimates of Pluvial Floods

| Pluvial Floods in the Study Area | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | | | B | | | C | | | D | | |
| | 2 - yr | 10- yr | 100- yr | 2 - yr | 10- yr | 100- yr | 2 - yr | 10- yr | 100- yr | 2 - yr | 10- yr | 100- yr |
| Area(sq.Km) | 35 | 35 | 35 | 217 | 217 | 217 | 119 | 119 | 119 | 82 | 82 | 82 |
| DailyRF(mm) | 51.2 | 119.38 | 241.51 | 51.2 | 119.38 | 241.51 | 51.2 | 119.38 | 241.51 | 51.2 | 119.38 | 241.51 |
| Max Submergence depth(m) | 0.4 | 0.5 | 0.6 | 0.8 | 1 | 1.3 | 0.4 | 0.5 | 0.6 | 5.9 | 11.2 | 11.2 |
| Area (sq.Km) | 4.8 | 5.6 | 6.7 | 17.8 | 28.1 | 35.7 | 26 | 29 | 32.4 | 4.3 | 5.8 | 5.8 |
| Max Discharge (M^3/sec) | 16.4 | 41.5 | 96.1 | 81.8 | 230.9 | 498.9 | 50.8 | 152.6 | 326.9 | 35 | 105.3 | 225.2 |
| Quantity (MCM) | 1.1 | 3.26 | 7.165 | 6.85 | 20.2 | 44.4 | 2.59 | 11.08 | 24.36 | 2.59 | 7.64 | 16.79 |

Daily Rainfall vs. maximum discharge in the basins-

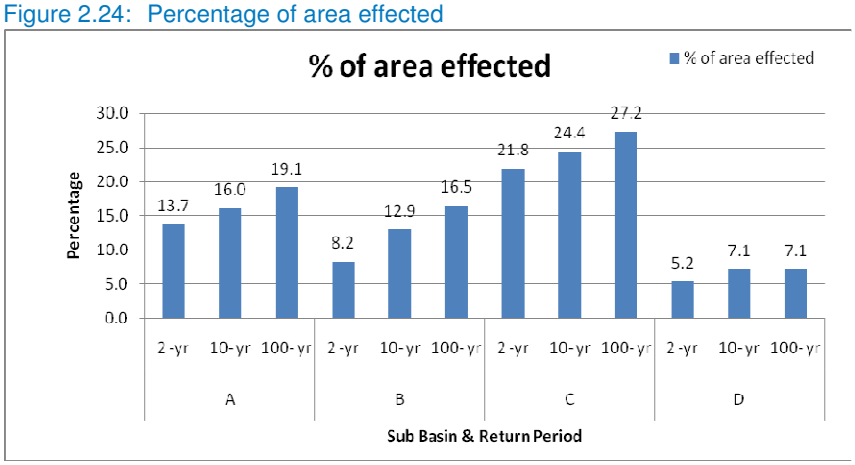
Figure 2.23: Daily Rainfall vs. maximum discharge in the basins




Source: MM analysis, Table: 2.9

From the Pluvial Floods study, the percentage of area affected in various sub-basins for different RP is given in Figure 2.24.

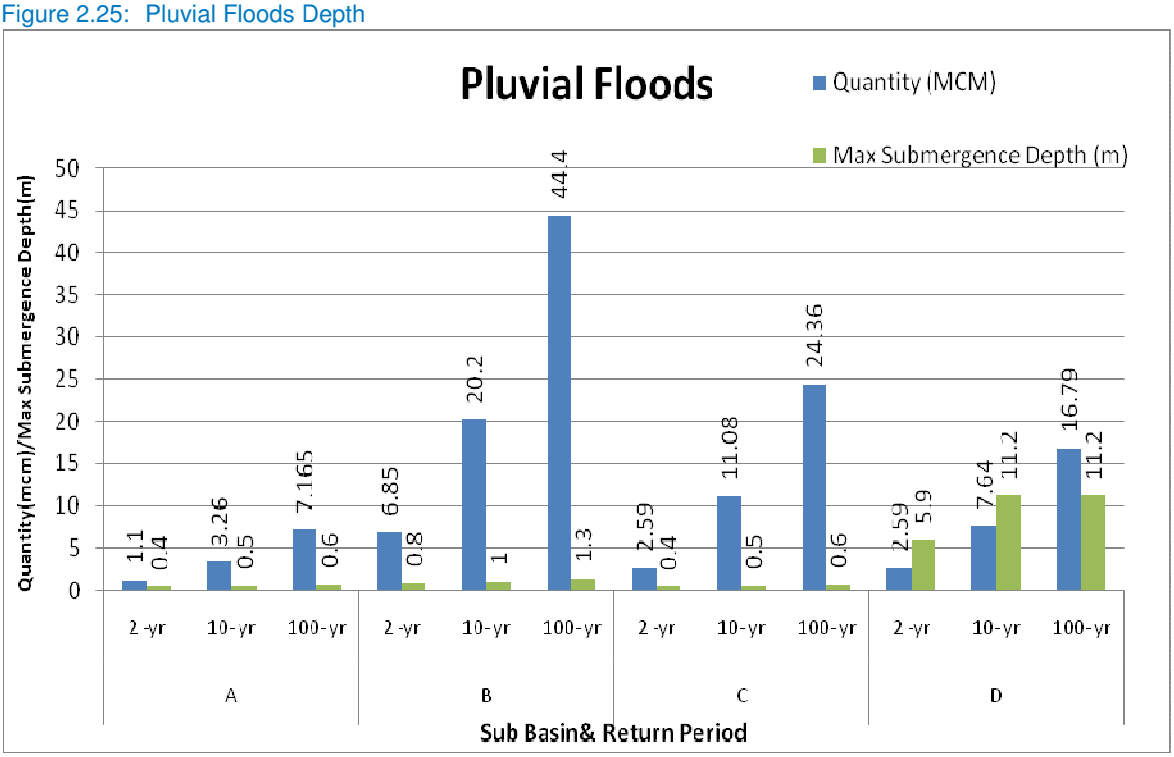
Figure 2.24: Percentage of area effected




Source: MM analysis, Table: 2.9

Quantity of water flowing in the area and the maximum submergence depth due to floods is given in Figure 2.25

Figure 2.25: Pluvial Floods Depth




Source: Estimates of Pluvial Floods, MM Analysis

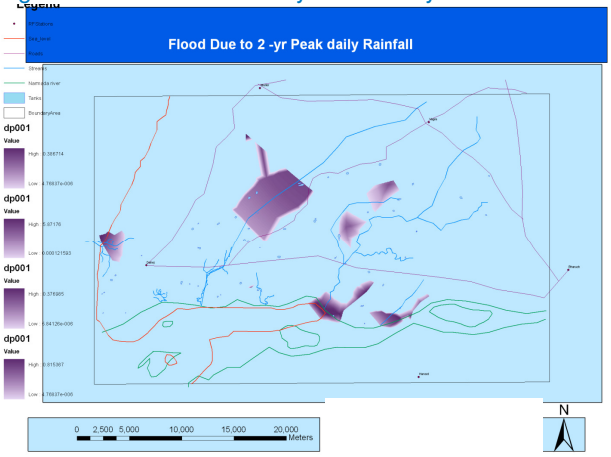
- As seen from the above graphs, it is very clearly seen that there is a lot of difference between 2 -yr daily rainfall flood vs. 10 -year Daily rainfall flood. The drainage is normally designed for 2-yr return period of maximum daily rainfall. If 2 –yr daily rainfall is about 51.2 mm. the 10 year max daily rainfall is in the order of 119.38mm. It can be easily seen that the difference and the flood

effect is maximized from 2-yr to 10 yr max daily rainfall flood. As 10 yr return period is common, the pluvial floods have to be controlled for better safety as well as protection of property.

- One of the major stabilizing facilities is construction of surface tanks as and where feasible which provide water in summer and stabilize the floods in rainy season. There are about 56 tanks deciphered from the satellite imagery covering an area of 1million sqm and approximately storing about 3.0 million cubic meters of water. It is advised to maintain the existing tanks and construct new tanks where ever feasible for controlling pluvial floods.
- The 100 year peak daily rainfall is more than 200 mm which cannot be controlled by normal management practices, it falls into disaster management criteria. Necessary steps have to be taken to control such highly unusual high rainfall and floods from thereof.

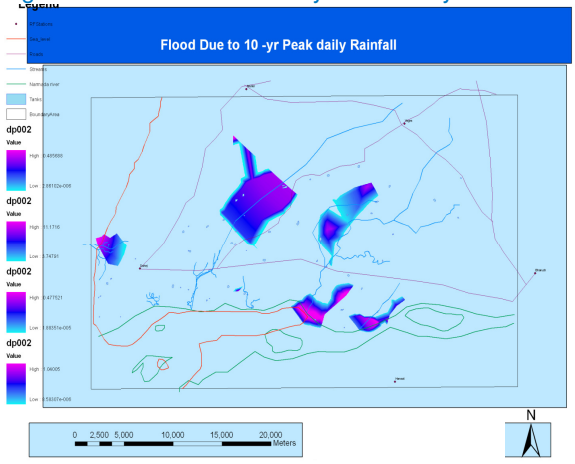
The spatial variation and distribution of pluvial floods resulting due to 2- yr and 10 yr and 100 yr peak daily rainfall is shown below-

Figure 2.26: Flood due to 2yr Peak Daily Rainfall




Source: Pluvial Flood Analysis, Appendix C.2 & C.3

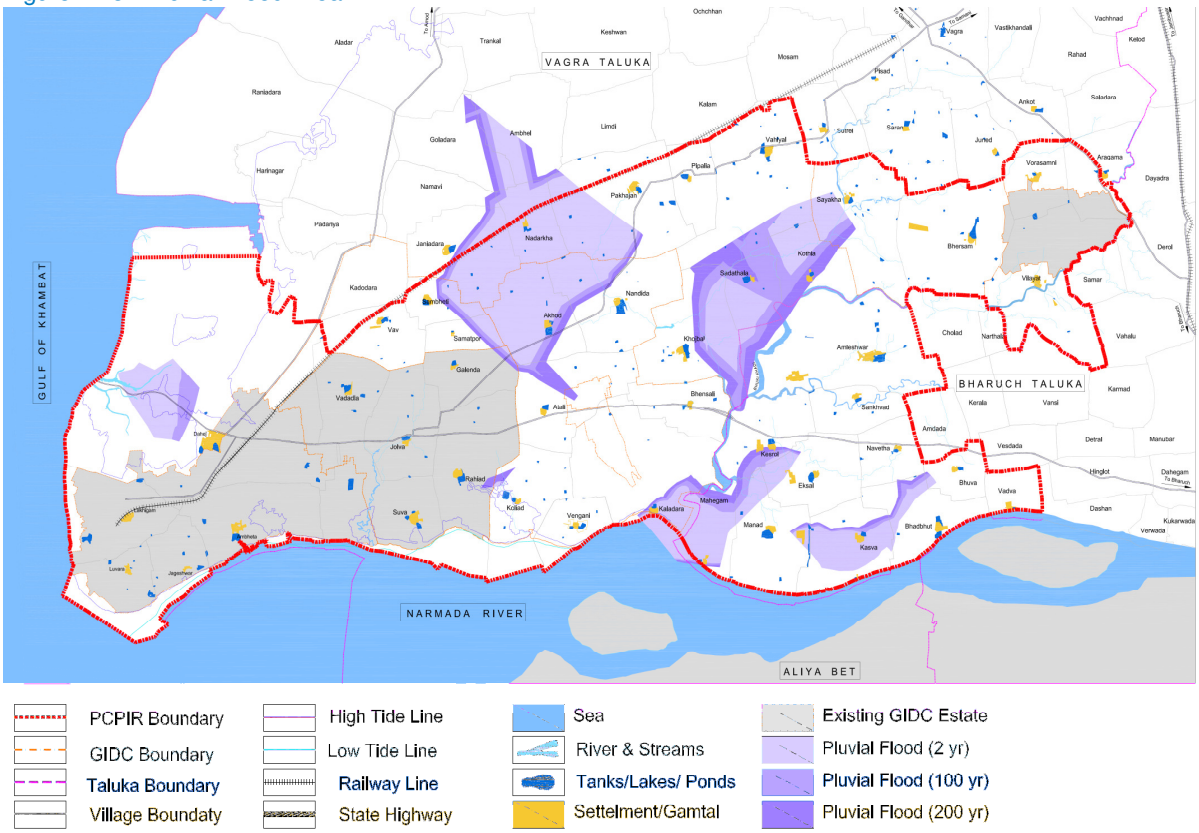
Figure 2.27: Flood due to 10yr Peak Daily Rainfall




Source: Pluvial Flood Analysis, Appendix C.2 & C.3

The spatial variation of pluvial floods for different return periods is given below.

Figure 2.28: Pluvial Flood Area




Source: MM Pluvial Flood Risk analysis, Appendix: C.3

### 2.2.3.8 Groundwater Flood

#### Groundwater quality

The groundwater quality data has been collected from GWRDC for pre-monsoon and post-monsoon periods of 2008 and 2009. The same is shown below.

Table 2.10: Groundwater Quality

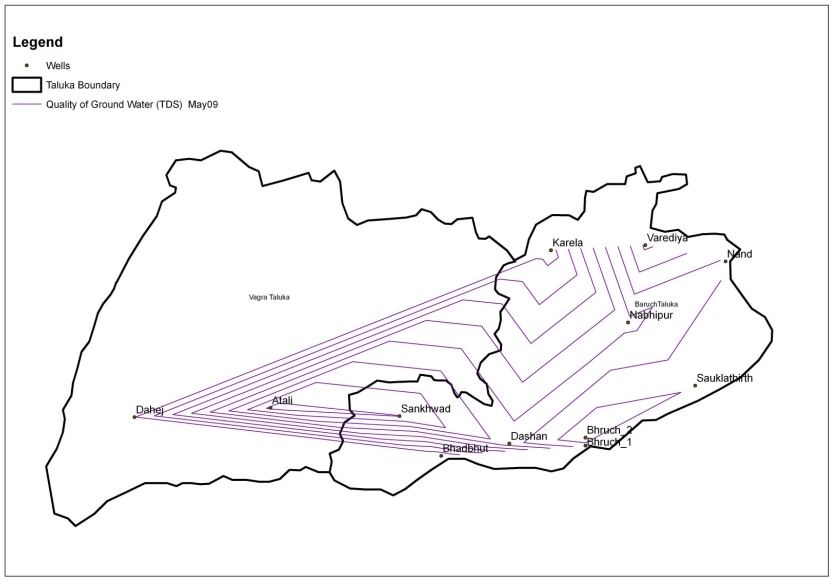
| Sr.No | Taluka | Village | May-08 | Oct-08 | May-09 | Oct-09 |
|---|---|---|---|---|---|---|
| 1 | Bharuch | Bharuch | 990 | 990 | 1220 | 1290 |
| 2 | Bharuch | Sankhwad | 500 | 390 | 490 | 620 |
| 3 | Bharuch | Varediya | 490 | 550 | 390 | 440 |
| 4 | Vagra | Dahej | 3730 | 3860 | 4030 | 3760 |
| 5 | Bharuch | Bhadbhut | 2870 | 3730 | 4400 | 3520 |
| 6 | Bharuch | Bharuch | 300 | 280 | 600 | 410 |
| 7 | Bharuch | Desan | 1800 | 1590 | 1710 | 1700 |
| 8 | Bharuch | Karela | 3830 | 4800 | 4200 | 5170 |
| 9 | Bharuch | Nabhipur | 510 | 1590 | 2140 | 1900 |
| 10 | Bharuch | Nand | 1910 | 1530 | 1580 | 1700 |
| 11 | Bharuch | Shuklatirth | 850 | 790 | 1060 | 950 |
| 12 | Vagra | Atali | 4100 | 440 | 380 | 370 |
| | | Average | 1823.3 | 1711.7 | 1850.0 | 1819.2 |

Source: GWRDC

There are considerable fluctuations in the quality of water from pre to post monsoon periods. Groundwater quality improves from pre monsoon to post monsoon period by about 2 to 6 %.

The spatial variation of quality of water for the pre-monsoon period of May 2009 was drawn and shown in the map below. Broadly, the total dissolved solids are in the order of about 4000 mg/l while it is reducing towards East and North of the area.

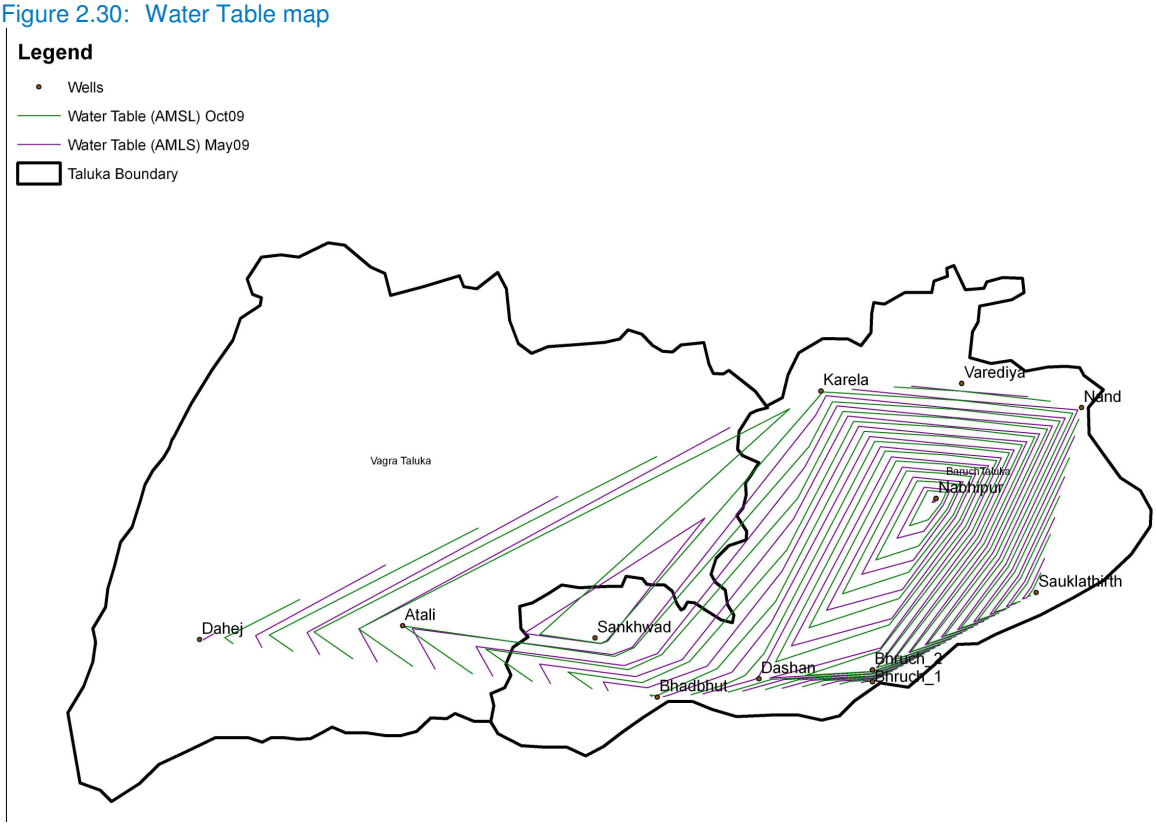
Figure 2.29: Groundwater quality




Source: GWRDC , MM analysis

### 2.2.3.9 Water table contours

Figure 2.30: Water Table map



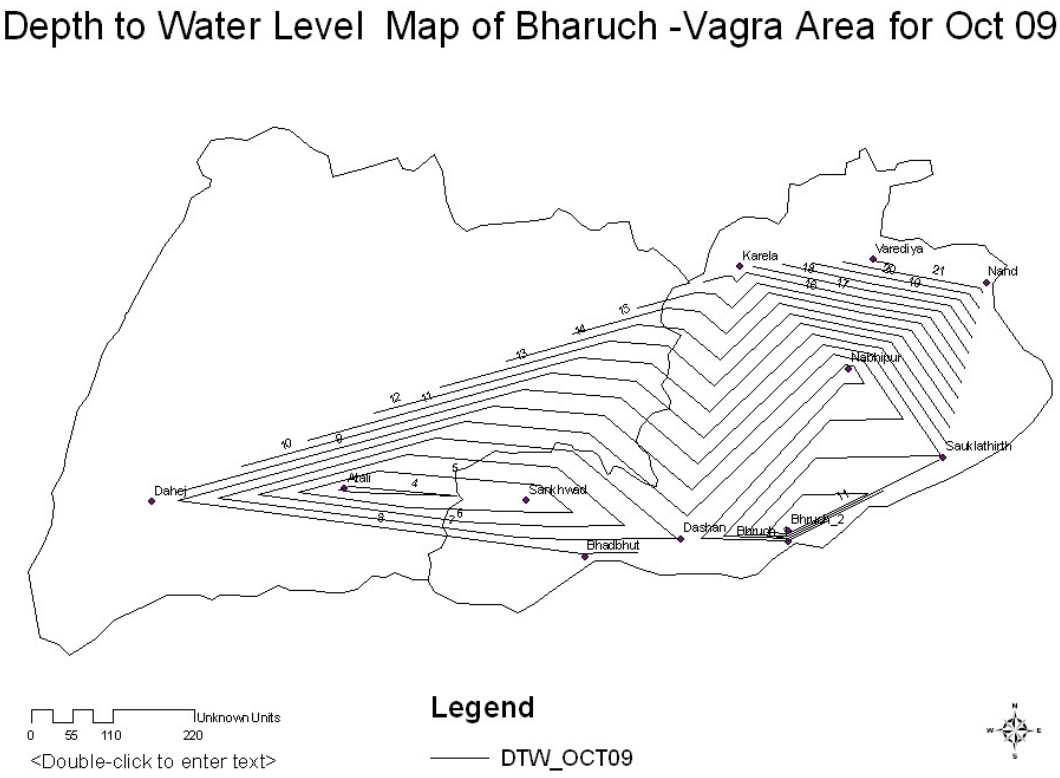

Source: GWRDC, MM Analysis

Water table contour map indicates that the water table is below sea level in the Dahej area while it is 0 to 1 m near Atali and Sankhwad. So, pumping water should not be allowed in these areas as the water table is either below sea level or just about 1 m above mean sea level. **Even though, there is no threat of groundwater flooding or water logging conditions in the area, but there is a threat of seawater intrusion and subsequent salinity intrusion in the area if groundwater pumping is allowed in the area.**

### 2.2.3.10 Flooding analysis

The depth to water level map for October 2009 indicates that the water levels are shallower to about 4 m below ground level near Atali and Sankhwad and it is higher in the other areas. As such, there is no danger of groundwater flooding as well as water logging conditions in the area.

Figure 2.31: Depth to Groundwater level, 2009




Source: MM analysis

It is also observed that the “Zero” water table contour shifts towards the sea in monsoon period indicating that the artificial recharge methods would work in these area and efforts should be made to push the sea water to west wards by using water harvesting and artificial recharge methods in the area to reduce the salinity ingression in the area during coming future years.

### 2.2.4 Preliminary FRA Conclusion

The Preliminary FRA exercise has shown sequential extent of flood in 2yr, 10 yr and 100yr floods.

Fluvial Floods in river Narmada indicated that about 57 to 74 sq.km of the area North of Narmada river would likely to be flooded for average flood of 9.6 lakh cusecs to about 30 lakh cusecs for 100 year to 200 year return period. The flood front may advance to about 1km north of the present flood area if no protection works are provided in the area.

Pluvial floods are expected to come once in 10 years. If the drainage design is not taken care of for 10 year flood, there is likelihood of pluvial floods in the area. The surface tanks work as stabilizing tanks and they should be constructed as and where possible. They will supply water in summer and stabilize floods in heavy rainfall times.

## 2.3 Flood Mitigation: Concepts

### 2.3.1 Introduction

The Flood Risk Assessment elaborated in the above sections entails the need for Flood Mitigation strategies and projects to be implemented in the GPCPSIR area for a long lasting development and smooth function of the Industrial area.

### 2.3.2 Flood Mitigation: Principle concept

#### 2.3.2.1 Crossing & roadways

Mitigation Methods: Culverts/ Elevated Roadways

Depending on the recurrence interval between floods, the availability of alternative access, and the level of need for access, it may be economically justifiable to elevate some roadways and improve crossing points.

For example, with sufficient downstream channel capacity, a small culvert that constricts flows and causes localized backwater flooding may be replaced with a larger culvert to eliminate flooding at the waterway crossing point.

#### 2.3.2.2 Channel improvement

Mitigation Methods: Dredging, canalisation, diversion

By improving channel conveyance, more water is carried away at a faster rate. Improvements generally include making a channel wider, deeper, smoother or straighter.

- **Dredging:** Deepening of channel in order to allow the channel carry larger volume of water
- **Channelisation:** Straightening, deepening and/or widening a stream or river channel. properly sloped and planted channel banks are more aesthetically and environmentally appealing, and can prove cheaper to maintain than concrete ditches
- **Diversion** is a new channel that sends floodwaters to a different location, thereby reducing flooding along an existing watercourse. Diversions can be surface channels, overflow weirs, or tunnels. During normal flows, the water stays in the old channel. During flood flows, the floodwaters spill over to the diversion channel or tunnel, which carries the excess water to a receiving lake or river

#### 2.3.2.3 Mitigation by landuse:

Mitigation Methods: Compatible landuse for flood mitigation

Water retaining agricultural practice can be practised along the coasts, which are also promises economic returns. These areas can be utilised for water based recreational activities through adequate infrastructure development.

#### 2.3.2.4 Drainage & storm water improvement:

Mitigation Methods: Utilise natural drainage pattern

Man-made ditches and storm sewers help drain areas where the surface drainage system is inadequate, or where underground drainage ways may be safer or more practical. Storm sewer improvements include installing new sewers, enlarging small pipes, and preventing back flows. Particularly appropriate for depressions and low spots that will not drain naturally, drainage and storm sewer improvements usually are designed to carry the runoff from smaller, more frequent storms.

A combination of restored wetland detention, vegetated swales, infiltration trenches and other best management practices that increase infiltration (reducing runoff), and improve water quality can be implemented in conjunction with storm water system improvements.

#### 2.3.2.5 Local structure protection

Mitigation Methods: Plantation buffer, Build-up local embankment

On a more local scale, there are a wide variety of flood management structures. These may include:

- Flood protection bunds around fields or communities;
- Road/rail culverts to convey minor streams and drains;
- Local land drainage and river diversion works, especially for water supply and abstraction purposes;
- Local flood storage areas, to store floodwater from local runoff

These are all designed to deal with low intensity flooding and, in the case of severe flooding, will be ineffectual, or often damaged.

#### 2.3.2.6 Reservoir Detention

Mitigation Methods: Dredging of ponds, Pond expansion

Reservoirs control flooding by holding high flows behind dams or in storage basins. After a flood peaks, water is released or pumped out slowly at a rate that the river can accommodate downstream. The lake created may provide recreational benefits or water supply (which could help mitigate a drought).

Reservoirs are suitable for protecting existing development downstream from the project site. Reservoirs are most efficient in deeper valleys where there is more room to store water, or on smaller rivers where there is less water to store.

### 2.3.3 Impact on Proposed population/ development

The northern bank of River Yamuna is projected to be effected by fluvial flood. GPCPSIR residential zone along the flood plain would have an adverse impact on the township. As a result to prevent, a buffer for flood is suggested along the river flood plain.

### 2.3.4 Ship building policy & zone

Gujarat Government policy for Ship Building and its declaration of developing Narmada River front for shipbuilding industries provides an added advantage to the location as well as strategic solution to the flood issues. Ship building can bring development along the coast by dredging, deepening of valley/channels, constructing levees or embankments.

The policy, when implemented will automatically mitigate the risk of flood and bring forth an economic activity.

***The concepts discussed in this section and other flood mitigation measures have been applied on the GPCPSIR site in Flood Mitigation Plan detailed out in Volume II, Chapter 4 of Volume 2. Mitigation plan addresses the pluvial flood caused by Bhukhi Khadi and its drainage network and flood prone areas along coast as fluvial flood.***

# 3. Industrial Studies

## 3.1 Introduction

Gujarat's chemical and petrochemicals industry is one of the fastest growing sectors in the State's economy. The industry offers a wide spectrum of opportunities for the investors both from India and abroad. The well diversified chemical industry has complete portfolio of chemical products including petrochemicals and downstream products, pharmaceuticals, dyes and intermediates. To derive an appropriate value chain for GPCPSIR brief studies have been done on following aspects:

- Existing industrial Survey
- Studies of similar PCP estates
- Studies of Chemical products
- Feedstock Selection

## 3.2 Existing Industry Profile

Dahej-Bharuch belt is booming with the industrial development. It is an excellent industrial base in diversified sectors like chemicals & petrochemicals, textiles, drugs & pharmaceuticals and ports & ship building. With the emergence of GPCPSIR, Dahej SEZ and vicinity to Delhi Mumbai Industrial Corridor (DMIC), it is expected to further fuel the industrial and economic growth of the district.

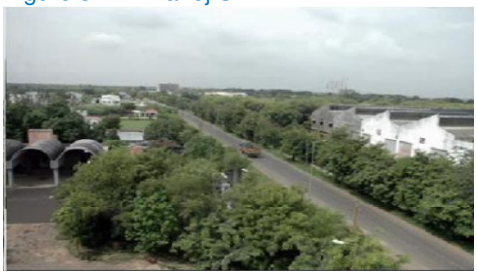
### 3.2.1 Existing Industrial Estates

GIDC is pro-actively involved in developing industrial estates since 1990s in this belt. Presently Dahej 1 including Dahej SEZ and Vilayet are already developed and allotted to industries in GPCPSIR (refer Figure 3.2). Few of the industries are already operational in these estates as indicated in Table 3.1.

#### 3.2.1.1 Dahej 1 including Dahej SEZ

This has been developed by GIDC and it is the only fully functional industrial estate within the site. The estate stretches over an area of 4000 hectare and houses some large industrial units. The internal infrastructure such as concrete roads, drainage network, telecommunication network, water supply network, etc has been developed in the estate to a large extent.

Figure 3.1: Dahej SEZ



Source: MM Industrial Survey 2009

Dahej SEZ, India's fourth largest notified multi product SEZ is being promoted through a special purpose vehicle under joint venture of GIDC and ONGC is also located within Dahej Estate. The SEZ which is primarily multi-product in nature spans an area of 1718.93 hectares. Few industries have started production in SEZ also and there are numerous industries which are under construction.

#### 3.2.1.2 Vilayet Estate

GIDC has also developed an industrial estate at Vilayat. Major corporate houses such as Jubilant, Grasim, Assam Company and Biotor have acquired land for setting up industries or SEZs in the estate. These are **Gujarat Hydrocarbon and Energy SEZ, Jayant Oil and Derivatives SEZ and Jubilant Organosys SEZ.**

#### 3.2.1.3 Expansion of estates

GIDC is in the process of acquiring land as illustrated in the following table to further facilitate industrial growth in the region. These areas are Dahej III, Dahej IV, Vilayet Expansion I and Vilayet Expansion II.

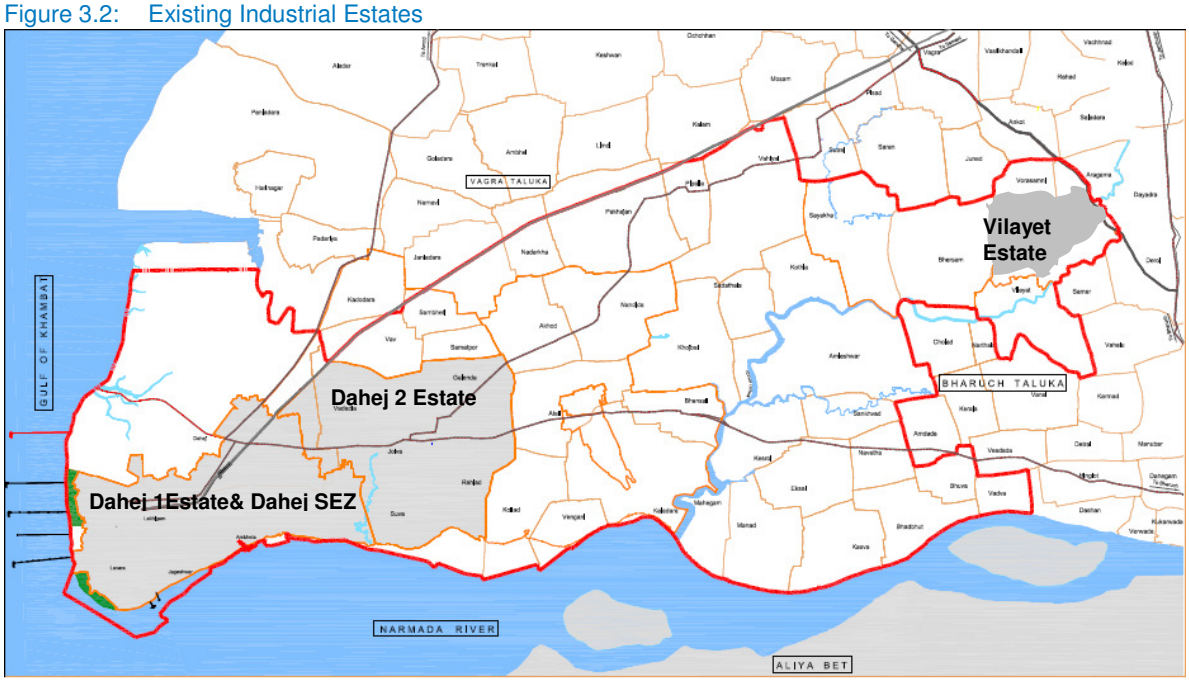
Table 3.1: List of Industrial Estates at GPCPSIR

| Estate | Industrial (Ha) | Land acquisition status | Villages notified for the estate |
|---|---|---|---|
| Dahej including Dahej SEZ | 4000 | Acquired, developed and allotted | Dahej, Ambheta, Luvara, Suva, Lakhigam and Jageshwar |
| Dahej 2 | 4220 | 90% private land (3798ha) has been acquired, developed and allotted | Rahiyad, Dahej, Suva, Jolva, Galenda, Vadadla |
| Dahej 3 | 1943 | Only primary notification has been done (landuse frozen) | Vav, Sambheti, Samatpor, Kadodara (amongst these Kadodara is out of our site area) |
| Dahej 4 | 5869 | Only submitted land acquisition proposals | Akhod, Nandida, Atali, Bhensali, Koliad, Vengani, and Kaladra |
| Vilayat | 1100 | Acquired, developed and allotted | Bhersam, Aragama and Vilayet |
| Vilayat Expansion 1 | 1161 | Section 4 of Land Acquisition Act 1984 has been issued | Aragama, Juned, Vorasamni and Ankot - Amongst these, Juniad and Ankot are beyond our site area |
| Vilayat Expansion 2 | 2334 | Only submitted land acquisition proposals | Sayakha and Bhersam |
| Total | 20627 | | |

Source : GIDC

The detailed list of allotted industries provided Appendix D.

Figure 3.2: Existing Industrial Estates




Source: Mott MacDonald

### 3.2.2 Anchor Tenant - ONGC Petro Additions Limited (OPaL)

The Gujarat Government has identified ONGC Petro additions Limited (OPaL) as anchor tenant for GPCPSIR. OPaL is a Joint Venture Company promoted by Oil and Natural Gas Corporation Ltd. (ONGC), Gas Authority of India Limited (GAIL) and Gujarat State Petroleum Corporation (GSPC). ONGC holds 26% equity, GAIL 19% and GSPC 5%. The remaining equity is shared between strategic investors, financial institutions and public. OPaL is setting up a dual-feed cracker at an investment of INR 12,440 crores. The construction of this project commenced in December 2007. They are also setting up $C_2$-$C_3$-$C_4$ Extraction Plant at Dahej at an investment of INR 3,400 crores. A petrochemical SEZ has also been planned in GPCPSIR called Dahej SEZ Limited, a joint venture company of ONGC and GIDC. Infrastructure for the Petrochemical Complex of OPaL will be provided by Dahej SEZ.

**Project Status – Key features:**

- 507 hectare land acquired from Dahej SEZ.
- Environment and statutory clearances obtained.
- Site Infrastructure development tender awarded to M/s IVRCL, India.
- Dual Feed Cracker Job awarded to M/s Linde and M/s Samsung.
- Product selection technology under progress. Imported technology will be used for the plant and process.
- Site work under progress, infrastructure work 70% completed.

Source: Meeting with OPaL officials

The cracker plant with a capacity of 1100 KTPA will produce maximum polymer grade Ethylene and Propylene as petrochemical feedstock to downstream basic polymer units of Linear Low Density Polyethylene (LLDPE) High Density Polyethylene (HDPE), Polypropylene (PP) and Styrene Butadiene Rubber (SBR). LNG will be shipped to the terminal from Qatar. The product range of OPaL has been presented in Table 3.2. Discussions with OPaL officials reveal their enthusiasm for the project but at the same time concerns about the progress of infrastructure works by GIDC emerges as an issue for them.

Figure 3.3: OPaL construction site at Dahej

Table 3.2: Product range of OPaL

| Type of Product (name of the products) | Major Feedstock / Raw material used | Source Internally / Externally (specify the state or country) |
|---|---|---|
| Upstream products<br>Ethylene – 1100 KTPA | a) Aromatic Rich Naphtha (ARN)<br>b) Light Aromatic Naphtha (LAN) | a) ONGC Hazira Gas processing Complex (HGPC)and Uran plant |
| Downstream products<br>a) HDPE, } 2 x 360 KTPA<br>b) LLDPE, }<br>c) LDPE,<br>d) PP – 340 KTPA<br>e) Benzene – 135 KTPA<br>f) Butadiene – 95KTPA<br>g) Carbon Black Feedstock – 70KTPA | c) C2-C3-C4<br>d) C5 from HGPC | b) C2-C3-C4 recovery plant |

Source: OPaL Brochures, Discussions with OPaL officials

The Anchor Unit, OPaL, has planned to operate through a dual feed cracker, obtaining Naphtha from its own operating plants at Hazira (pipeline transportation) and Uran (to be transported by sea to Dahej Port). Opal will source 9, 73,000 MTPA feedstock (C2, C3, and C4) from the Petronet LNG (via its extraction unit) and 1.5 MMTPA naphtha from its Hazira and Uran units. Feed LNG will be supplied by PLL (Petronet LNG Ltd., JV of ONGC) and after extracting of C2, C3 &C4, lean LNG will be sent back to PLL. OPaL through its $C_2$-$C_3$-$C_4$ recovery plant is providing the opportunities to invite the downstream units (plastic converters) to come to GPCPSIR and set up their manufacturing units. Opal will supply feedstock for these industries assuring long term supplies with global quality standards at competitive prices.

### 3.2.3 Proposed Industries at Bharuch and GPCPSIR

Further the Table 3.3 indicates the proposed small and medium industrial units along with investment in sub districts of Vagra and Bharuch.

Table 3.3: Proposed Industrial Units

| Taluka | No. of units | Investment INR in Crore | Employment |
|---|---|---|---|
| Vagra | 48 | 27737 | 29118 |
| Bharuch | 47 | 22399 | 15424 |

Source: DIC, Bharuch

The state marketed GPCPSIR during Vibrant Gujarat Investor Summit (VGIS) – 2009, 273 MOUs have been signed with the investment of INR 74,003 crore and proposed employment of 1,00,002. 69 MoUs were signed only for GPCPSIR. Within this, 4 MoUs were signed having investment more than INR 1000 Crores. Cumulative investment is INR 14,400 Crores. Refer Table 3.5 for list of VGIS 2009.

Table 3.4: Proposed Industries- Vibrant Gujarat Summit 2009

| Parameters | Units (no.) | Proposed investment (INR.) | Employment (No.) |
|---|---|---|---|
| MSME DIC | 27 | 73.47 | 1578 |
| MSME GIDC | 114 | 250.53 | 2072 |
| Medium and Large Industries | 132 | 73678.62 | 96352 |
| Total | 273 | 74002.62 | 100002 |

Source: indextB

Table 3.5: List of few industries from VGGIS 2009

| Sl. No. | Company name / Address / Contact Person / Designation | Location | Project Details / Sector |
|---|---|---|---|
| 1 | Action Peroxide Pvt. Ltd. | Dahej | Hydrogen peroxide |
| 2 | Aero Agro Chemical Industries Ltd. | NA | Agro-chemical |
| 3 | Aetgen Pharma Pvt. Ltd. | Dahej | Petro Chemical |
| 4 | Ankaleshwar Rotary Education Society | NA | Institute of Chemical Technology |
| 5 | Ashland India Pvt. Ltd. | NA | Petro Chemical |
| 6 | Astar Silicates Pvt. Ltd. | NA | Petro Chemical |
| 7 | Astral Biochem Pvt. Ltd. | Dahej | Ethanol |
| 8 | Bharat Forge Ltd. | Dahej | Petro Chemical |
| 9 | Bharuch Enviro Infrastructural Ltd. | Dahej | Incinerator |
| 10 | BOC India Ltd. | Dahej | Petro Chemical |
| 11 | Bodal Chemical Ltd. | NA | Reactive dyestaff, Beta napthol, Sulphuric Acid, specialty chemicals |
| 12 | Cheenmoy Silicates Pvt. Ltd. | NA | Sodium Silicate Food Grade on Bio gas as fuel and CO2 Bottling plant |
| 13 | Chimera Chemicals Pvt. Ltd. | Dahej | Petro Chemical |
| 14 | DIC Fine Chemical Pvt. Ltd. | Dahej | Petro Chemical |
| 15 | Dipak Nitrate Ltd. | Dahej | Petro Chemical |
| 16 | Expanded Polymers Systems Pvt. Ltd. | Dahej | Petro Chemical |
| 17 | Firmenish Aromatics Prod (I) Ltd. | Dahej | Petro Chemical |
| 18 | Hemani Intermediates P. Ltd. | Dahej | Petro Chemical |
| 19 | Indofil Chemicals Co. | Dahej | Petro Chemical |

| Sl. No. | Company name / Address / Contact Person / Designation | Location | Project Details / Sector |
|---|---|---|---|
| 20 | Insecticides (India) Limited | Dahej | Petro Chemical |
| 21 | Galaxy Surfactants Ltd. | NA | Petro Chemical |
| 22 | J Fox Sox Pvt. Ltd. | NA | Petro Chemical |
| 23 | Jai Tiles Pvt. Ltd. | NA | Porcelain tiles |
| 24 | Jushi (India) FRP Accessories Pvt. Ltd. | NA | Glass Fibre Products |
| 25 | Krishi Rassayan Export Pvt. Ltd. | Dahej | Petro Chemical |
| 26 | Lanxess India Pvt. Ltd. | NA | Ion exchange resins, rubber chemicals |
| 27 | Luna Chemicals Industries Pvt. Ltd. | Dahej | Petro Chemical |
| 28 | Matangi Industries | Dahej | Petro Chemical |
| 29 | MCT Enviro Infrastructure Ltd. | Dahej | Petro Chemical |
| 30 | Multi Mantech International Pvt. | Dahej | Water supply project for Dahej Region and PCPSIR |
| 31 | Narayan Organics Pvt. Ltd. | Dahej | Petro Chemical |
| 32 | Neesa Infrastructure India Pvt. Ltd. | Dahej | Petro Chemical |
| 33 | Neesa Leasure Limited | Dahej | Hotel project |
| 34 | NOCIL Ltd. | Dahej | Chemical Project |
| 35 | Organic Industries Limited | Dahej | Petro Chemical |
| 36 | Panama Petrochem Ltd. | Dahej | Petroleum speciality |
| 37 | Pidilite Industries Ltd. | Dahej | Petro-Chemical - Synthetic Elastomer |
| 38 | Pooja Glassworks Pvt. Ltd. | NA | Petro-Chemical |
| 39 | Reshmika Minerals and Chemicals Pvt. | NA | Petro-Chemical |
| 40 | RFCL Ltd. | Dahej | Petro Chemical |
| 41 | Rallis India | Dahej | Petro Chemical |
| 42 | Rallis India Ltd | Dahej | Petro Chemical |
| 43 | Ramdev Chemical Industries | Dahej | Petro Chemical |
| 44 | Roxul-Rockwool Insulation India | Dahej | Stone wool insulation 30000MT |
| 45 | Sajjan Specialty Ltd. | Dahej | Petro Chemical |
| 46 | SBS Colours and Chemiques Pvt. Ltd. | | Petro Chemical - Pigments |
| 47 | Sapthagiri Hospitality Pvt. Ltd. | Dahej | Hospitality sector |
| 48 | Sarju Impex Ltd. | Dahej | Petro Chemical |
| 49 | Shell and Pearl Ceramics Ltd. | Dahej | Manufacture of Vitrified tiles |
| 50 | Spectrum Ethers Ltd. | Dahej | Agrochemicals |
| 51 | SRF Ltd. | Dahej | Petro Chemical |
| 52 | Stepan India P. Ltd. | Dahej | Surfactants and specialities which include anionics, non-anionics cationics and amphoterics |
| 53 | Tagros Chemicals India Pvt. Ltd. | Dahej | Institute of Chemical Technology |
| 54 | Torrent Pharmaceuticals Ltd. | Dahej | Petro Chemical |
| 55 | United Phosperous Ltd. | Dahej | Vidicide, fungicide and intermediate |
| 56 | Walchandnagar Industries Ltd. | Dahej | Developing an Offshore platform fabrication yard under joint venture |

Source: indextB

### 3.2.4 Regionally emphasized Industries

Key growth areas as identified by the Government of Gujarat are as follows:

- Petrochemicals
- Refinery Downstream Projects
- Mineral Resource-based Projects
- Nanotechnology-based Projects
- Basic Chemicals
- Specialty Chemicals
- Knowledge chemicals
- High Performance chemicals
- Agrochemicals
- Engineering thermoplastics compound
- Large plastic crates / pallets
- PVC profiles for door and windows
- Plasticisers
- Pigments and coating products
- Bio Refineries

GoG has even identified the following Chemical and petrochemical projects where investors are invited:

- Methanol
- Propylene oxide and propylene glycol
- Cumene
- Phenol / Acetone
- Nitrobenzene and Aniline
- Diphenylmethane diisocyanate (MDI and toluene di-isocynate (TDI)
- Polyvinyl Chloride
- ABS Resin
- Polycarbonate resin
- Polyethylene terephthalate (PET) chips
- Styrene butadiene Rubber (SBR)
- Bi-axially oriented polypropylene (BOPP) Films
- Polyethylene (PE) Multi layer film project
- Polyolefins compounding and masterbatches
- Polypropylene (PP) ropes
- Fibre and filament
- Plastic crates
- Bisphenol A
- Mono chloro Acetic Acid (MCA)
- Bromine
- Titanium Tetrachloride / Titanium Dioxide
- Chlorosilanes
- Synthetic Zeolite – Zeolite A
- Contract research and manufacturing services (CRAMS)

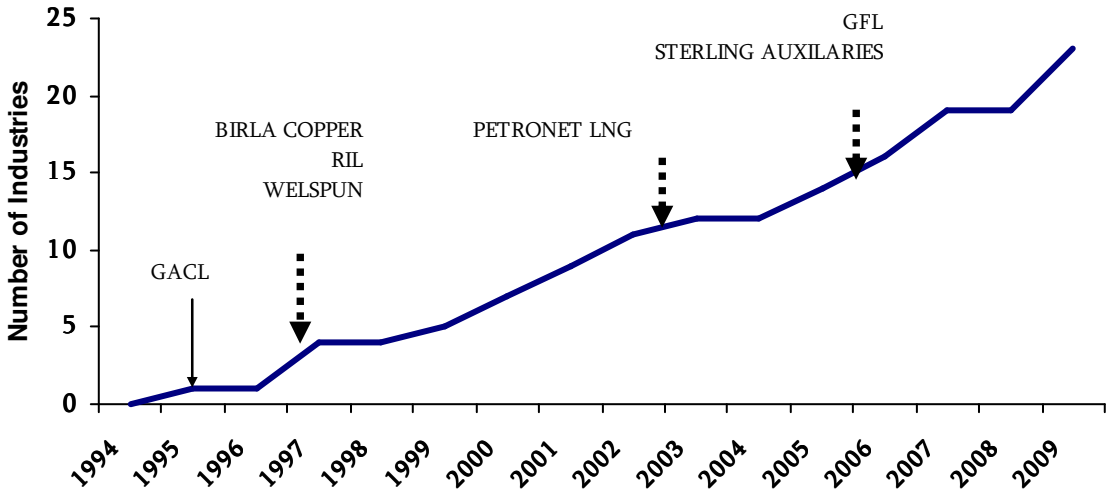
### 3.2.5 Industrial Survey and Analysis

According to a primary survey conducted by Mott MacDonald study team, presently there are 29 operational industrial units in GPCPSIR. Industrial activity took the first step in the year 1995 with the establishment of a chlor-alkali complex by Gujarat Alkalies & Chemicals Limited (GACL) and thereafter the region has never looked back in terms of industrial development. The historic perspective in the overall development of industries within the site is illustrated in Figure 3.4

The industrialization was slow in the initial years but after 2000 it gained strong momentum. The industrial establishment is likely to accelerate at much higher rate in the years to come with large number of projects in pipeline. Apart from industrial activities, ONGC is carrying out full fledged exploration and production activities in the region as well as supply of natural gas to industries in the district.

The distribution of present industries in the region shows the dominance of Chemical and Petrochemical sector with a share of 48% in terms of units and 74% in terms of area covered. Ceramics and Engineering are the other important industrial segment in the region.

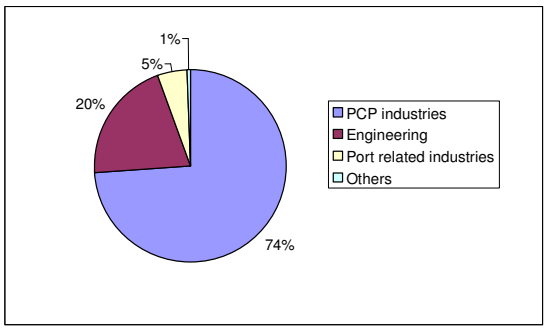
Figure 3.4: Historic Trend in Industrial developments – GPCPSIR




Source: IMM Analysis

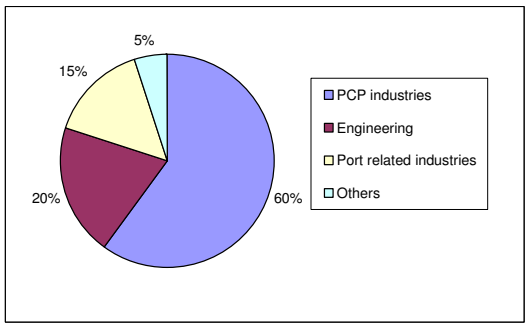
The overall structure of present industrial activities in the region is captured in the Figure 3.5 and Figure 3.6. Mott MacDonald study team carried out a primary survey of 29 operational units within the site to gather information on production, employment and available infrastructure.

Figure 3.5: Areawise sectoral distribution among industries




Source: Primary Industrial Survey 2009

Figure 3.6: Number wise sectoral distribution among industries




Source: Primary Industrial Survey 2009

Table 3.6: List of Surveyed Industries

| Sl. No. | Name of Industry | Types of Products | Employment | Area (Ha) | Fixed Investment (INR) |
|---|---|---|---|---|---|
| 1 | BASF Styrenics Private Limited | Polystyrene – HIPS/GPPS | 95 | 0.24 | Capital investment was very low, totalling to maximum of 2 crores |
| 2 | Gujarat Alkalies & Chemicals | Chlor-alkali products | 700 | 140.95 | NA |

| Sl. No. | Name of Industry | Types of Products | Employment | Area (Ha) | Fixed Investment (INR) |
|---|---|---|---|---|---|
| | Limited | | | | |
| 3 | Meghmani Finechem Ltd. | Chlorine, Hydrogen, Dilute sulphuric acid, HCL, Sodium Hydrochlorite | 300 | 65 | NA |
| 4 | Chlorides India | Calcium Chloride, Ammonium Chloride concentrate | 16 | 0.223 | NA |
| 5 | Sitaram Energy & Logistics Ltd. | packaging of DAP/NPK | 25 | 1.523 | NA |
| 6 | Standard Enterprise | Motor windings | 18 | 0.239 | NA |
| 7 | Hindalco Industries Limited | Copper anode, cathode, sulphuric, acid, Phosphoric acid, DAP, NPK, | 2500 | 356.35 | NA |
| 8 | Organic Industries Limited | KMnO4, Boric Acid powder | 135 | 17.15 | 200 crores |
| 9 | Petronet LNG Limited | Natural Gas | 180 | 50001, 82.5 | NA |
| 10 | Indofil Chemicals Company | Mangozeb | 98 | 9.87 | 78 crores |
| 11 | Luna Chemical Inds. P. Ltd. | Nitro Aromatics, Aniline Oil, Nitro Benzene | 50 | 6.894 | NA |
| 12 | ONGC – Gas Gathering Station | Others (Oil & gas gathering st.) | 10 | NA | NA |
| 13 | Shoft Shipyard Private Limited | Ship building | 250 | NA | 5 crores |
| 14 | Pavit Ceramics Pvt. Ltd. | Ceramics tiles | 60 | NA | NA |
| 15 | Welspun Gujarat Stahl Rohren Ltd. | Longitudinal Saw Pipe, Spiral Saw Pipe, Fabricated Pipe | 500 | NA | NA |
| 16 | GCPTCL | Storage farm | 90 | NA | 6crores |
| 17 | Grow More Enterprise / Narmada Enterprise / Jayson Enterprise (A Group of Kaneria Group of Industries) | Sodium Silicate, Ceramics Frit | 25 | NA | NA |
| 18 | Gujarat Fluoro Chemicals Limited | PTFE- PT-PTFE & TFE, Chloro Methane, Caustic Soda | | NA | NA |
| 19 | ISGEC | High pressure vessels, Boiler, Heat Exchanger | 300 | NA | NA |
| 20 | Nahar Colours & Coating Ltd. | Ceramic Tiles | 60 | NA | NA |
| 21 | Sterling Auxiliaries Pvt. Ltd. | D/s Petrochemical product | 98 | 11.19 | NA |
| 22 | Kaneria Granito Limited | Vitrified tiles | 350 | NA | NA |
| 23 | Universal Chemicals & Industries Pvt. Ltd. | KMnO4, KOH | 150 | 9.35 | 100 crores |
| 24 | Jolly Abrasives | Process Copper Slag | 15 | 2.191 | 12440 crores |
| 25 | Eurostar Crystal Marble | Artificial marble | 30 | NA | NA |
| 26 | Reliance Industries limited | Petrochemical | >500 | 681.61 | 400 crores approx |

| Sl. No. | Name of Industry | Types of Products | Employment | Area (Ha) | Fixed Investment (INR) |
|---|---|---|---|---|---|
| 27 | ABG Shipyard Ltd. | Shipbuilding | >500 | 17.99 | NA |
| 28 | Daya Glass Industries Pvt. Ltd. | Glass Bottles | 93 | NA | NA |
| 29 | ONGC Petro additions Ltd. (OPaL) | Petrochemical | >500 | 507 | NA |

Source: Primary Industrial Survey 2009

Some of the observations from the primary survey have been listed below;

1. Raw materials and products

- Availability of Natural gas and setting up plants by OPaL has led proliferation of petrochemical products in the GPCPSIR (even though OPaL is not operational yet). This has also led to development chlor-alkali, soda ash and other ancillary plants.
- Wide-scale availability of salt in the region has resulted in the development of 5 Chlor-alkali manufacturing facilities opening huge avenues for integration of petrochemicals and chemicals segment. Chlor-alkali products like caustic soda, chlorine, hydrochloric acid, hydrogen and others cannot be hauled long distances hence manufacturing units of these products have been developed within close distances.
- GACL has entered into strategic joint venture with Dow chemicals to establishing chloromethane production facility at Dahej
- Organic Industry would expand their capacity in the future with strategic technological partner.
- All the chemical and petrochemical units in the region rely primarily on imported technologies for manufacturing products. Any technological change in the plants would involve setting up of new imported technology.
- Availability of depth of water and surrounding port led development has also proliferated in development of Shipbuilding Industries.

Figure 3.7: Reliance Industries

Source: MM Industrial Survey 2009

2. Raw Material Transportation

It was found that the inputs and outputs of production of the industrial units in the site are moved through waterways, roads, rails, overhead transmission lines (power) and under ground pipelines. The following table shows that majority of the industries are dependent on road for its material movement, and then comes port and pipelines.

Table 3.7: Material Movement

| Mode of transportation | Raw material Movement (%) | Material despatch (%) |
|---|---|---|
| Road | 68.97 | 75.86 |
| Port | 31.03 | 34.48 |
| Rail | 6.90 | 6.90 |
| Pipeline | 24.14 | 24.14 |

Source: Primary Industrial Survey 2009

### 3. Employment

With the varying size of Industries, employment is also varying amongst the existing operational industries. Single largest employer within the site is Hindalco (Birla Copper) having employment of 2500.

### 4. Fuel Consumption Details

The industries use all the major types of fuel for heating and power generation, the details of which are given in Table 3.8. Natural gas and coal dominates overall energy profile of industries followed by diesel and furnace oil.

Table 3.8: Fuel Consumption of Industries

| Type of Fuel | Quantity |
|---|---|
| Natural Gas | 1.1 MMSCMD |
| Furnace Oil | 25 KLPD |
| Coal | 2400 MTPD |
| High Speed Diesel, Light Diesel Oil | 50 KLPD |

Source: Primary Industrial Survey 2009

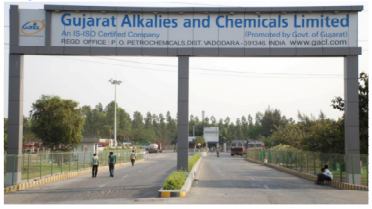
The major fuel intensive industries are GACL, Gujarat Fluorochemicals Limited, Meghmani Finechem Limited, Birla Copper and Welspun Stahl Rohren Gujarat Limited.

### 5. Infrastructure Assessment

It is observed from the survey exercise that most of the industrial units are dependent on outside intervention in the matters of transportation of materials, power, water, parking space for vehicles and commutation of employees.

To carry out the exercise, first the operations of an individual unit have been divided into three phases, viz. Pre-production & production, Post production and Common services, so as to study the flow of production input & output materials and the requirement of physical infrastructure at each and every stages of operation. Based upon the data collected through the above Field Survey, a matrix was drawn to show the items of infrastructures, for which the units are dependent on outside intervention (Refer Appendix D: Infrastructure Matrix of Industrial Survey)

Figure 3.8: GACL




Source: Primary Industrial Survey 2009

The overall perception of industries with respect to infrastructure – industrial as well as social is **"Below Average"**. The major problems and issues raised by industries with respect to infrastructure are provided below:

- Public Transportation facility connecting Dahej with Bharuch & Ankleshwar is very poor. The employees and workers have to pre-dominantly depend on facilities provided by the company. Flexibility of public movement within the estate as well as outside estate during odd hours is very difficult not only for the employees but their family members as well.

Figure 3.9: LNG Petronet Jetty

Source: Primary Industrial Survey 2009

- Overall social infrastructure in the region is highly under-developed. There are no proper education, healthcare, hotel & restaurant and recreational facility options for the people of the region and have to depend on facilities of Bharuch to a large extent.

- Industries face power problems with respect to unscheduled cuts which affects the productivity, especially in the continuous process plants. In order, to make up for the production loss, industries have to operate DG sets which eventually increases the overall production cost.

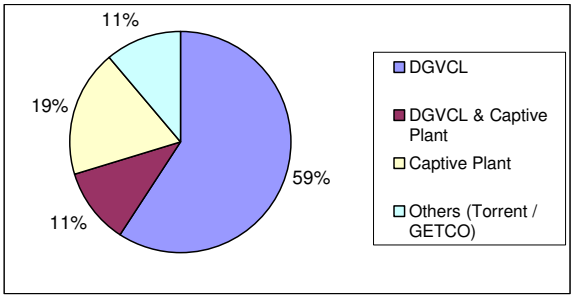
- Industries face shortage of technical skilled manpower primarily because of establishment of large number of competing industries in the region. The nearest industrial technical institute (ITI) is located at Ankleshwar & Bharuch and is anticipated that it would fail to meet the growing need of skilled manpower in the years to come

- GIDC has not laid down complete water distribution system even in the Dahej Estate and some industries procure water through tanker or via other industries. This increases delivered price of water by significant amount.

- The world-class healthcare facility in the region has not been developed and nearest such facility is located at Bharuch. Few industries such as RIL and Birla Copper have fully functional healthcare facility and other industries have developed occupational health share

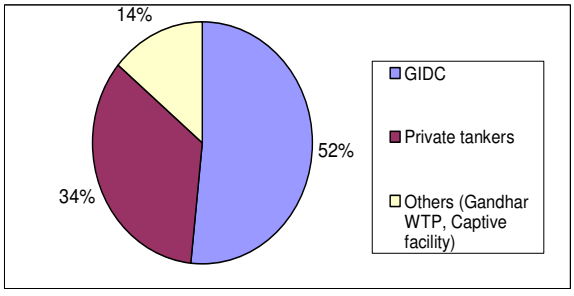
- Although overall road infrastructure is the region is excellent, approach roads to some of the industries has not been developed. This problem is primarily faced by the industries which are not the part of GIDC developed estates/SEZs and are scattered across the region.

Figure 3.10: Situation of Power supply situation




Source: <Insert Source here>

Figure 3.11: Situation of Water supply




Source: <Insert Source here>

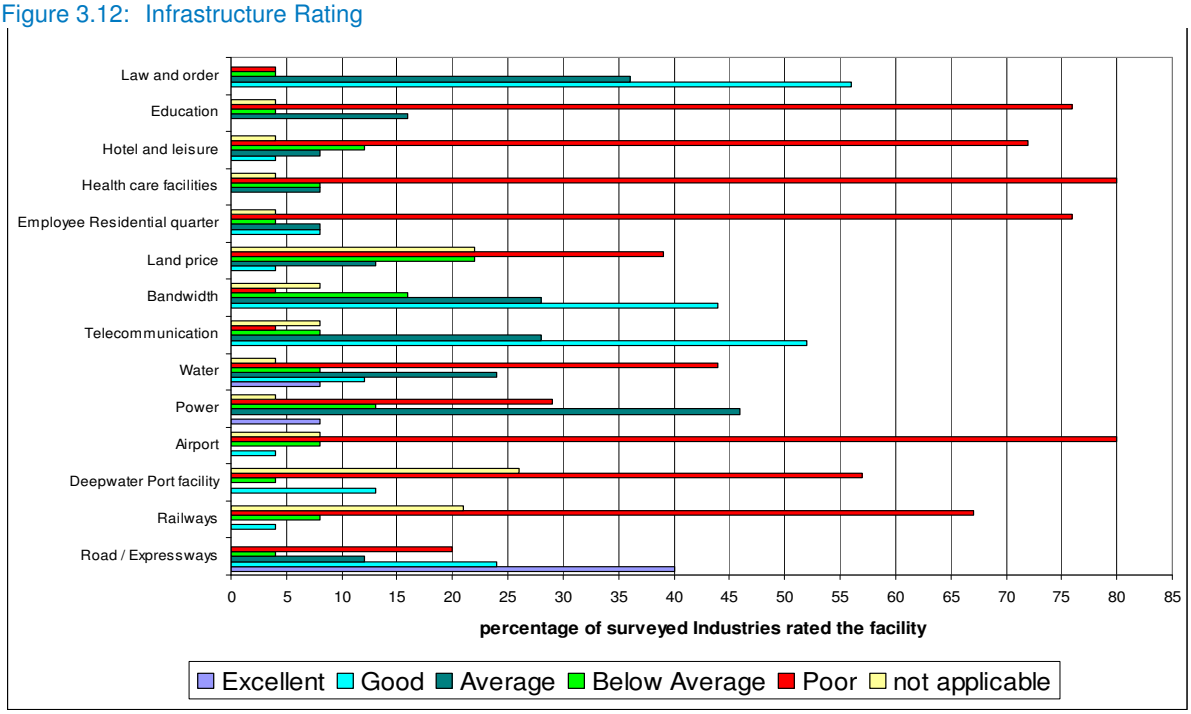
- The nearest public fire station in the region is located at Bharuch which is nearly 60 KM from the Dahej estate. Although few industries have fire-fighting facility and fire-handling system, it is mainly restricted for the captive purpose. With the development of chemical and petrochemical industries, need for public fire fighting in the vicinity to clusters arises on the priority basis.

- The other issues which industries have to deal with are – illicit liquor problem, soil erosion on the banks and shores of the river bed, land encroachment and harassment from the local villagers.

- The deepwater port facility for handling solid cargo is presently not available and industries importing or exporting materials depends on either Mumbai port or Kandla port. However Adani & Petronet are jointly developing jetty for handling solid cargoes thereby giving providing momentum to overall industrialization in the region.

- The land prices have increased steeply over the near past in anticipation of growing need of land for the development of industries. Such sustainable rise in the prices could dampen overall rate of industrialization in the years to come. The infrastructure rating has been presented in Figure 3.12.

Figure 3.12: Infrastructure Rating




Source: IMM analysis

## 6. Expansion Plans of Industries

The expansion plans based on the feedback received from the existing players is provided in Table 3.9:

Table 3.9: Proposed Expansion details of existing industries

| Name of the Unit | Expansion Product | Investment (INR. Lakh) |
|---|---|---|
| ISGEC | High pressure vessels / Boilers / Heat exchangers | 10,000 |
| Gujarat Fluoro Chemicals Limited | PTFE- PT-PTFE & TFE / Chloro Methane / Caustic Soda | 30,000 |
| GCPTCL | Two Storage Tanks | 1, 200 |
| Petronet LNG | Power Plant of 1200 MW | - |
| Organic Industries Limited | Potassium Permanganate / Boric Acid | 20,000 |
| Chlorides India | Phosphorous | - |
| GACL | Chloromethane | 60,000 |

Source: Primary Industrial Survey 2009

Only few players have shown interest in expanding their production capacity, primarily because majority of the units in the region are newly established. Also in the light of global financial crisis and sluggish market conditions, many players have put their plans on hold and would wait for overall economic and market to recover before committing further investments.

## 7. Other Infrastructure

**a.** **Truck Parking Bay / Container Yard:** Presently there is no common Truck Parking Bay / Container Yard in the site. Only RIL has well managed Truck Plaza outside their plant premise to manage overall material movement through road. Almost 64% industries have truck parking bay outside their premises.

b. **ICT Infrastructure:** BSNL and all major private telecom players provide telecommunication services to the industries in the region. Tata Teleservices has laid down optical fibre network in the Dahej region. The telecommunication services provided by private telecom players are more satisfactory as compared to those provided by the PSUs. Few industries like Petronet LNG and RIL have also invested in strengthening overall ICT infrastructure to support their operations. Industrial Survey reveals that 86% industries have proper ICT infrastructure

c. **R&D Centre:** All the major industrial units have R&D centre with the intention to improve the quality of the products and develop new applications for their existing product. These R&D centre could be either within plant premise or located at other centralized locations in India. GPCPSIR existing Industrial Survey also reveals that almost 62% industries have the facility of R&D centre.

**d.** **Housing:** The details of housing facilities as provided by industries for their employees are detailed in Table 3.10.

Table 3.10 : Details of Companies providing housing facility for employees

| Name of the Company | Location of Housing Facility |
|---|---|
| Welspun Stahl Rohren Gujarat Limited | Bharuch |
| HINDALCO Limited – Unit: Birla Copper | Dahej |
| Reliance Industries Limited – DMD | Bharuch / Dahej |
| Gujarat Alkalies & Chemicals Limited | Bharuch |
| Pavit Ceramics Private Limited | Jolwa |

Source: IMM Analysis

The housing facilities provided by the companies are mainly for employees and not for the workers. Workers generally live in nearby villages or towns of Ankleshwar and Bharuch.

### 3.2.6 Inferences

The following important points can be inferred from then above study:

- Big players like OPaL can supply enough feedstock to the downstream industries. Hence these big players will play a significant role in supplying feedstock.
- With the downstream industries few ancillary industries have also come up like packaging, engineering industries.
- Concerned authority need to develop critical physical infrastructure like water supply, power supply, sold waste management to run the industrial activity smoothly
- Presently the region is lacking any kind of logistic facilities. But judicious planning of an industrial area needs such facilities for planned activities.
- Due to lack of Housing facilities people have to travel from long distance.
- Skilled manpower is also lacking in this belt. Hence strong technical education system and environment needs to build up.
- PCP industries needs pipe line corridor to easy transportation of materials.
- Villages within the industrial estates need to be buffered properly so the respective activities can be carried out without any hindrance.
- When planning proposed industrial area, proportionate land needs to be kept to accommodate expansion plans of existing industries, and new industries which are supposed to come as per VGGIS 2009.

## 3.3 Studies of Other PCP estates

### 3.3.1 Introduction

This section briefly summarises the configuration, genesis and management of the some of the major mega Chemical Estates operating globally. This section also summarises the available information on the status of the chemical estates / clusters operational in India and abroad. These PCP estates have been studied as listed in Table 3.11 for benchmarking various parameters like product mix, employment and facilities available.

Table 3.11: Benchmark Estates

| International PCP Estates | National PCP Estates |
|---|---|
| Port of Rotterdam, Netherlands | RIL, Dahej / Gandhar, Gujarat |
| Port of Antwerp, Belgium | RIL Jamnagar, Gujarat |
| Jurong Islands, Singapore | RIL Hazira, Gujarat |
| Shanghai Chemical Industrial Park, China | RIL Vadodara, Gujarat |
| Nanjing Chemical Industrial Park, China | RIL Naroda, Gujarat |
| Bayport Chemical Estate, Houstan, USA | RIL, Nagothane, Maharashtra |

### 3.3.2 Brief Description on the Estates

#### 3.3.2.1 International PCP Estates

##### Port of Rotterdam, Netherlands

The Port of Rotterdam (POR) is one of the world's major oil and chemical centres due to its strategic location as the European main port which offers access to the west and east Europe. Measured in cargo throughput, this has been the number one port in the world since the last 40 years. Crude oil is the single largest commodity shipped into Rotterdam (100 million annually), which has led to the establishment of petrochemical cluster.

The development of POR area to manufacture the chemicals and petrochemicals has been done in four separate well-demarcated zones, viz, Pernis, Boltek, Europort and Maasvlakte. The refineries and chemical units are located in all the four zones. The initial development started from the Pernis with the setting up of the refinery by Shell.

Co-siting is an excellent way of managing the activities between various companies in such mega estate. The Port management also encourages co-siting as in this case two or more companies run operations on one site and they share the facilities and put raw materials to better use. There is a high-degree of co-siting including the finished or by-product of one company being used as the raw material for another.

##### Port of Antwerp, Belgium

The Port of Antwerp has been closely linked to industrial companies especially chemical companies located in the port area. The POA is among the top three ports in the entire Europe. The POA is in the delta of the Scheldt, Meuse and Rhine which means that it has excellent links to Belgium's 1500 kms of waterways and the European waterway system. The total area of POA is 13500 hectares, of which about 2000hectares is the water surface. The POA is the home for the largest petrochemical complex in Europe and the total area occupied by the oil and chemical sector is around 3000 hectares. BASF Antwerp is the single large chemical complex in the POA located in 600 hectares with 53 production installations having the total production capacity of 12 MMTPA of different products including mineral fertilisers, plastics and their precursors, artificial fibre products, basic chemicals and value added products.

The pipelines integrate the chemical cluster in POA and with the entire Western Europe. This transport mode enables the companies operating in the POA to supply and distribute their products safely the other logistic providers provide the services in gas and product storage, transportation and throughput, waste treatment and management, import and trading of POL and products, transportation and throughput, waste treatment and management, import and trading of POL and products, transportation and supply of industrial gases, integrated cargo handling.

##### Jurong Islands, Singapore

Singapore is located on the world's busiest shipping routes and is the world's busiest container port. Initially three refineries were set up in the tree islands in Singapore which propelled other chemical industries to start operations. Further, amalgamation of the islands forming Jurong Islands was put

in place. This is done by reclaiming the channels between the islands in phases and the total area currently available is 3200 hectares.

The major feedstock for the petrochemical sector being in place, the downstream integration to this sector started in 1970s. The industries operating here are taking the benefits of comprehensive infrastructure and production synergies from this area. Co-siting in this island is reported to have saved companies 10-15% of their total logistics cists. Output of a plant is used as feedstock by other chemical plants (of the same owner) or sold to neighbouring facilities owned by other companies.

### Shanghai Chemical Industrial Park, China

Shanghai Chemical Industrial Park (SCIP) located on the bank of Hong Zhou Bay, with a total area of around 300 hectares is one of the largest chemical industrial estates developed in China during the period of the 10$^{th}$ Five Year Plan.

SCIP is the first industrial zone specialized in the development of petrochemical and fine chemistry businesses, and also one of the four industrial production bases in Shanghai. It is built with advanced development conception of World-Class and large-scaled Chemical Park. It is to provide investors in the Park with best investment environment by combination of production projects, public utilities, logistics, and environmental protection and administration services. SCIP is set out to be one of the largest and the most integrated and advanced world petrochemical bases in Asia.

The utilities including domestic water, industrial water, wastewater treatment, co-generation facility, jetty, tank farm and industrial gas is available to all industries at competitive rates from the service providers.

### Nanjing Chemical Industrial Park, China

Nanjing Chemical Industrial Park (NCIP) is located in the north of the Nanjing Municipality on the northern bank of Yangtze River. The total planned area of NCIP is 5000 hectares. NCIP was the second chemical industrial park in China to be accorded the state level Chemical Hub status in January 2003. The development in NCIP focuses on the six areas, viz, petrochemical and natural gas derivatives, basic organic chemical feedstock, fine chemicals, polymers, life sciences and pharmaceuticals and new chemical materials. The park has almost 30 no. jetties to provide berthing for 25000-30000 ton vessels all year round.

### Bayport Chemical Estate, Houstan, USA

The well developed Port of Houston was the backbone for the development of the Bayport Industrial Chemical Complex. The 50-mile long Houston Ship Channel is the world's sixth largest seaport and it handles the highest water-borne tonnage of USA. The refinery of Exxon Mobil, two petrochemical units and two research centres in the Bayport Industrial Area and provides the basic raw material for the Chemical estate in the Bayport region. This is a world centre for petrochemicals representing more than 45% of the base petrochemicals manufacturing capacity in the U.S.

A multitude of feedstock's such as ethylene and propylene area available by pipeline. Chemical capacities are integrated with large refineries or upstream gas processing facilities, thereby earning savings through product flow.

#### 3.3.2.2 National PCP Estates

##### RIL, Dahej / Gandhar, Gujarat

RIL, Dahej Manufacturing Division located near Bharuch, Gujarat, is spread over 1,778 acres. It comprises of an ethane / propane recovery unit, a gas cracker, a caustic chlorine plant and 4 downstream plants, which manufacture polymers and fibre intermediates. The complex has its own facility for separating ethane/propane from rich gas containing recoverable amounts of ethane / propane purchased from GAIL. The lean gas from which the ethane / propane has been extracted is returned to GAIL. The ethane / propane mixture is then used as a feedstock for the gas cracker plant. The Caustic Chlorine, VCM and PVC plants in Phase I was commissioned in 1997. After this, in Phase II, HDPE plant, MEG plant, ethane / propane recovery plant and gas cracker unit were commissioned in 2000.

##### RIL Jamnagar, Gujarat

Jamnagar Manufacturing Division is located near Jamnagar, Gujarat. It comprises of a petroleum refinery and associated petrochemical plants. The refinery is equipped to refine various types of crude oil (sour crude, sweet crude or a mixture of both) and manufactures various grades of fuel from motor gasoline to Aviation Turbine Fuel (ATF). The petrochemicals plants produce plastics and fibre intermediates. The Jamnagar Manufacturing Division has a 33 - million tonnes per annum refinery that is fully integrated with downstream petrochemicals units which manufacture naphtha-based aromatics as well as propylene-based polymers.

Situated on the northwest coast of India, the integrated refinery-cumpetrochemicals complex is located at Motikhavdi, Lalpur Taluka, Jamnagar District, in the state of Gujarat. It is in proximity to the Gulf of Kutch, a sheltered bay close to the Middle-East crude oil sources. The location of RIL's refinery on the west coast of India supported by world-class logistics and port facilities provides the Company with freight advantages.

##### RIL Hazira, Gujarat

Hazira Manufacturing Division is located near Surat, Gujarat. It comprises of a Naphtha cracker feeding downstream fibre intermediates, plastics and polyester plants. The first phase of the complex was commissioned in 1991-92 to generate power/utility and to manufacture Ethylene Oxide (EO), Mono Ethylene Glycol (MEG), Vinyl Chloride Monomer (VCM), Poly Vinyl Chloride (PVC) and High Density Polyethylene (HDPE). A jetty was built for loading and unloading operation of raw material and final products.

The second phase of the project, started in 1995, involved commissioning of the Polyester Complex (POY & PSF) and continued in full backward integration with commissioning of the new Polypropylene (PP), Naphtha Cracker, Purified Terephthalic Acid (PTA) plants and also involved expansion of existing phase 1 plants.

##### RIL Vadodara, Gujarat

RIL, Vadodara Manufacturing Division located in Vadodara, Gujarat. It comprises of a Naphtha cracker and 15 downstream plants for the manufacture of polymers, fibres, fibre intermediates and chemicals.

### RIL Naroda, Gujarat

Naroda Manufacturing Division located near Ahmedabad, Gujarat, is RIL's first manufacturing facility. This synthetic textiles and fabrics manufacturing facility manufactures and markets woven and knitted fabrics for home textiles, synthetic and worsted suiting and shirting, ready to wear garments and automotive fabrics.

Complex represents the largest investment in the textile industry at a single location. Naroda complex is India's most modern textile complex - a recognition bestowed by the World Bank. The activities at Naroda complex, since its inception, have also witnessed substantial growth. Fabrics of various types - suiting, shirting, home textiles - are manufactured here. The most distinctive feature of Naroda complex is the varied product group manufactured requiring different creative techniques are all housed under one complex. This feature of Naroda is without a parallel.

The Naroda Manufacturing Division continues to maintain technological edge and continues to enjoy the status as one of the most modern, state-of-the-art textile plants in the country.

### RIL, Nagothane, Maharashtra

Nagothane Manufacturing Division is located near Raigadh, Maharashtra. It comprises of an ethane and propane gas cracker and five downstream plants for the manufacture of polymers, fibre intermediates and chemicals.

Nagothane Manufacturing Division contains one Gas Cracker, LDPE Plant, Butene-1 Plant, LLDPE / HDPE Plant, Polypropylene Plant, and MEG / Ethylene Oxide Plant.

The basic benchmarking information on plant area, employment, product mix and facilities area has been tabulated in the Table 3.12.

Table 3.12: Benchmarking of PCP estates

| Name of estates | Area (ha) | Employment | | Product mix) | | | | | | | | | | | Facilities available | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Direct | Indirect | Refinery | Cracker plant | Building Blocks: Ethylene | Propylene | Butadiene | Benzene | Toluene | Xylene | Commodities | Intermediates | Final products | Port | Pipeline | Airport | Storage / Warehouse | Container terminal | Third-party logistics park* |
| Port of Rotterdam | 5,000 | 12,000 | 60,000 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | Y |
| Port of Antwerp | 13,500 | 63,080 | 1,50,000 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | -- | Y | | -- |
| Bayport Chemical Estate Houstan | 3,000 | NA | NA | Y | Y | Y | Y | Y | Y | Y | Y | -- | -- | -- | Y | Y | -- | 2.2ha | 18ha | -- |
| Jurong Island, Singapore | 3,200 | NA | NA | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | -- | -- | -- | 18million cubic metre | | 80ha |
| Sanghai Chemical Industry Park (SCIP) | 3,000 | NA | NA | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | - | -- |
| Nanjing Chemical Industry Park | 5,000 | NA | NA | Y | Y | Y | Y | Y | Y | Y | Y | -- | Y | -- | -- | -- | -- | -- | -- | chemical exchange centre* |
| RIL (IPCL), Dahej / Gandhar | 700 | 1,600 | NA | N | Y | Y | -- | -- | -- | -- | -- | Y | -- | -- | Y | Y | N | Y | -- | N |
| RIL, Jamnagar | 3,036 | NA | NA | Y | Y | Y | -- | -- | -- | -- | -- | Y | | | Y | Y | N | Y | -- | N |
| RIL, Hazira | 405 | NA | NA | N | Y | Y | -- | -- | -- | -- | -- | Y | Y | Y | Y | Y | N | Y | -- | N |

Source: In-house database from Mott MacDonald

### 3.3.3 Inferences

Lessons drawn from the above studies, it is apparent that such mega chemical estates essentially need the basic feedstock (in order to cater to a wide gamut of industries), which in most cases comes from the petrochemical Industry. The feedstock for these petrochemical industries comes either from refinery or natural gas. Thus the product configuration of the major chemical estates is primarily based on refinery output and has the major petrochemical building blocks. These complexes are generally located close to a major port facility. And these needs large investments i.e. these must have presence of large international chemical companies.

## 3.4 Studies on various chemical products

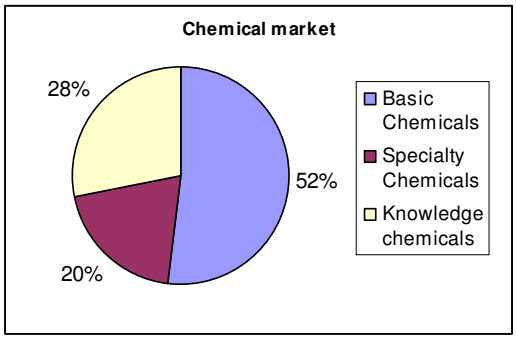
Extensive desk research on chemical industry covering the major Chemical sub-sectors, viz., Organic Chemicals including Petrochemicals, Inorganic Chemicals, Fine & Speciality Chemicals, Pharmaceuticals, Agrochemicals, Fertilizers, Dyes & Paints etc. has been done to understand the market scenario of these products.

### 3.4.1 Study of chemical sub-sectors

The chemical industry is a key contributor to the world economy. The industry supplies to virtually all sectors of the economy and produces more than 80,000 products. The growth in revenues within the chemical industry depends largely on the overall growth of the economy and industrial production and is often measured as a multiple of GDP growth.

Global chemical industry is classified into Basic Chemicals, Specialty Chemicals and Knowledge Chemicals.

Figure 3.13: Chemical Market




Source: MM Desk Research

a) Basic Chemical

The **Basic Chemicals** include Organic Chemicals, petrochemicals, fertilizers, inorganic chemicals, soaps & toiletries and other industrial chemicals. Globally, the Basic Chemicals are approximately US $ 1 Trillion industry accounting for 52% of the global chemical market. This segment is characterized by high capital intensity, high volumes and stringent regulations on health, safety and environment. Organic chemicals (including Petrochemicals), inorganic chemicals, fertilizers, soaps & toiletries account for more than 95% of the total Basic Chemicals segment.

b) Speciality Chemicals

**Speciality Chemicals** are low investment high value added products such as paints & coatings, catalysts, plastic additives, adhesives & sealants, additives for pharmaceuticals etc. The Specialty Chemicals industry is valued around US $ 0.4 Trillion industry accounting for 20% of the total output of the global chemicals market in value terms. Specialty chemicals are characterized by high levels of R&D to develop new products and applications. Western Europe is the largest regional market.

The capital investments for this segment are much lower than Basic Chemicals but investments in R&D to develop new products and applications are high.

c) Knowledge Chemicals

**Knowledge Chemicals** include agrochemicals, pharmaceuticals and bio-technology products which are used to induce specific outcome in humans, animals, plants and other life forms. Knowledge chemicals are a USD 0.5 trillion industry accounting for 28% of the global chemical market. The bio-technology sub-sector is, expected to be the driver, as product applications are being developed to either substitute or provide improved manufacturing processes for other chemical segments such as basic chemicals and speciality chemicals. Knowledge Chemicals market relies extensively on R&D for new products and is capital intensive. Patents and regulations to protect intellectual capital are key considerations for companies entering new markets in this segment. Agro chemicals & Pharmaceuticals mainly constitute the Knowledge Chemicals segment.

The following sections discusses in brief the global and domestic market scenario of major Chemical sub- sectors in the three major segments of the Chemical Industry as detailed in Table 3.22.

Table 3.13: Sub-sectors of the Global Chemical Industry

| Segment | Chemical Sectors |
|---|---|
| Basic | Organic Chemicals ( including Petrochemicals) |
| | Inorganic Chemicals |
| | Fertilizers |
| | Soaps & Toiletries |
| | Dyes & Paints |
| Speciality | Speciality Chemicals |
| Knowledge | Agrochemicals |
| | Pharmaceuticals |

Source: MM Desk Research

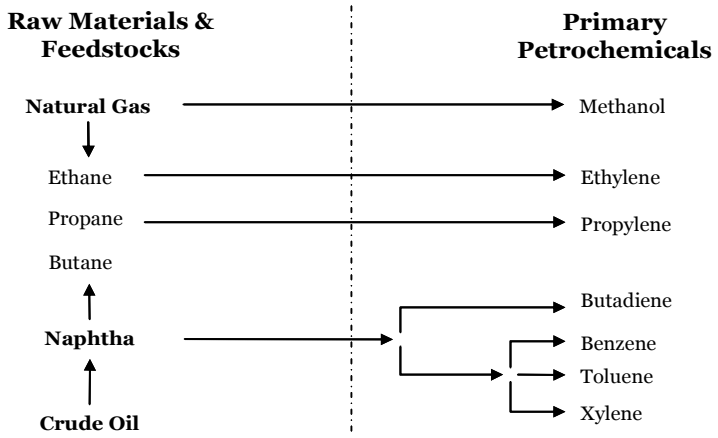
### 3.4.1.1 Organic Chemicals

Augmentation in the petrochemical technology has propelled the widespread growth of polymers as well as new product and production technology. Polyethylene and Polypropylene, commonly used polymers, which are derived from ethylene and propylene respectively, are the basic building blocks of petrochemical industry. Several other polymers like PVC, PB, SBR, etc which at present are commonly used in day-to-day life are also derivatives of petrochemical products. Currently, oil and gas are the main sources of the raw materials because they are the least expensive, most readily available, and can be processed most easily into the primary petrochemicals.

Primary Petrochemicals

"Primary Petrochemicals" include: olefins (ethylene, propylene and butadiene), aromatics (benzene, toluene, and xylenes); and methanol. Olefins are unsaturated molecules of Carbon (C) and hydrogen (H) that appear as short chains, of two, three or four Carbons in length. Aromatics contain a six Carbon ring structure. The oxygen/hydrogen (OH) group in methanol denotes that it is an alcohol. Refer Figure 3.14 for typical feedstock to primary petrochemicals conversion tree.

Figure 3.14: Feedstock to Primary petrochemicals




Source: MM Desk Research

### Intermediates and Derivatives

Petrochemical intermediates are generally produced by chemical conversion of primary petrochemicals to form more complicated derivative products. Petrochemical derivative products can be made in a variety of ways:

- directly from primary petrochemicals;
- through intermediate products which still contain only Carbon and hydrogen; and,
- Through intermediates which incorporate chlorine, nitrogen or oxygen in the finished derivative.

In some cases, they are finished products; in others, more steps are needed to arrive at the desired composition.

Of all the processes used, one of the most important is polymerization. It is used in the production of plastics, fibres and synthetic rubber, the many finished petrochemical derivatives. Some typical petrochemical intermediates and their application areas are shown in Figure D.1 in Appendix D.

### Ethylene Scenario

a) Product: Ethylene ($C_2H_4$) is the simplest alkenes (Olefin) and a primary feedstock in the petrochemical industry, which is generally derived from the cracking of higher hydrocarbons. Its production is considered to be the prime indicator of petrochemical Industry worldwide.

Various downstream products manufactured from ethylene like polyethylene, Ethyl Benzene, Ethylene oxide Ethylene dichloride, Alpha-olefins, fatty alcohols, Vinyl Acetate Monomer (VAM) etc.

Globally, the demand of ethylene is crucially linked to its key end-use segment – Polyethylene, comprising of High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), and Linear Low Density Polyethylene (LLDPE). This segment accounts for nearly 60% of the global ethylene demand. Other consuming segments include Ethylene Di-Chloride (EDC), Ethylene Oxide (EO) and Ethylene Glycol (EG), and others.

b) Demand: The demand of ethylene is anticipated to augment by nearly 4% over the short term, primarily owed to the growth in the Polyethylene segment. However, it is anticipated that the global capacity additions will outpace the demand growth by a significant extent, as capacity additions in the Middle East and Asian regions will take the nameplate global capacity to nearly 145 million tons in 2013. The direct demand of the Ethylene in India stands at about 3% of the total demand indicating the net imports into the region.

c) Major players: Ethylene is produced by 4 major players in the country as depicted in Table 3.14. Majority of the production facility is located on the coastline, especially western India. The total installed capacity in India in the year 2009 stands at 3.8 million metric tons.

Table 3.14: Major players of Ethylene Industry

| Company | Installed Capacity (MT) |
|---|---|
| Gas Authority of India Ltd. (GAIL) | 4,00,000 |
| Reliance Industries Ltd. (RIL) | 18,83,400 |
| Haldia Petrochemicals Ltd. (HPL) | 6,70,000 |
| Indian Oil Corp. Ltd. (IOCL)* | 8,57,000 |
| Total installed Capacity | 38,10,400 |

Source: Company Annual Reports, IMM analysis, * - Recently Commissioned

The domestic ethylene production trend is shown in theTable 3.15 below:

Table 3.15: Ethylene Production Trend

| Year | Production (MT) |
|---|---|
| 2004-05 | 2,648,023 |
| 2005-06 | 2,719,182 |
| 2006-07 | 2,683,401 |
| 2007-08 | 2,805,941 |
| *2008-09* | 2,785,680 |

The consumption of Ethylene in the year 2005-06 in the country was recorded at 2.76 million metric tons. More than 60% of the demand came from the Polyethylene segment. Majority of the demand of EO comes from EG segment. The demand of EG primarily comes from the polyester segment, which finds its application in Textiles, packaging and Engineering. It is also used as anti freeze / coolant.

Styrene Monomer is primarily used in manufacturing Polystyrene of various types - General Purpose-High Impact Poly Styrene (GPPS/HIPS) and Expandable Polystyrene (EPS), which are used in rigid packaging, casing, cutlery and models. Currently, styrene being entirely imported, this segment is hardly making any contribution to ethylene demand growth.

d) Future Outlook: With billions worth of investment lining up to augment the production ethylene capacity, it is expected that ethylene production facility would increase from existing 3.8 million metric ton to 10.4 million metric tons by 2014-15; this enhancement in the production capacity (Refer Table 3.16) would increase self-reliance and reduce the dependency on imports.

Table 3.16: New Capacity/ Expansion Planned in India

| Company | Capacity (MT) | Year of Start up |
|---|---|---|
| ONGC - Dahej | 11,00,000 | 2012 |
| Essar Gujarat Petrochemicals | 13,00,000 | 2013 |
| RIL - Jamnagar | 18,00,000 | 2012 |
| CPCL - Chennai | 12,00,000 | 2014 |
| HPCL/Mittal Energy/Oil India/GAIL | 10,00,000 | 2012 |
| Brahmaputra Cracker | 2,20,000 | 2012 |
| *ONGC/MRPL* | 10,00,000 | N.A. |

Source: MM Desk Research

Considering the strong future demand scenario of downstream ethylene products, both public sector and private sector industries are mobilizing capital into ethylene manufacturing infrastructure.

### Propylene Scenario

a) Product: Propylene ($C_3H_6$) is the basic petrochemical building block, which is widely used in the manufacturing of large-scale petrochemical products which finds its application in the day-to-day life. It is second simple alkenes (olefin) after ethylene in the world that is derived as by-product in petroleum refining and as co-product in Natural Gas Liquid/ Naphtha cracking.

Other derivatives of propylene include Iso-propanol, Acrylic Acid, acrolein, propylene dimmer, Propylene Oxide, etc. It is also used in petroleum industry for octane improvement.

b) Major players: Propylene is manufactured by nine major players in the country. Majority of the production facility is located on the coastline, especially at Western India. The total installed capacity in India in the year 2008-09 stood at 1.9 million metric tons, as shown in the table below:

Table 3.17: Propylene Installed Capacity

| Company | Installed Capacity (MTPA) |
|---|---|
| RIL | 1,445,460 |
| IOCL | 48,000 |
| CPCL | 30,000 |
| HPL | 275,000 |
| HPCL | 35,000 |
| BPCL | 75,000 |
| HOCL | 29,000 |
| NOCIL - Petrochemical Division | 35,000 |
| **Total** | **1,972,460** |

Source: MM Desk Research

The capacity utilization has consistently been recorded over 100% from 2006-07 to 2008-09.

The future domestic capacity addition details are as shown in Table 3.18

Table 3.18: Propylene Future Capacity Additions

| Major players | Capacity (MTPA) | Start-up |
|---|---|---|
| Assam Gas Cracker - Lepetkata | 60,000 | 2011-12 |
| IOC – Panipat | 650,000 | 2010-11 |
| Kochi Petrochemical Complex – Kochi | 100,000 | 2013-14 |
| MRPL – Mangalore | 300,000 | 2010-11 |
| ONGC – GSPC Dahej | 340,000 | 2011-12 |

Source: IMM analysis

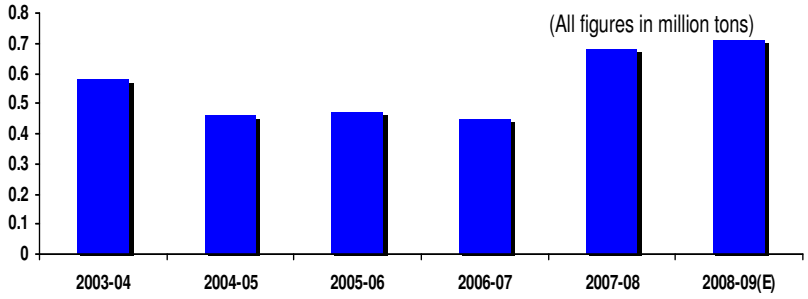
### Benzene

a) Product: Benzene (molecular formula - $C_6H_6$) is a colourless, flammable and volatile liquid with a distinct, characteristic odour. Ethyl benzene accounts for major application of benzene, which is the

principal raw material for production of styrene. Benzene is also an important raw material for Cumene. The other applications include manufacturing some types of rubbers, dyes, detergents, lubricants, explosives and pesticides.

b) Demand: Global installed capacity of benzene during 2003 was estimated at about 43.6 million tons which further augmented to about 49.6 million tons during the year 2008. Asia dominates the global supply accounting for about 31% of the total installed capacity owing to good operating margins. Domestic demand of Benzene in India during 2003-04 stood at about 0.59 million tons. The demand for benzene grew at a CAGR of about 10% to reach an estimated 0.71 million tons during 2008-09. The following figure depicts the domestic demand of Benzene during the period 2003-09.

Figure 3.15: Domestic Demand of benzene during 2002-2009




Source: MM Desk Research

It is noted that

- The demand of Benzene in domestic market is largely driven by its end use segment.
- The domestic demand remained constant from 2004 to 2007.

The demand of benzene is largely driven by end users. The domestic installed capacity of benzene during 2002-03 stood at about 0.6 million tons. The capacity is estimated to further augment to about 0.9 million tons during the year 2008-09. It is noted that domestic capacity was enough to cater to the requirement of local market. The average capacity utilisation stood at above 80% during the year 2007-08.

c) Major players: The domestic market is catered by the players like RIL, BPCL, and Haldia Petrochemicals. The Consultants note that about 30% of the total domestic production is exported from India. The following table illustrates major Benzene players in domestic market.

Table 3.19: Major Domestic Players

| Sr. No | Players | Location | Estimated Capacity (Million Tons Per Annum) |
|---|---|---|---|
| 1 | Reliance Industries Limited (RIL) | Gujarat | 0.75 |
| 2 | Haldia Petrochemicals Limited | West Bengal | 0.10 |
| 3 | BPCL-Kochi Refineries | Kerala | 0.09 |
| 4 | Others | - | 0.16 |
| | Total | | 1.1 |

Source: Company Annual Reports

The Consultants note that Benzene has surplus capacity at present and hence there is no demand supply gap existing in the domestic market. With average capacity utilisation of above 80% the local players are able to cater the requirement of domestic market.

Methanol

a) Product: Methanol is an organic chemical and forms an important part of the Indian petrochemical industry. Methanol is manufactured from natural gas that has methane content. Methanol is used primarily in the production of Formaldehyde, MTBE, Acetic Acid and Acetic Anhydride. Other uses of methanol include silicones, refrigerants, adhesives, specialty plastics and coatings, textiles and water treatment chemicals.

Beside these, the greatest consumption of methanol may turn out to be as fuel in admixture with gasoline and diesel. Methanol is a cleaner fuel for cars with better thermal efficiency and less pollution.

b) Demand: The demand for Methanol is expected to be around 1 MMTPA by the end of this decade, which will be mainly driven by the end-use sectors, viz. Acetic acid and Formaldehyde. Imports will continue at the existing pace. Existing players have to increase their capacity in order to meet the demand supply gap by the end of the decade. It has been found out that based on growth of key end user sectors; the growth in demand for Methanol is expected to increase at 8.5% per annum in future. Indian industry may venture into MTBE production to meet twin objective of methanol consumption and octane booster replacing TEL from air pollution point of view.

c) Major Players: The major companies producing methanol in India are:
- RCF in Mumbai
- NFL in Rupnagar
- IOCL in Chennai
- Century Enka in Pune
- India polyfibres Ltd in Barabanki
- GNFC in Bharuch

Thus it shows that the **organic chemical industry** appears to have very high potential to be present in GPCPSIR as these have **high demand in both domestic and internationally** and these are both **investment and employment potential**.

### 3.4.1.2 Inorganic Chemicals

The **chlor-alkali industry (Caustic Soda, Chlorine, and Soda Ash)** is the most important sub--sector of the inorganic chemical industry. The chlor-alkali industry in India is around 60 years old. It began with a modest capacity of a few thousand tonnes per annum. The Soda Ash industry in India traces its origin to the 1930s when Dhrangadra Chemical Works (DCW Ltd) set up the first plant in Gujarat, based on the availability of salt and limestone – the principal raw material. This was followed by Tata Chemicals Limited in Mithapur, Gujarat. Hence these three products have been discussed briefly:

Caustic Soda

a) Product: Around three-quarters of end use demand of caustic soda tracks GDP growth and, for this reason, the profitability of the industry is highly cyclical. The supply of caustic soda can be influenced by the chlorine derivatives markets since nearly all caustic soda is co-produced with chlorine. With the major markets in the US, Western Europe and Japan being mature and only

growing slowly, China is driving the growth in demand for caustic soda. China is the world's largest consumer of caustic soda accounting for 28% of world demand and is also the largest producer.

b) Demand: Caustic soda along with Chlorine is the basic building block of the chemical processing industry. The Indian Caustic Soda Industry was growing at 5-6% till second quarter of 2008-09. The total capacity has increased from 1.7 Million MT in 2001-02 to 2.30 Million MT in 2006-07. The production in 2007-08 stood at 2.18 Million MT an increase of 14% over the previous year. The largest segment of caustic soda is the paper industry with newsprint claiming nearly 20-25%. Manmade fibres account for 19% of consumption and soaps and detergents claim approximately 20%. The installed capacity in India for caustic soda in 2007 was 25.48 Lakh MT. The following table shows the production of caustic soda through 2004- 2009

Table 3.20: Production and Installed Capacity of Caustic Soda in India, 2004-09

| Year | Installed capacity in operation ('000 MT) (as on 31st March) | Production ('000 MT) | Capacity Utilisation (%) |
|---|---|---|---|
| 2004-2005 | 2,076.8 | 1,812.4 | 87.3 |
| 2005-2006 | 2,291.5 | 1,936.7 | 84.5 |
| 2006-2007 | 2,547.8 | 1,993.1 | 86.7(Avg) |
| 2007-2008 | 2,741.8 | 2160.3 | 83.3 (Avg) |
| 2008-2009 | 3,050.4 | 2,192.4 (E) | 72.0 (E) |

Source: Ministry of Commerce and Finance

From the above table we can see that he capacity utilisation has reduced by almost 13.5% from 2007-08 to 2008-09. Possible reason for this could be a slowdown in demand due to recession. However with economic recovery on track and a rising demand for detergents and soaps mainly, one can hope to see an increase in the production levels and the utilisation rates in the near future.

The domestic demand for caustic soda in 2009-2010 was 24, 50,000 MT and is expected to increase to 2652, 000 by 2012-2013 and 3135,000 MT in 2019-2020. This represents a market growth rate of 2.5% over 2011-2020 period.

c) Major Players: Caustic soda is produced in regions that have high concentration/ availability of limestone. They can also naturally occur in arid regions, especially in the mineral deposits formed when seasonal lakes evaporate. Salt manufacturing activities are carried out in the coastal states of Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka, Orissa, West Bengal Goa and Hinterland State of Rajasthan. Among these States only Gujarat, Tamil Nadu and Rajasthan produces salt surplus to their requirement. Gujarat alone accounts for over 90% of caustic soda production; this is due to easy availability of limestone.

Gujarat Alkalies with an 18% market share, DCM Sriram, Grasim Industries enjoys an 11-12% market share and Reliance are the biggest players in this field. Other players include

- Punjab Alkalies
- Standard Industries
- United Phosphorous
- SIEL
- DCW
- Bihar Caustic and Chemicals
- Modi Alkalies

## Soda Ash

a) Product: Soda Ash is mainly used for preparation of glass, dyes, detergent, food additive, brick industry, foaming agent, water softner etc. In 2008, glass production accounted for half of global soda ash consumption, followed by chemicals (about 23%) and soaps and detergents (about 4%). World soda ash consumption is projected to grow at an average annual rate of about 2% through 2013. Projected regional average annual growth rates range from 4% for Asia to -0.2% for North America and -0.1% for Europe. Developed countries have higher soda ash consumption but lower growth rates compared to developing countries. However, the end-use patterns are basically the same for both. India accounts for about 6% of global soda ash capacity.

b) Demand: The market for soda ash was valued at INR 30 billion in 2007-08. Soda Ash forms an important part of the Chlor Alkali segment of the Indian inorganic chemical industry. The largest consumer of soda ash is the detergents industry followed by glass and the chemical industry. The following table shows the % share of each segment.

Table 3.21: Market Segmentation of Soda Ash Industry

| Segment | Share (%) |
|---|---|
| Soaps and Detergents | 40 |
| Glass | 24 |
| Chemical Industry | 14 |
| Sodium Silicates | 10 |
| Others | 12 |

Source: CIER

The soda ash industry has considerable scope to expand, especially consumption-driven growth. It is apparent in the per capita consumption where India consumes just 2.7 kilograms compared to countries like China at 9.8 kilos and the US with 22.

Therefore, the demand for soda ash in 2009-2010 stood at 2954,000 MT and is expected to increase to 3197,000 MT by 2011-2012 and 4206,000 MT by 2019-20. The main growth of the industry has been from the rise/increase in the detergents industry. The detergents industry is currently growing at 2.5% but is expected to grow at 5.2% in the time period of 2011-2020, while the glass industry has been seeing somewhat of a slowdown.

c) Major Producing States: This industry is regionally concentrated where salt is available in abundance. In Gujarat, the Saurashtra region accounts for about 90% of the soda ash production in the country due to large availability of limestone and salt, both key components of soda ash. Salt manufacturing activities are carried out in the coastal states of Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka, Orissa, West Bengal Goa and hinterland State of Rajasthan. Among these States only Gujarat, Tamil Nadu and Rajasthan produces salt surplus to their requirement. Tata Chemicals, Nirma and Gujarat Heavy Chemicals Ltd (GHCL) are the top 3 producers of soda ash and claim 85% of the capacity.

## Carbon Black

a) Product: Carbon Black is an elemental Carbon in the form of colloidal particles that are produced by incomplete combustion or thermal decomposition of gaseous or liquid hydrocarbons under controlled conditions. Its physical appearance is that of a black, finely divided pellet or powder. Its use in tires, rubber and plastic products, printing inks and coatings is related to properties of specific surface area, particle size and structure, conductivity and colour. Carbon Black is also in the top 50 industrial chemicals manufactured worldwide, based on annual tonnage. Current worldwide

production is about 18 billion pounds per year [8.1 million metric tons]. Approximately 90% of Carbon Black is used in rubber applications, 9% as a pigment, and the remaining 1% as an essential ingredient in hundreds of diverse applications.

b) Demand: Tyres are the main source of about 65% of the demand for Carbon Black the rest being taken by rubber (34%) and 1% by paints dyes and inks. The industry is reported to have an installed production capacity of 455,000 tonnes annually. The production in 2007-08 stood at 483,000 tonnes and has been producing at >100% capacity utilisation. Production and consumption of Carbon Black has increased at a high rate in recent years because of increased tyre production. The tyre industry presently consumes around 65% of total production. India's tyre production is estimated to have increased only 1.2% in FY2009, as compared with a 3-year CAGR of 10.5% during FY2006-08. Future growth in tyre production is expected to be healthy driven by moderate growth in automotive production, increased replacement demand, and higher exports.

c) Major Players: Since Carbon Black is manufactured by the incomplete combustion of heavy petroleum products, manufacturing units are located largely in states where petroleum and petrochemical industries are based or are in abundant supply. The states of Gujarat, Tamil Nadu and Maharashtra are the largest manufactures. Phillips Carbon Black is the market leader with a share of over 40%. Aditya Birla Nuvo follows close being at >35%. Cabo India enjoys a market share of >10%. The other 15% is accounted by others that include Indian Rayon, Continental Carbon, Ralson Carbon Black etc.

Chlorine:

a) Product: Chlorine end-products are used for manufacturing of long-lasting products such as PVC tubes, frames and doors, polyurethane insulation. Therefore, demand for chlorine is directly related to the construction industry and in turn on the economy. Of all the chorine products, PVC and polyurethane account for about 55% of global demand which is growing at a rate of 3.8%.

b) Demand: Given its varied uses, chlorine has witnessed capacity utilisation of around 85-90%. Global chlorine capacity has also been growing with most of the additions in northeast Asia. Chlorine capacity has also grown the fastest in China reaching 25m tonne/year by 2009. CMAI notes that an average of 3m tonne/year has been added each year in the last four years and a further 2m tonne/year is expected to be added in 2010 and 2011. Global chlorine production was recorded at 56 million MT in 2008. Asia and Europe are the two leading regions for chlorine production contributing 47% and 23% respectively. India's per capita chlorine consumption is only 1.85 kg as against China's 13 kg. This figure can grow only if the industry invests heavily in vinyls – the key end use market for chlorine. India imports around 400,000 tonnes of PVC annually.

c) Major Players: Industry is characterised by around 40 players. Major Players are –

- Gujarat Alkalies & Chemicals - Vadodara
- DCM Sriram - Kota
- Kanoria Chemicals - Ahmedabad
- Andhra Sugar - Kovvur
- Punjab Alkalies – Jallandhar

d) Future Outlook: In India, there is potential to develop as a chlorine hub in Dahej where Gujarat Alkali and Chemicals Ltd (GACL) plan to link its chlor-alkali facility with an investment in chloromethane in joint venture with Dow Chemical. Reliance Industries already has a cracker at the

site and ONGC is planning one which should have ethylene to spare for a vinyls unit. All that is needed is to bring in a few more investors to complete the chlorine chain. Other chlor-alkali facilities at the site include one operated by Reliance Industries and a second being built by Meghmani Organics.

Sulphuric Acid

a) Product: Sulphur is a major by-product of energy industry. Development in the energy industry will ensure continuous increase in the sulphur output irrespective of market demand. Therefore, it is considered as the chemical with the highest total annual production globally. Principal uses of sulphuric acid include ore processing, fertilizer manufacturing, oil refining, waste water processing and chemical synthesis.

b) Demand: World consumption of sulphuric acid has risen from $4.5 billion in 1992 to $5.4 billion in 2000. Japan, Canada and Germany are the leading exporters. Main sulphur consumers are large (more than 1m mt/y) producers of fertilizers: the USA, Morocco, Tunisia, India, China and Brazil.

In 2008-09, total production of sulphuric acid was recorded at 6.4 million MT in India. Over last 10 years, production has signifying an average growth of 4.7%. The domestic installed capacity is estimated to be over 9 million tons. Sizeable capacities exist in the western region, which has the highest number of consuming industries in India. The apparent domestic consumption of sulphuric acid in 2006-07 is estimated at nearly 7.4 million tons, indicating a rise of nearly 5% as compared to 2005-06, driven by increased consumption in key end use sectors. The average growth in consumption from 2000-01 to 2006-07 works out to be 4.7%.

The phosphates fertilizer segment accounts for major chunk of the demand, in the range of 50 – 60%, followed by dyes and dyes intermediates, drug and drug intermediates, chemicals, batteries and others. Majority of the consuming industries have installed sulphuric acid manufacturing facilities, thereby ensuring a continuous supply of the acid.

c) Major Players: As of 2005-06, Sterlite Industries enjoyed the highest market share, followed by DMCC, Hindustan Zinc and Tata Chemicals.

Hence the above products have high potential to coexist with the organic chemicals in the GPCPSIR as it will improve the product range of the value chain.

#### 3.4.1.3 Fertiliser Sector

Fertilizer consumption in India is among the lowest in the world .The fertilizer prices are government regulated. Chemical fertilizers have played a key role in the success of the green revolution in India. Out of the three main nutrients i.e Nitrogen, Phosphate and Potash required for various crops, the raw material is available in India mainly for nitrogenous fertilizers.

The Indian fertiliser industry produces Nitrogen (N) and Phosphate requirements (P) and the entire demand for Potash (K) is met through imports. The principal nitrogenous fertiliser in the country is urea contributing to roughly 85% of total N consumption. P is supplied primarily by DAP and SSP. IFFCO is one of the largest player in this sector in India.

Besides, the government is firming up a policy for conversion of existing non-gas based Urea units to natural gas /LNG which are cost effective sources of energy. This will depend upon additional availability of natural gas through new gas fields and imported LNG. As GPCPSIR has location advantage also in getting LNG, Fertiliser products can be included in product value chain.

#### 3.4.1.4 Speciality Chemical

This industry is extremely skill driven and requires multi disciplinary technical expertise to cater to the specific customer needs. This industry is not volume intensive but is often knowledge driven with patent protection. The business yields high margins as they are application specific and customized. The global specialty chemicals industry is estimated to have a share of around 20% of the global chemical industry.

The largest use of specialty chemicals is in the pharmaceutical industry, which accounts for around 45% of total global demand for specialty chemicals. Another important segment is agrochemicals, which accounts for one fifth of the total consumption. Specialty chemicals can be divided into two groups- **Fine Chemicals** and **Performance Chemicals**.

Fine Chemicals: These products are used as intermediates in the manufacture of various chemical products such as pharmaceuticals, flavours and essences, agrochemicals, detergents etc. These products are characterized by medium to low sales volume and higher prices compared to commodities. These products are described by their chemical and physical properties.

Performance Chemicals: These products enable the achievement of specific results on their application. The chemicals have varied Chemical composition. They are typically designed for specific applications, sometimes for specific customers; many of them are formulations or mixtures of various chemical ingredients. Some of the major categories of specialty chemicals include Leather chemicals, Rubber chemicals, Textile chemicals, Polymer additives, Catalysts and Water Treatment chemicals.

Since this sector is of high margin business, there is minimum scope for financial and operational cost reductions. Players are focused on being competitive through reducing the manufacturing costs. These products are also vividly used as plastic additives, catalysts, intermediates and actives etc. hence these product category will add value to the final product value chain of GPCPSIR.

#### 3.4.1.5 Soaps & Toiletries

Soaps & toiletries account for 10% of the Indian chemical industry and are valued at US $ 3 billion. The consumption of soap has grown at CAGR of 10% over the decade. Hindustan Lever is the market leader with around one fifth of total market share. The growth in population and rising per capita income would help the industry to grow at a steady growth rate of 10% till 2008 and then taper of to 8% till 2015.

The soaps and toiletries sector has limited potential to be within the Mega Chemical Industrial Estate like GPCPSIR because it is high value low volume industry, which does not offer any linkages.

#### 3.4.1.6 Dyes & Paints

Nearly 60% of the dyes produced in India are exported. The fragmentation of dye industry has resulted in cost inefficiencies thereby affecting the profitability of most dyestuff companies in India. The growth of dye stuff would depend on product innovation, brand building, environment friendliness and greater customer orientation through improved technical standardisation of quality and packing. Production of paints has grown at CAGR of 5.7% during the past five years and exports have grown at CAGR of 17% during the same period. Thus the dyes and paints industry offers limited potential to be present within the Mega Chemical Industrial Estate as it low volume, high value addition business. The industry can be tenant in MCIE.

#### 3.4.1.7 Knowledge Chemicals

Agrochemicals and pharmaceuticals sub sector are the major constituents of knowledge chemicals.

##### Agrochemicals

Six global manufacturers control 80 % of the world market. India has 80 players in the organised sector and more than 500 small players in the unorganised sector. The Indian agro chemical market is estimated at US $ 1 billion. India is the second largest manufacturer of agrochemicals in Asia, next only to Japan. Insecticides are the major agrochemical in India, as against herbicides in the world market. Most agrochemical units in India operate at half of their installed capacities. This is mainly due to seasonality of demand and capacities exceeding the demand.

India with its lower cost manufacturing advantages would be a global sourcing hub for generic agrochemicals. It is also expected that consolidation of companies in the organised and unorganised sector will take place. Agrochemicals are a low volume industry. It has a limited potential to exist within the Mega Chemical Industrial Estate.

##### Pharmaceutical Industry

The pharmaceutical industry is highly fragmented both in terms of the number of manufacturers and the variety of products. There are close to 23000 units of which only 250 are in the large scale category. The top Indian pharmaceutical companies include Dr. Reddy Labs, Cipla, Ranbaxy, Aurobindo Pharma and Glaxo Smithk-kline. A large number of companies are located in Maharashtra (Formulation), Gujarat (Bulk Drugs) and Andhra Pradesh (Bulk Drugs).

The unorganised sector accounts for over 30 % of the total industry sales. A large percentage of them are engaged in the manufacture of formulations. Most of the Indian formulation manufacturers have integrated backwards to consolidate their position and improve their profitability.

The industry does not require large infrastructure facilities. Rather, it is driven by clean room technologies and follows strict environmental regulations. Very few pharmaceutical companies are present in the Mega chemical complexes worldwide because of its limited potential.

### 3.4.2 Inference

Considering three major factors i.e. global demand supply balance, presence of the chemical sub-sectors in the other Petrochemical Estates in India and abroad and industry opinion, it is clear that petrochemical building blocks and its derivatives has the best potential to anchor in the GPCPSIR. Further, the other factors such as investment potential, employment potential, export intensity etc also favours the petrochemical industry to be present in the PCP estates. The Table 3.13 shows the comparison matrix of the above factors, which have finally lead to the product selection for GPCPSIR.

Moreover, considering the regional sectoral emphasis as discussed in Section 3.2.4, the category of products have been selected, which comprises a large number of chemical and petrochemical industries, plastic and elastomer processing industries, ancillary and service industries, which have very good potential to co exist in GPCPSIR.

Table 3.22: Product Selection Matrix

| Sr no | Parameters | Basic Chemicals | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Organic Chemicals | | | | | | | | | Inorganic Chemicals | | | | | | | | | | Fertilizers | | | Soaps and Toiletries | | | Dyes and Paints | | | Specialty chemicals | | | Knowledge chemicals | | | | | |
| | | Petrochemicals | | | Methanol | | | Ethanol | | | Chlor-alkali | | | Carbon Black | | | Others | | | | | | | | | | | | | | | Agrochemicals | | | Pharmaceuticals | | |
| | | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L | H | M | L |
| 1 | Demand Supply Balance – International | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | ✓ | |
| 2 | Demand Supply Balance – Domestic | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | ✓ | |
| 3 | Investment Potential | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | ✓ | | | ✓ | | | | ✓ | ✓ | | | | | ✓ | | | | ✓ |
| 4 | Employment potential | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | ✓ | | | ✓ | | | ✓ | | | | ✓ | | | ✓ | | | ✓ | | | | ✓ |
| 5 | Interest of Anchor Developer/industry | ✓ | | | | | ✓ | | | ✓ | ✓ | | | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | ✓ |
| 6 | Forward & Backward linkages | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | ✓ | | | | ✓ | | | ✓ | | ✓ | | | | | ✓ | | | ✓ | | | | ✓ |
| 7 | Infrastructure requirement | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | ✓ | | | ✓ |
| 8 | Export Intensity | ✓ | | | ✓ | | | | ✓ | | | | ✓ | ✓ | | | | | ✓ | | | ✓ | | | ✓ | | ✓ | | | ✓ | | | | ✓ | | ✓ | | |
| 9 | Presence in other PCP estates | ✓ | | | ✓ | | | | ✓ | | ✓ | | | ✓ | | | | | ✓ | | ✓ | | | ✓ | | | | ✓ | ✓ | | | | ✓ | | | | ✓ | |
| 10 | Industry Opinion | ✓ | | | | | ✓ | | | ✓ | ✓ | | | ✓ | | | | | ✓ | | | ✓ | | | ✓ | | | ✓ | ✓ | | | | ✓ | | | | ✓ | |

H - High, M - Medium, L – Low

Source: Mott MacDonald In-house Study

## 3.5 Feedstock Selection

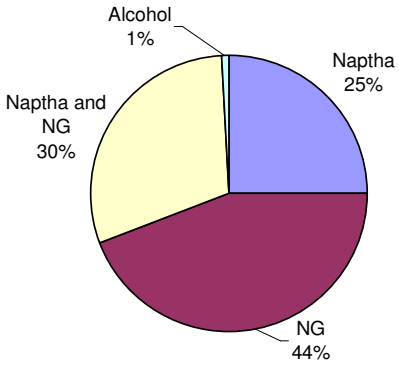
A wide range of alternative feed stocks such as naphtha, ethane/propane, alcohol, and LPG, NGL and gas oil can be used for production of Petrochemicals. In India, naphtha and C2/C3 fractions from natural gas are the main feedstock used. LPG is normally used as domestic fuel, while gas oil is not used because it is heavier fraction and needs complex processing. In India, some refineries crack LPG in their fluidised catalytic cracking units to produce propylene. A summary of various feedstocks used by Indian petrochemical majors is presented in Table 3.23.

Table 3.23: Feedstock used by Indian Petrochemical Majors

| Complex | Ethylene Capacity (TPA) | Feed stocks |
|---|---|---|
| RIL, Vadodara | 1,30,000 | Naphtha |
| IPCL-MGCC, Nagothane | 4,00,000 | Gas (C2/C3 7:3), ethane-propane fraction |
| RIL, Gandhar | 3,00,000 | Gas (C2/C3 7:3), ethane-propane fraction |
| RIL, Hazira | 7,50,000 | Naphtha / Natural Gas Liquid |
| NOCIL, Thane | 75,000 | Naphtha |
| HPL, Haldia | 4,20,000 | Naphtha |
| GAIL, Auriya | 4,00,000 | Gas (C2/C3 9:1) |
| Oswal Agro, Mumbai | 22,000 | Alcohol |

Source: Secondary research by MM

Figure 3.16: Feedstock choice




Source: Secondary research by MM

From Table 3.23 and Figure 3.16, it is apparent that about 44% of India's cracking capacity is based on natural gas, 25% is based on Naphtha feedstock and 30% is using Naphtha and NG both. Industrial alcohol which was an attractive feedstock in the days of alcohol price control is no longer an important feedstock and accounts for only 1% of the total ethylene production in the country. The major factors which affect the choice of feedstock are the relative yields of olefins and aromatics, desired energy costs, investment levels, availability and relative pricing. Natural gas and liquid Natural Gas yield a much higher proportion of ethylene. Hence, they are preferred when the polyolefins output of a cracker is sought to be maximised. On the other hand, naphtha is preferred when a wider range of output products (including propylene and butadiene derivatives) is desired.

Study reveals that refineries in Gujarat produce a good quantity of Naphtha for meeting feedstock requirement of the petrochemical industry, which is expected to increase significantly with the commissioning of the proposed refinery of Essar (18MMTPA). The growing demand of petroleum and petrochemical products in the region would also influence the existing players to increase their refining capacity in the plant over the years. Availability of gas for use as petrochemical feedstock is limited as meeting demand from the fertilizer and power sectors are given priority.

Hence in GPCPSIR, for steady feedstock supply regional feedstock can be considered or it can also be obtained from outside which can be obtained through chemical terminal of GCTCPL.

## 3.6 Conclusion

### 3.6.1 Product Configuration

Thus the above analysis reveals that the proposed GPCPSIR will ideally house oil refinery/s, petrochemicals, and chemicals and down stream units based on subsequent feasibility studies for the projects.

- However, refinery-petrochemical integration is amenable to the local situation. It is revealed from reference studies done abroad and in India, that product mix in all major chemical estates is based on refinery output and/or major building blocks.
- It would also house dual cracker units, as dual feed crackers are flexible to handle 100% gaseous or 100% liquid feedstock or a mixture of the two. Accordingly the downstream plants can be designed.
- The estate would require a substantial investment which would necessitate FDI i.e. existence of MNCs.
- The proposed area should have one or more than one SEZs with the necessary environment & infrastructure to attract investment.
- This industry requires the presence and linkages of infrastructure facilities like solid cargo port, chemical port, roads, container terminals, power plants, tank terminals, gas pipelines, effluent disposal pipeline. The presence of utilities and logistic service providers also adds to the investment potential.
- Keeping the above things in mind the following industry mix has been selected, which can be developed in phases (Table 3.24)

The following industry mix has been used as the basis to do the projections related to the Industries elaborated in Volume II, Chapter 1

a. ***Refinery / Cracker based projects:*** The following table presents the probable value chain which has been developed taking care of the above mentioned explanations.

Table 3.24: Refinery based product mix

| Feedstock | Feedstock | Primary Intermediates | Secondary Intermediates | Final products |
|---|---|---|---|---|
| **Natural Gas / Crude Oil / Condensate** | Methane / Refinery residue / Synthesis Gas | Methanol | Formaldehyde | Glues, Resins |
| | | Ammonia, Nitric Acid | Urea, AN, CAN, UAN | Fertilisers |
| | C2-C3 --> Naphtha --> Ethylene | LDPE, HDPE, LLDPE, EDC, VCM, PVC | | Plastic processing - Polymers, EPDM, Copolymers |
| | | Ethylene Oxide | Glycols, EVOH, | Ethylene Glycols For Specialty Chemicals |
| | | Mono Ethylene Glycol (MEG) | Ethyl NBO, Glycol Ethers | Alcohol-Based Products, Solvent |
| | | | Ethanol | Specialty chemicals, Detergents |
| | | | Ethoxylates | |
| | C2-C3 -->Naphtha --> Propylene, Propane | Polypropylene (PP) | PP co-polymers | Plastic Processing, PP fibre |
| | | Propylene oxide | Propylene Glycol, Polyethers | Polymers e.g. polyurethane, specialty chemicals, resins |
| | | Acrylonitrile | | Acrylic fibres, fabrics, garments, industrial fabrics |
| | | | Cumene, Phenol, Bisphenol, Polycarbonates | Specialty Chemicals, resins, engineering plastic components/ articles |
| | | | | Specialty chemicals, solvent |
| | | | | Adhesives, Resins |
| | | Isopropyl Alcohol | | Epoxy and other resins |
| | | Acrylic Acid | | |
| | | Epichlorohydrin | | |
| **Crude Oil** | Refinery Off-gases / Naphtha--> Mixed C4 | Polybutenes | | Additives, Specialty Chemicals |
| | | Butadiene | Polybutadiene | Acrylonitrile, Styrene, PBR, SBR, ABS, and plastic / elastomer processing, latex |
| | | | | Specialty chemicals |
| | | | MEK | Additives, Specialty Chemicals |
| | Naphtha | | MTBE | Solvents, Specialty Chemicals |
| | | | CBFS | Automobile tubes and tyres, conveyer belts |
| | Naphtha --> Benzene / Naphtha --> Toluene | Ethyl Benzene | Styrene / Polystyrene | Plastic processing |
| | | | Chlorobenzene, Nitrobenzene, Nitrochlorobenzenes, | Specialty Chemicals |
| | | | Aniline, | Polyurethane processing |
| | | | Cumene, Caprolactum, | Nylon- Yarn, Tyre Cord, Polymer. Plastic processing |

| Feedstock | Feedstock | Primary Intermediates | Secondary Intermediates | Final products |
|---|---|---|---|---|
| | | | TDI, MDI, | Polyurethanes, plastic processing |
| | | | TDI | Polyurethanes, plastic processing |
| | | | Phthalic Anhydride, | Phthalates, Resins, Pigments |
| | Naphtha --> Mixed Xylene | O,P-Xylene | Purified Terephthalic Acid | PET, Polyester- Yarn Grade, Bottle Grades, Staple Fibre, fabrics, garments, Polyester resins |
| **Sea water / Brine, Chlorine, NaOH** | EDC, Phosgene | VCM | PVC, MDI, Hypochlorites | Plastics, polyurethane, bleach |

**b. Alternative feedstock based projects:**

i. Petrochemical Working Group Study of Department of Chemical and Petrochemicals states that as per their Industry projections and trends in petrochemicals products along with the proven reserves of crude oil and natural gas, the Crude oil and Natural gas is likely to remain the main sources of feedstock for the petrochemicals for the next 10 to 15 years however, the pricing of the natural gas is going to be a crucial issue in attracting investment in gas cracker complexes.

ii. The development will focus on maximizing the value addition by way of increased hydrocarbon utilization.

iii. The increasing availability of Natural Gas with major percentage of methane content have already generated research activity on Gas to Liquid Technology (Natural gas to Methanol) which could be easily transported and used as chemical feedstock.

iv. Various Research and Developments are also on Coal Bed Methane as a feedstock for chemicals.

v. There is renewed interest due to high crude oil prices on the coal based monomers for the manufacture of chemicals like acetylene based chemicals through calcium carbide route and others.

vi. Nowadays there are emphasis on 'Sustainability, industrial ecology, and green chemistry' that are guiding the development of the next generation of materials, products and processes. The alternative bio-based feed-stocks, like Agricultural and plant origin, Animal Origin, Microbial origin hold promise for achieving the goals of sustainable development and implementing the principles of industrial ecology.

vii. Hence the **gas based** and **agri-based** categories of industry can be developed and integrated with the hydrocarbon based industry mix for long term sustainability of the GPCPSIR: (refer Table 3.25)

Table 3.25: Alternative feedstock based projects

| Primary | Secondary1 | Secondary2 | Tertiary onwards |
|---|---|---|---|
| Gas based projects | | | |
| | Methanol | Acetic acid | Specialty chemicals |
| | Fertilizers (Ammonia, Urea) | Nitrophosphatic fertilizers | Mixed fertilizers |
| Agri based – Bio Refinery | | | |
| | Organic chemicals | Biopolymers | Plastic processing |
| | | | Specialty chemicals |

Source: MM

***c. Projects identified from stakeholder interaction:***

From stakeholder interaction it is identified that a petrochemical complex of the size and type of GPCPSIR shall require several inputs in addition to the basic feedstock and energy. There is a potential of producing some of the following products for supplying to various industries in the region:

- Specialty catalysts
- Additives (for polymers and elastomers)
- Specialty chemicals
- Solvents
- Industrial gases
- Packaging material

***d. Shipbuilding Activity***

Being a coastal zone, shipbuilding activity can be encouraged here as a substantial area of GPCPSIR is coming under CRZ.

***e. Other supportive Engineering Industry***

Engineering industry which supports chemical and petrochemical base by way of fabricating/ supplying equipments, piping, process control and instrumentation, etc, and maintenance related services, dock and terminal activities becomes an integral part of the region for the self sustainability. In turn, engineering industry shall require support from metallurgical industry.

***f. Oil terminal / warehousing / Area for Third-party Logistics:***

This segment is very essential for a PCP estate. Oil terminal / Warehousing area typically has tankage, either above ground or underground, and gantries for the discharge of products into road tankers or other vehicles (such as barges) or pipelines. Ownership-wise it can be of individual, or of a consortium or of a third party service provider.

### 3.6.2 Siting of Projects:

- Projects shown under a,b,c can be sited separately
- Under a, primary and secondary1 projects to be sited together, considering integration of product streams and utilities seconday2 can be sited separately
- And tertiary products could be sited separately
- Even if above criteria is followed, there should be a provision of connectivity between each by way of a corridor for product pipelines and preferably utility pipelines also.

# Appendices

# Appendix A. FRA Baseline study data

## A.1. Basic Rainfall Data

| Max Daily Rain (mm) | | | | | | | Annual Rainfall (mm) | | | | | | | No of Rainy Days |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Bharuch | Hansot | Muller | Vagra | Dahej | **Station YR** | Year | Bharuch | Hansot | Muller | Vagra | Dahej | **Station YR** | Bharuch |
| 1962 | 103.0 | 57.9 | | 78.7 | 129.8 | 92.35 | 1962 | 617.5 | 433.7 | | 416.6 | 537 | 501.20 | 56 |
| 1963 | 155.0 | 96.7 | | 165.5 | 72 | 122.30 | 1963 | 893.9 | 644.8 | | 850.8 | 793.7 | 795.80 | 60 |
| 1964 | 213.0 | | | 103 | 80.5 | 132.17 | 1964 | 1032 | | | 918.1 | 916.1 | 955.40 | 28 |
| 1965 | 280.2 | 175 | | 159 | | 204.73 | 1965 | 606 | 588.2 | | 639.6 | | 611.27 | 42 |
| 1966 | 82.0 | 180 | | 93 | | 118.33 | 1966 | 576.3 | 893 | | 541.2 | | 670.17 | 38 |
| 1967 | 106.0 | 48 | | 173.5 | 40.13 | 91.91 | 1967 | 787.2 | 268 | | 773.8 | 422.6 | 562.90 | 56 |
| 1968 | 237.0 | 262 | 97 | 141 | 254 | 198.20 | 1968 | 810.7 | 895 | 342.8 | 596.2 | 581.4 | 645.22 | 25 |
| 1969 | 213.0 | 92 | 54.4 | 79.1 | 53.3 | 98.36 | 1969 | 645.1 | 554.2 | 227.4 | 681.8 | 423.1 | 506.32 | 42 |
| 1970 | | 248 | 162.7 | 246.2 | 553 | 302.48 | 1970 | | 1656.7 | 731.5 | 1502.5 | 1456.6 | 1336.83 | |
| 1971 | 277.8 | 65 | 60 | 104.7 | 110 | 123.50 | 1971 | 1458.8 | 596.5 | 465 | 611.4 | 958.1 | 817.96 | 70 |
| 1972 | 183.8 | 74 | 38.7 | 58.5 | 57 | 82.40 | 1972 | 935 | 476 | 160.6 | 328.2 | 335 | 446.96 | 64 |
| 1973 | 254.2 | 87 | 93.6 | 77.5 | 102 | 122.86 | 1973 | 863 | 835 | 900.9 | 752.2 | 778.8 | 825.98 | 62 |
| 1974 | 14.5 | 124 | 62 | 60.5 | 28 | 57.80 | 1974 | 117.4 | 490 | 181 | 372.3 | 183.5 | 268.84 | 25 |
| 1975 | 220.0 | 82 | 108.5 | 114 | 50 | 114.90 | 1975 | 682.7 | 908 | 1182.9 | 903.8 | 429.9 | 821.46 | 40 |
| 1976 | 96.0 | 240 | 100 | 119.3 | 168 | 144.66 | 1976 | 219.5 | 1757.8 | 1009 | 1110.3 | 1009 | 1021.12 | 13 |
| 1977 | 106.5 | 67 | 110 | 104.1 | 121 | 101.72 | 1977 | 577.5 | 670.1 | 1574 | 742.6 | 772.5 | 867.34 | 53 |
| 1978 | 136.5 | 135 | 100 | 132.2 | 93 | 119.34 | 1978 | 758.6 | 921 | 688 | 767.8 | 613 | 749.68 | 36 |
| 1979 | 213.0 | 112 | 175 | 59.6 | 129 | 137.72 | 1979 | 592 | 633 | 1055 | 570.6 | 737 | 717.52 | 34 |
| 1980 | 50.0 | 75 | 75 | 45.7 | 58 | 60.74 | 1980 | 397 | 572.2 | 809 | 454.4 | 504 | 547.32 | 39 |
| 1981 | | 90 | 105 | 125.6 | 149 | 117.40 | 1981 | | 674 | 1219.6 | 782.9 | 900 | 894.13 | |
| 1982 | | 89 | 88 | 82.2 | 50 | 77.30 | 1982 | | 417 | 304 | 433.5 | 187 | 335.38 | |
| 1983 | 50.0 | 214 | 110 | 62.2 | 140 | 115.24 | 1983 | 596.8 | 1285 | 967 | 998.1 | 1397 | 1048.78 | 55.0 |
| 1984 | 120.0 | 130 | | 114.3 | 92.5 | 114.20 | 1984 | 604.4 | 807 | | 597.5 | 793 | 700.48 | 52.0 |
| 1985 | 254.0 | 150 | 116 | 46 | 355 | 184.20 | 1985 | 1111.3 | 872 | 582 | 321.8 | 1760 | 929.42 | 42.0 |
| 1986 | 201.0 | 150 | 75 | 59 | 65 | 110.00 | 1986 | 1090 | 613 | 521 | 301.8 | 441 | 593.36 | 37.0 |
| 1987 | 192.0 | 99 | | 29 | 174 | 123.50 | 1987 | 1017.5 | 506 | | 182 | 645 | 587.63 | 34.0 |
| 1988 | 315.0 | 238 | | 104 | 172 | 207.25 | 1988 | 1671 | 1665 | | 689 | 1241 | 1316.50 | 51.0 |
| 1989 | 165.0 | 153 | 174 | 80 | 225 | 159.40 | 1989 | 1306 | 819 | 564 | 575 | 1209 | 894.60 | 38.0 |
| 1990 | 112.0 | 118 | | 89 | | 106.33 | 1990 | 439.4 | 726.5 | | 456 | | 540.63 | 30.0 |
| 1991 | 47.0 | 66 | | 33 | | 48.67 | 1991 | 231 | 393 | | 255 | | 293.00 | 28.0 |
| 1992 | 91.0 | 280 | | 76 | | 149.00 | 1992 | 769.5 | 1469 | | 606 | | 948.17 | 43.0 |
| 1993 | 94.0 | 152 | 120 | 54 | | 105.00 | 1993 | 459 | 884 | 601 | 413 | | 589.25 | 40.0 |

| Max Daily Rain (mm) | | | | | | Annual Rainfall (mm) | | | | | | No of Rainy Days |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 80.0 | 128 | 62 | 52 | 80.50 | 1994 | 913.5 | 1330 | 620 | 612 | 868.88 | 71.0 |
| 1995 | 119.0 | 104 | 46 | 40 | 77.25 | 1995 | 635 | 561 | 339 | 297 | 458.00 | 35.0 |
| 1996 | 212.0 | 65 | 100 | 100 | 119.25 | 1996 | 739 | 594 | 446.5 | 475 | 563.63 | 51.0 |
| 1997 | 111.0 | 72 | 96 | 58 | 84.25 | 1997 | 890 | 787 | 463 | 460 | 650.00 | 53.0 |
| 1998 | 150.0 | 102 | 115 | 80 | 111.75 | 1998 | 1760 | 943 | 1139 | 631 | 1118.25 | 56.0 |
| 1999 | 65.0 | 103 | 60 | 44 | 68.00 | 1999 | 527 | 593 | 384 | 254 | 439.50 | 37.0 |
| 2000 | 186.0 | 132.2 | 50 | 77 | 111.30 | 2000 | 541 | 373.5 | 373 | 361 | 412.13 | 32.0 |
| 2001 | 215.0 | 115.8 | | 92 | 140.93 | 2001 | 926 | 769.4 | | 685 | 793.47 | 50.0 |
| 2002 | 160.0 | 230 | | 170 | 186.67 | 2002 | 1092 | 1033.4 | | 936 | 1020.47 | 31.0 |
| 2003 | 48.0 | 88 | 72 | 96 | 76.00 | 2003 | 947.5 | 894.8 | 828 | 1155 | 956.33 | 68.0 |
| 2004 | 210.0 | 107 | 75 | 96 | 122.00 | 2004 | 1070 | 964.4 | 811 | 912 | 939.35 | 52.0 |
| 2005 | 97.0 | 204 | 100 | 205 | 151.50 | 2005 | 826 | 1368.7 | 1135 | 1187.5 | 1129.30 | 46.0 |
| 2006 | 325.0 | 349.4 | 220 | 270 | 291.10 | 2006 | 973 | 1080.4 | 1649 | 1347 | 1262.35 | 60.0 |
| 2007 | 463.0 | 379 | 190 | 241 | 318.25 | 2007 | 1339 | 1293.3 | 686 | 997 | 1078.83 | 41.0 |
| 2008 | 127.0 | 113.5 | 100 | 126 | 116.63 | 2008 | 960 | 1090.7 | 2140 | 925 | 1278.93 | 52.0 |

## A.2. Rainfall Analysis

| Year | Rank (m) | Return Period (T) | Probability (P) | P*100 | Station YR (ARF-mm) | Station YR(DRF-mm) |
|---|---|---|---|---|---|---|
| 2007 | 1 | 48.00 | 0.02 | 2.08 | 1336.83 | 318.25 |
| 1970 | 2 | 24.00 | 0.04 | 4.17 | 1316.50 | 302.48 |
| 2006 | 3 | 16.00 | 0.06 | 6.25 | 1278.93 | 291.10 |
| 1988 | 4 | 12.00 | 0.08 | 8.33 | 1262.35 | 207.25 |
| 1965 | 5 | 9.60 | 0.10 | 10.42 | 1129.30 | 204.73 |
| 1968 | 6 | 8.00 | 0.13 | 12.50 | 1118.25 | 198.20 |
| 2002 | 7 | 6.86 | 0.15 | 14.58 | 1078.83 | 186.67 |
| 1985 | 8 | 6.00 | 0.17 | 16.67 | 1048.78 | 184.20 |
| 1989 | 9 | 5.33 | 0.19 | 18.75 | 1021.12 | 159.40 |
| 2005 | 10 | 4.80 | 0.21 | 20.83 | 1020.47 | 151.50 |
| 1992 | 11 | 4.36 | 0.23 | 22.92 | 956.33 | 149.00 |
| 1976 | 12 | 4.00 | 0.25 | 25.00 | 955.40 | 144.66 |
| 2001 | 13 | 3.69 | 0.27 | 27.08 | 948.17 | 140.93 |
| 1979 | 14 | 3.43 | 0.29 | 29.17 | 939.35 | 137.72 |
| 1964 | 15 | 3.20 | 0.31 | 31.25 | 929.42 | 132.17 |
| 1987 | 16 | 3.00 | 0.33 | 33.33 | 894.60 | 123.50 |
| 1971 | 17 | 2.82 | 0.35 | 35.42 | 894.13 | 123.50 |
| 1973 | 18 | 2.67 | 0.38 | 37.50 | 868.88 | 122.86 |

| Year | Rank (m) | Return Period (T) | Probability (P) | P*100 | Station YR (ARF-mm) | Station YR(DRF-mm) |
|---|---|---|---|---|---|---|
| 1963 | 19 | 2.53 | 0.40 | 39.58 | 867.34 | 122.30 |
| 2004 | 20 | 2.40 | 0.42 | 41.67 | 825.98 | 122.00 |
| 1978 | 21 | 2.29 | 0.44 | 43.75 | 821.46 | 119.34 |
| 1996 | 22 | 2.18 | 0.46 | 45.83 | 817.96 | 119.25 |
| 1966 | 23 | 2.09 | 0.48 | 47.92 | 795.80 | 118.33 |
| 1981 | 24 | 2.00 | 0.50 | 50.00 | 793.47 | 117.40 |
| 2008 | 25 | 1.92 | 0.52 | 52.08 | 749.68 | 116.63 |
| 1983 | 26 | 1.85 | 0.54 | 54.17 | 717.52 | 115.24 |
| 1975 | 27 | 1.78 | 0.56 | 56.25 | 700.48 | 114.90 |
| 1984 | 28 | 1.71 | 0.58 | 58.33 | 670.17 | 114.20 |
| 1998 | 29 | 1.66 | 0.60 | 60.42 | 650.00 | 111.75 |
| 2000 | 30 | 1.60 | 0.63 | 62.50 | 645.22 | 111.30 |
| 1986 | 31 | 1.55 | 0.65 | 64.58 | 611.27 | 110.00 |
| 1990 | 32 | 1.50 | 0.67 | 66.67 | 593.36 | 106.33 |
| 1993 | 33 | 1.45 | 0.69 | 68.75 | 589.25 | 105.00 |
| 1977 | 34 | 1.41 | 0.71 | 70.83 | 587.63 | 101.72 |
| 1969 | 35 | 1.37 | 0.73 | 72.92 | 563.63 | 98.36 |
| 1962 | 36 | 1.33 | 0.75 | 75.00 | 562.90 | 92.35 |
| 1967 | 37 | 1.30 | 0.77 | 77.08 | 547.32 | 91.91 |
| 1997 | 38 | 1.26 | 0.79 | 79.17 | 540.63 | 84.25 |
| 1972 | 39 | 1.23 | 0.81 | 81.25 | 506.32 | 82.40 |
| 1994 | 40 | 1.20 | 0.83 | 83.33 | 501.20 | 80.50 |
| 1982 | 41 | 1.17 | 0.85 | 85.42 | 458.00 | 77.30 |
| 1995 | 42 | 1.14 | 0.88 | 87.50 | 446.96 | 77.25 |
| 2003 | 43 | 1.12 | 0.90 | 89.58 | 439.50 | 76.00 |
| 1999 | 44 | 1.09 | 0.92 | 91.67 | 412.13 | 68.00 |
| 1980 | 45 | 1.07 | 0.94 | 93.75 | 335.38 | 60.74 |
| 1974 | 46 | 1.04 | 0.96 | 95.83 | 293.00 | 57.80 |
| 1991 | 47 | 1.02 | 0.98 | 97.92 | 268.84 | 48.67 |
| Avg | | | | | 772.55 | 129.77 |
| n | | | | | | 47 |

## A.3. Hourly, Daily and Annual Rainfall vs. Return period

| T (Years) | P | P (%) | DRF(mm) | ARF (mm) | (HRF-mm) |
|---|---|---|---|---|---|
| 2 | 0.5 | 50 | 112.37 | 693.98 | 47.31 |
| 5 | 0.2 | 20 | 172.00 | 963.09 | 88.49 |
| 10 | 0.1 | 10 | 217.10 | 1166.67 | 119.64 |
| 50 | 0.02 | 2 | 321.83 | 1639.36 | 191.97 |
| 100 | 0.01 | 1 | 366.93 | 1842.94 | 223.12 |
| 200 | 0.005 | 0.5 | 412.03 | 2046.52 | 254.27 |
| 500 | 0.002 | 0.2 | 471.65 | 2315.63 | 295.44 |
| DRF | | | Daily Rainfall(SYR) | | |
| ARF | | | Annual Rainfall(SYR) | | |

| T (Years) | P | P (%) | DRF(mm) | ARF (mm) | (HRF-mm) |
|---|---|---|---|---|---|
| HRF | | | Hourly rainfall (BH) | | |

## A.4. Hourly Rainfall Distribution

| S.No | Time | % | 10yr T | Cumulative (mm) | max depth(mm) | Intensity (mm/hr) |
|---|---|---|---|---|---|---|
| 1 | 8.30 - 9.30 | 11.03 | 13.19 | 13.19 | 13.19 | 13.19 |
| 2 | 9.30-10.30 | 3.42 | 4.10 | 17.29 | 21.30 | 10.65 |
| 3 | 10.30-11.30 | 7.00 | 8.37 | 25.66 | 31.36 | 10.45 |
| 4 | 11.30-12.30 | 7.75 | 9.28 | 34.93 | 41.17 | 10.29 |
| 5 | 12.30-13.30 | 1.36 | 1.63 | 36.56 | 49.36 | 9.87 |
| 6 | 13.30-14.30 | 1.21 | 1.45 | 38.01 | 57.49 | 9.58 |
| 7 | 14.30-15.30 | 0.45 | 0.54 | 38.55 | 59.78 | 8.54 |
| 8 | 15.30-16.30 | 0.25 | 0.30 | 38.85 | 61.22 | 7.65 |
| 9 | 16.30-17.30 | 1.91 | 2.29 | 41.14 | 63.48 | 7.05 |
| 10 | 17.30-18.30 | 6.80 | 8.13 | 49.27 | 71.61 | 7.16 |
| 11 | 18.30-19.30 | 6.84 | 8.18 | 57.45 | 75.20 | 6.84 |
| 12 | 19.30-20.30 | 10.40 | 12.44 | 69.89 | 77.48 | 6.46 |
| 13 | 20.30-21.30 | 7.40 | 8.85 | 78.75 | 81.34 | 6.26 |
| 14 | 21.30-22.30 | 8.41 | 10.06 | 88.81 | 88.81 | 6.34 |
| 15 | 22.30-23.30 | 8.21 | 9.82 | 98.63 | 98.63 | 6.58 |
| 16 | 23.30-0.30 | 1.21 | 1.45 | 100.07 | 100.07 | 6.25 |
| 17 | 0.30-1.30 | 1.28 | 1.54 | 101.61 | 101.61 | 5.98 |
| 18 | 1.30-2.30 | 1.16 | 1.39 | 102.99 | 102.99 | 5.72 |
| 19 | 2.30-3.30 | 8.16 | 9.76 | 112.75 | 112.75 | 5.93 |
| 20 | 3.30-4.30 | 3.00 | 3.58 | 116.33 | 116.33 | 5.82 |
| 21 | 4.30-5.30 | 0.57 | 0.69 | 117.02 | 117.02 | 5.57 |
| 22 | 5.30-6.30 | 1.81 | 2.17 | 119.19 | 119.19 | 5.42 |
| 23 | 6.30-7.30 | 0.38 | 0.45 | 119.64 | 119.64 | 5.20 |
| 24 | 7.30-8.30 | 0 | 0.00 | 119.64 | 119.64 | 4.99 |
| | | 100.00 | 119.64 | | | |

## A.5. Depth Intensity Curve

| Depth Intensity curves | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S.No | Duration (Minutes) | Duration (hr) | 2-yr | | 10-yr | | 100-yr | | 200 -yr | |
| | | | Depth (mm) | Intensity (mm/Hr) | Depth (mm) | Intensity (mm/Hr) | Depth (mm) | Intensity (mm/Hr) | Depth (mm) | Intensity (mm/Hr) |
| 1 | 5 | 0.08 | 1.05 | 7.75 | 2.44 | 19.58 | 4.94 | 36.52 | 5.62 | 41.63 |
| 2 | 10 | 0.17 | 1.68 | 7.05 | 3.93 | 17.81 | 7.95 | 33.22 | 9.06 | 37.87 |
| 3 | 15 | 0.25 | 2.23 | 6.64 | 5.19 | 16.78 | 10.50 | 31.29 | 11.96 | 35.67 |
| 4 | 20 | 0.33 | 2.71 | 6.35 | 6.32 | 16.04 | 12.79 | 29.92 | 14.58 | 34.11 |
| 5 | 30 | 0.50 | 3.58 | 5.94 | 8.35 | 15.01 | 16.90 | 27.99 | 19.26 | 31.90 |
| 6 | 40 | 0.67 | 4.37 | 5.65 | 10.18 | 14.27 | 20.59 | 26.62 | 23.47 | 30.34 |
| 7 | 50 | 0.83 | 5.09 | 5.42 | 11.87 | 13.70 | 24.01 | 25.56 | 27.36 | 29.13 |
| 8 | 60 | 1.00 | 5.77 | 5.24 | 13.45 | 13.24 | 27.21 | 24.69 | 31.01 | 28.14 |
| 9 | 120 | 2.00 | 9.29 | 4.54 | 21.65 | 11.47 | 43.81 | 21.39 | 49.92 | 24.38 |
| 10 | 180 | 3.00 | 12.27 | 4.13 | 28.61 | 10.44 | 57.88 | 19.46 | 65.96 | 22.17 |
| 11 | 240 | 4.00 | 14.95 | 3.84 | 34.86 | 9.70 | 70.53 | 18.09 | 80.37 | 20.61 |
| 12 | 300 | 5.00 | 17.43 | 3.61 | 40.64 | 9.14 | 82.21 | 17.03 | 93.69 | 19.40 |
| 13 | 360 | 6.00 | 19.76 | 3.43 | 46.06 | 8.67 | 93.18 | 16.16 | 106.19 | 18.41 |
| 14 | 420 | 7.00 | 21.96 | 3.27 | 51.20 | 8.28 | 103.59 | 15.43 | 118.05 | 17.57 |
| 15 | 480 | 8.00 | 24.07 | 3.14 | 56.12 | 7.94 | 113.54 | 14.79 | 129.40 | 16.85 |
| 16 | 540 | 9.00 | 26.10 | 3.02 | 60.85 | 7.64 | 123.11 | 14.23 | 140.30 | 16.21 |
| 17 | 600 | 10.00 | 28.06 | 2.91 | 65.42 | 7.37 | 132.35 | 13.73 | 150.83 | 15.64 |
| 18 | 660 | 11.00 | 29.96 | 2.81 | 69.85 | 7.13 | 141.31 | 13.28 | 161.04 | 15.12 |
| 19 | 720 | 12.00 | 31.81 | 2.73 | 74.15 | 6.90 | 150.01 | 12.86 | 170.96 | 14.65 |
| 20 | 780 | 13.00 | 33.60 | 2.65 | 78.34 | 6.70 | 158.49 | 12.48 | 180.63 | 14.21 |
| 21 | 840 | 14.00 | 35.36 | 2.57 | 82.44 | 6.51 | 166.77 | 12.13 | 190.06 | 13.81 |
| 22 | 900 | 15.00 | 37.07 | 2.50 | 86.44 | 6.33 | 174.87 | 11.80 | 199.29 | 13.44 |
| 23 | 960 | 16.00 | 38.76 | 2.44 | 90.36 | 6.17 | 182.79 | 11.49 | 208.32 | 13.08 |
| 24 | 1020 | 17.00 | 40.40 | 2.37 | 94.20 | 6.02 | 190.57 | 11.20 | 217.18 | 12.76 |
| 25 | 1080 | 18.00 | 42.02 | 2.32 | 97.97 | 5.87 | 198.20 | 10.93 | 225.88 | 12.45 |
| 26 | 1140 | 19.00 | 43.61 | 2.26 | 101.68 | 5.73 | 205.70 | 10.67 | 234.43 | 12.15 |
| 27 | 1200 | 20.00 | 45.18 | 2.21 | 105.32 | 5.60 | 213.08 | 10.43 | 242.83 | 11.87 |
| 28 | 1260 | 21.00 | 46.72 | 2.16 | 108.91 | 5.48 | 220.34 | 10.20 | 251.11 | 11.61 |
| 29 | 1320 | 22.00 | 48.23 | 2.11 | 112.45 | 5.36 | 227.50 | 9.98 | 259.27 | 11.36 |
| 30 | 1380 | 23.00 | 49.73 | 2.07 | 115.94 | 5.24 | 234.55 | 9.77 | 267.31 | 11.11 |
| 31 | 1440 | 24.00 | 51.20 | 2.03 | 119.38 | 5.14 | 241.51 | 9.56 | 275.24 | 10.88 |

## A.6. Peak flow of Narmada River

| S.No | Year | Discharge at Garudeshwar (lace cusecs) |
|---|---|---|
| 1 | 1948 | 8.44 |
| 2 | 1949 | 9.47 |
| 3 | 1950 | 16.1 |
| 4 | 1951 | 3.66 |
| 5 | 1952 | 4.96 |
| 6 | 1953 | 6.04 |
| 7 | 1954 | 10.11 |
| 8 | 1955 | 10.29 |
| 9 | 1956 | 4.78 |
| 10 | 1957 | 9.42 |
| 11 | 1958 | 6.96 |
| 12 | 1959 | 13.7 |
| 13 | 1960 | 7.51 |
| 14 | 1961 | 15.3 |
| 15 | 1962 | 13.72 |
| 16 | 1963 | 5.39 |
| 17 | 1964 | 6.91 |
| 18 | 1965 | 5.72 |
| 19 | 1966 | 4.59 |
| 20 | 1967 | 8 |
| 21 | 1968 | 20.5 |
| 22 | 1969 | 11 |
| 23 | 1970 | 24.5 |
| 24 | 1971 | 7.01 |
| 25 | 1972 | 16.94 |
| 26 | 1973 | 21.62 |
| 27 | 1974 | 11.14 |
| 28 | 1975 | 11.9 |
| 29 | 1976 | 6.86 |
| 30 | 1977 | 8.16 |
| 31 | 1978 | 13.33 |
| 32 | 1979 | 17.3 |
| 33 | 1980 | 9.36 |
| 34 | 1981 | 14.83 |
| 35 | 1982 | 5.8 |
| 36 | 1983 | 7.77 |
| 37 | 1984 | 17.84 |
| 38 | 1985 | 4.84 |
| 39 | 1986 | 11.72 |
| 40 | 1987 | 1.8 |

| S.No | Year | Discharge at Garudeshwar (lace cusecs) |
|---|---|---|
| 41 | 1988 | 8 |
| 42 | 1989 | 5 |
| 43 | 1990 | 17.81 |
| 44 | 1991 | 6.5 |
| 45 | 1992 | 2.77 |
| 46 | 1993 | 10.25 |
| 47 | 1994 | 22 |
| 48 | 1995 | 4.13 |
| 49 | 1996 | 10.41 |
| 50 | 1997 | 8.83 |
| 51 | 1998 | 11.38 |
| 52 | 1999 | 10.7 |
| 53 | 2000 | 1.64 |
| 54 | 2001 | 3.41 |
| 55 | 2002 | 10.17 |
| 56 | 2003 | 4.93 |
| 57 | 2004 | 4.8 |
| 58 | 2005 | 3.23 |
| 59 | 2006 | 19.95 |
| 60 | 2007 | 8.05 |
| 61 | 2008 | 1.26 |

## A.7. Storage of Tanks

| Tank N0/ Id | Area (sqm) | Watershed | cumulative Quantity stored with 3m depth (cum) | cumulative Quantity stored with 3m depth (mcm) |
|---|---|---|---|---|
| 36 | 3218.0 | A | 9654 | 0.009654 |
| 38 | 7733.0 | A | 23199 | 0.023199 |
| | 10951.0 | | 32853 | 0.032853 |
| 26 | 40218.0 | B | 120654 | 0.120654 |
| 30 | 4007.0 | B | 12021 | 0.012021 |
| 31 | 10016.0 | B | 30048 | 0.030048 |
| 32 | 5846.0 | B | 17538 | 0.017538 |
| 33 | 26354.0 | B | 79062 | 0.079062 |
| 34 | 5871.0 | B | 17613 | 0.017613 |
| 35 | 12684.0 | B | 38052 | 0.038052 |
| 37 | 10728.0 | B | 32184 | 0.032184 |
| 39 | 12918.0 | B | 38754 | 0.038754 |
| 40 | 6477.0 | B | 19431 | 0.019431 |
| 41 | 11142.0 | B | 33426 | 0.033426 |
| 42 | 9243.0 | B | 27729 | 0.027729 |
| 43 | 16309.0 | B | 48927 | 0.048927 |
| 44 | 41520.0 | B | 124560 | 0.12456 |
| 45 | 32868.0 | B | 98604 | 0.098604 |

| Tank N0/ Id | Area (sqm) | Watershed | cumulative Quantity stored with 3m depth (cum) | cumulative Quantity stored with 3m depth (mcm) |
|---|---|---|---|---|
| 46 | 24812.0 | B | 74436 | 0.074436 |
| 47 | 36339.0 | B | 109017 | 0.109017 |
| 48 | 10570.0 | B | 31710 | 0.03171 |
| 49 | 8828.0 | B | 26484 | 0.026484 |
| 50 | 40077.0 | B | 120231 | 0.120231 |
| 51 | 11211.0 | B | 33633 | 0.033633 |
| 52 | 52671.0 | B | 158013 | 0.158013 |
| 53 | 22150.0 | B | 66450 | 0.06645 |
| 54 | 5939.0 | B | 17817 | 0.017817 |
| | 458798.0 | | 1376394 | 1.376394 |
| 9 | 27011.0 | C | 81033 | 0.081033 |
| 10 | 33954.0 | C | 101862 | 0.101862 |
| 11 | 5234.0 | C | 15702 | 0.015702 |
| 12 | 7121.0 | C | 21363 | 0.021363 |
| 13 | 11339.0 | C | 34017 | 0.034017 |
| 14 | 1696.0 | C | 5088 | 0.005088 |
| 15 | 30247.0 | C | 90741 | 0.090741 |
| 16 | 35977.0 | C | 107931 | 0.107931 |
| 17 | 24854.0 | C | 74562 | 0.074562 |
| 18 | 16141.0 | C | 48423 | 0.048423 |
| 19 | 12810.0 | C | 38430 | 0.03843 |
| 20 | 21829.0 | C | 65487 | 0.065487 |
| 21 | 19200.0 | C | 57600 | 0.0576 |
| 22 | 30978.0 | C | 92934 | 0.092934 |
| 23 | 27535.0 | C | 82605 | 0.082605 |
| 24 | 5090.0 | C | 15270 | 0.01527 |
| 25 | 2363.0 | C | 7089 | 0.007089 |
| 27 | 24110.0 | C | 72330 | 0.07233 |
| 28 | 24491.0 | C | 73473 | 0.073473 |
| 29 | 57656.0 | C | 172968 | 0.172968 |
| 55 | 10603.0 | C | 31809 | 0.031809 |
| 56 | 37540.0 | C | 112620 | 0.11262 |
| | 467779.0 | | 1403337 | 1.403337 |
| 0 | 3566.0 | D | 10698 | 0.010698 |
| 1 | 279.0 | D | 837 | 0.000837 |
| 2 | 3691.0 | D | 11073 | 0.011073 |
| 3 | 6193.0 | D | 18579 | 0.018579 |
| 4 | 26154.0 | D | 78462 | 0.078462 |
| 5 | 9046.0 | D | 27138 | 0.027138 |
| 6 | 4730.0 | D | 14190 | 0.01419 |
| 7 | 28217.0 | D | 84651 | 0.084651 |
| 8 | 5958.0 | D | 17874 | 0.017874 |
| | 87834.0 | | 263502 | 0.263502 |

| Tank N0/ Id | Area (sqm) | Watershed | cumulative Quantity stored with 3m depth (cum) | cumulative Quantity stored with 3m depth (mcm) |
|---|---|---|---|---|
| Total | 1025362.0 | | 3076086 | 3.076086 |

## A.8. Tidal Levels at Dahej

| 2007 | | | | | 2008 | | | | 2009 | | | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Date | Time | Minutes | Wls | Date | Time | Minutes | Wls | Date | Time | Minutes | Wls | Time (mints) | Level (m) |
| Jan | 20 | 0:18 | 18.00 | 0.14 | 24 | 0:07 | 7 | 0.15 | 13 | 0:23 | 23 | -0.23 | 16.00 | 0.02 |
| | | 5:44 | 344.00 | 9.75 | | 5:38 | 338 | 9.65 | | 5:49 | 349 | 10.11 | 343.67 | 9.84 |
| | | 13:06 | 786.00 | 0.54 | | 12:52 | 772 | 0.27 | | 13:11 | 791 | 0:00 | 783.00 | 0.27 |
| | | 18:05 | 1085.00 | 8.17 | | 17:58 | 1078 | 8.27 | | 18:09 | 1089 | 13:26 | 1084.00 | 8.33 |
| Feb | 19 | 0:01 | 1.00 | -0.14 | 9 | 0:19 | 19 | 0.31 | 10 | 4:54 | 294 | 9.89 | 104.67 | 3.35 |
| | | 5:23 | 323.00 | 9.87 | | 5:40 | 340 | 9.42 | | 12:06 | 726 | -0.01 | 463.00 | 6.43 |
| | | 12:49 | 769.00 | -0.07 | | 12:59 | 779 | 0.34 | | 17:14 | 1034 | 8.76 | 860.67 | 3.01 |
| | | 17:51 | 1071.00 | 9.02 | | 18:07 | 1087 | 8.46 | 11 | 0:12 | 1452 | -0.21 | 1203.33 | 5.76 |
| Mar | 21 | 0:39 | 39.00 | -0.17 | 11 | 1:25 | 1525 | 0.32 | 11 | 4:34 | 274 | 9.42 | 612.67 | 3.19 |
| | | 5:37 | 337.00 | 9.54 | | 6:25 | 385 | 8.95 | | 11:44 | 704 | -0.19 | 475.33 | 6.10 |
| | | 13:04 | 784.00 | -0.75 | | 13:47 | 827 | -0.46 | | 16:59 | 1019 | 9.14 | 876.67 | 2.64 |
| | | 18:19 | 1099.00 | 9.95 | | 19:14 | 1154 | 9.5 | | 23:54 | 1434 | 0.07 | 1229.00 | 6.51 |
| Apr | 19 | 0:22 | 22.00 | 0.15 | 8 | 0:33 | 1473 | 0.26 | 25 | 4:04 | 244 | 8.25 | 579.67 | 2.89 |
| | | 5:14 | 314.00 | 8.98 | | 5:24 | 324 | 8.88 | | 11:16 | 676 | 0.05 | 438.00 | 5.97 |
| | | 12:36 | 756.00 | -0.69 | | 12:48 | 768 | -0.55 | | 16:43 | 1003 | 9.55 | 842.33 | 2.77 |
| | | 17:58 | 1078.00 | 10.29 | | 18:10 | 1090 | 10.03 | | 23:45 | 1425 | 0.82 | 1197.67 | 7.05 |
| May | 17 | 4:10 | 250.00 | 8.48 | 7 | 0:19 | 19 | 0.53 | 25 | 0:18 | 18 | 0.86 | 95.67 | 3.29 |
| | | 11:25 | 685.00 | -0.41 | | 5:06 | 306 | 8.47 | | 5:06 | 306 | 8.07 | 432.33 | 5.38 |
| | | 16:54 | 1014.00 | 10:32 | | 12:24 | 744 | -0.42 | | 12:17 | 737 | -0.1 | 831.67 | -0.03 |
| | 18 | 0:05 | 1445.00 | 0.61 | | 17:52 | 1072 | 10.29 | | 17:51 | 1071 | 10.13 | 1196.00 | 7.01 |
| June | 15 | 3:58 | 238.00 | 7.85 | 4 | 4:05 | 245 | 8.15 | 25 | 1:03 | 63 | 0.53 | 182.00 | 5.51 |
| | | 11:00 | 660.00 | 0.06 | | 11:17 | 677 | -0.22 | | 5:50 | 350 | 8.35 | 562.33 | 2.73 |
| | | 16:4 | 1000. | 10.0 | | 16:0 | 965 | 10.3 | | 12:5 | 774 | - | 913.00 | 6.77 |

| 2007 | | | | | 2008 | | | | 2009 | | | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Date | Time | Minutes | WIs | Date | Time | Minutes | WIs | Date | Time | Minutes | WIs | Time (mints) | Level (m) |
| | | 0 | 00 | 9 | | 5 | | 2 | | 4 | | 0.09 | | |
| | | 23:52 | 1432.00 | 0.95 | 5 | 0:59 | 1499 | 0.77 | | 18:26 | 1106 | 10.19 | 1345.67 | 3.97 |
| July | 31 | 0:01 | 1.00 | 1.05 | 4 | 4:51 | 291 | 8.16 | 24.00 | 4:51 | 290 | 8.6 | 194.00 | 5.94 |
| | | 5:02 | 452.00 | 7.96 | | 11:57 | 717 | -0.05 | | 12:00 | 720 | -0.34 | 629.67 | 2.52 |
| | | 11:57 | 717.00 | 0.22 | | 17:28 | 1048 | 10.18 | | 17:24 | 1044 | 10.31 | 936.33 | 6.90 |
| | | 17:23 | 1043.00 | 9.7 | 5 | 0:50 | 1490 | 0.54 | 25.00 | 0:50 | 1490 | 0.11 | 1341.00 | 3.45 |
| Aug | 29 | 4:42 | 282.00 | 8.72 | 1 | 3:57 | 237 | 7.98 | 21.00 | 4:41 | 281 | 9.09 | 266.67 | 8.60 |
| | | 11:44 | 704.00 | -0.11 | | 10:54 | 654 | 0.13 | | 11:48 | 708 | -0.44 | 688.67 | -0.14 |
| | | 16:55 | 1015.00 | 9.76 | | 16:30 | 990 | 9.09 | | 17:03 | 1023 | 10.09 | 1009.33 | 9.65 |
| | 29 | 0:24 | 1464.00 | 0.08 | | 23:45 | 1425 | 0.5 | 22.00 | 0:31 | 1471 | -0.34 | 1453.33 | 0.08 |
| Sep | 30 | 1:14 | 74.00 | -0.72 | 19 | 1:22 | 82 | -0.31 | 21.00 | 0:42 | 42 | -0.59 | 66.00 | -0.54 |
| | | 6:27 | 387.00 | 10.05 | | 6:37 | 397 | 9.55 | | 5:48 | 348 | 9.81 | 377.33 | 9.80 |
| | | 13:33 | 813.00 | 0.09 | | 13:36 | 816 | 0.46 | | 12:51 | 771 | 0.08 | 800.00 | 0.21 |
| | | 18:29 | 1109.00 | 8.7 | | 18:35 | 1115 | 8.49 | | 17:55 | 1075 | 8.95 | 1099.67 | 8.71 |
| Oct | 27 | 4:41 | 281.00 | 10.2 | 17 | 0:20 | 20 | -0.47 | 19.00 | 4:47 | 287 | 9.85 | 196.00 | 6.53 |
| | | 11:51 | 711.00 | 0.06 | | 5:35 | 335 | 10.03 | | 11:49 | 709 | 0.33 | 585.00 | 3.47 |
| | | 16:42 | 1002.00 | 8.8 | | 12:46 | 766 | 0.25 | | 16:57 | 1017 | 8.5 | 928.33 | 5.85 |
| | 28 | 0:07 | 1447.00 | -0.7 | | 17:35 | 1055 | 8.47 | 20.00 | 0:04 | 1444 | -0.34 | 1315.33 | 2.48 |
| Nov | 26 | 5:10 | 310.00 | 10.35 | 15 | 5:20 | 320 | 10.26 | 5.00 | 0:08 | 8 | -0.09 | 212.67 | 6.84 |
| | | 12:25 | 745.00 | 0.35 | | 12:37 | 757 | 0.39 | | 5:35 | 335 | 9.78 | 612.33 | 3.51 |
| | | 17:18 | 1038.00 | 8.14 | | 17:25 | 1045 | 8.18 | | 12:44 | 764 | 0.62 | 949.00 | 5.65 |
| | 27 | 0:26 | 1466.00 | -0.27 | 16 | 0:37 | 1477 | -0.31 | | 17:37 | 1057 | 7.88 | 1333.33 | 2.43 |
| Dec | 25 | 5:02 | 302.00 | 10.08 | 14 | 5:11 | 311 | 10.25 | 4 | 5:22 | 322 | 9.99 | 311.67 | 10.11 |
| | | 12:16 | 736.00 | 0.53 | | 12:29 | 749 | 0.41 | | 12:38 | 758 | 0.56 | 747.67 | 0.50 |
| | | 17:16 | 1036.00 | 7.94 | | 17:21 | 1041 | 8.13 | | 17:31 | 1051 | 7.93 | 1042.67 | 8.00 |
| | 26 | 0:15 | 1455. | 0.04 | 15 | 0:26 | 1466 | - | 5 | 0:35 | 1475 | - | 1465.33 | -0.08 |

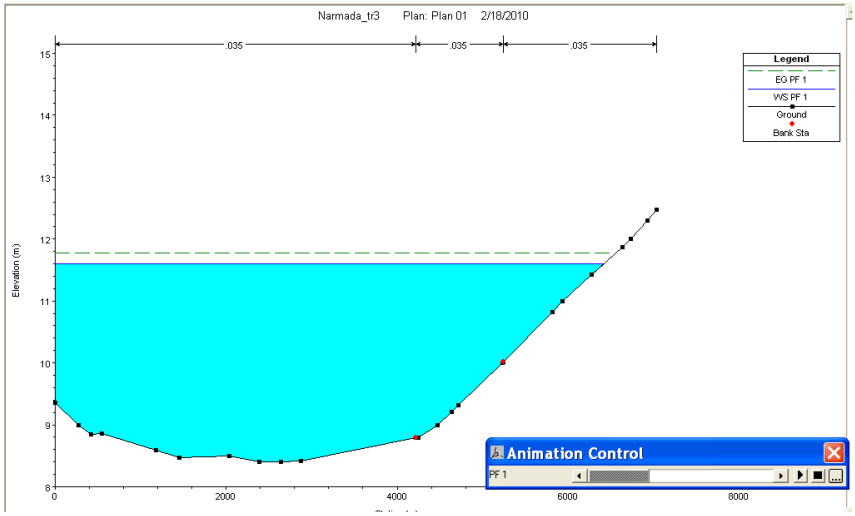
| 2007 | | | | | 2008 | | | | 2009 | | | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Date | Time | Minutes | WIs | Date | Time | Minutes | WIs | Date | Time | Minutes | WIs | Time (mints) | Level (m) |
| | | | 00 | | | | | 0.22 | | | | 0.05 | | |

# Appendix B. Fluvial Floods Analysis

## B.1. Profiles

### B.1.1. Profile 1 at the 33975.86 Cross Section

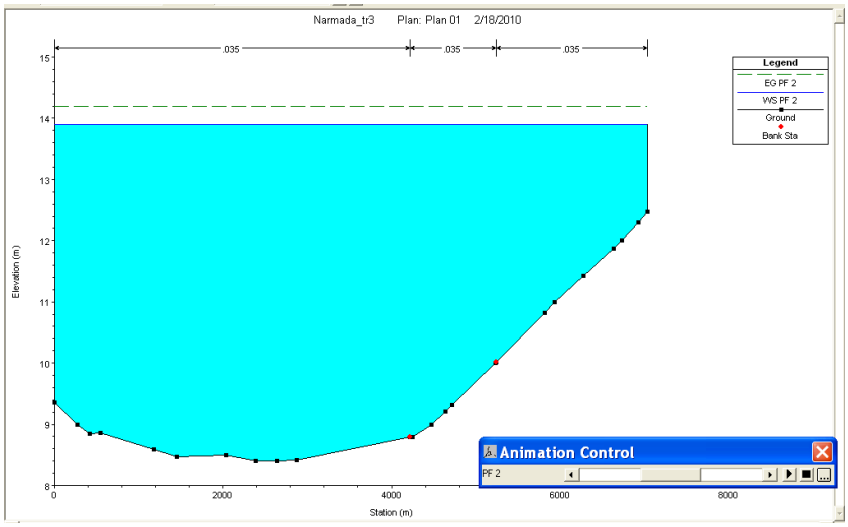
Profile 1 at the 33975.86 Cross Section




Source: MM

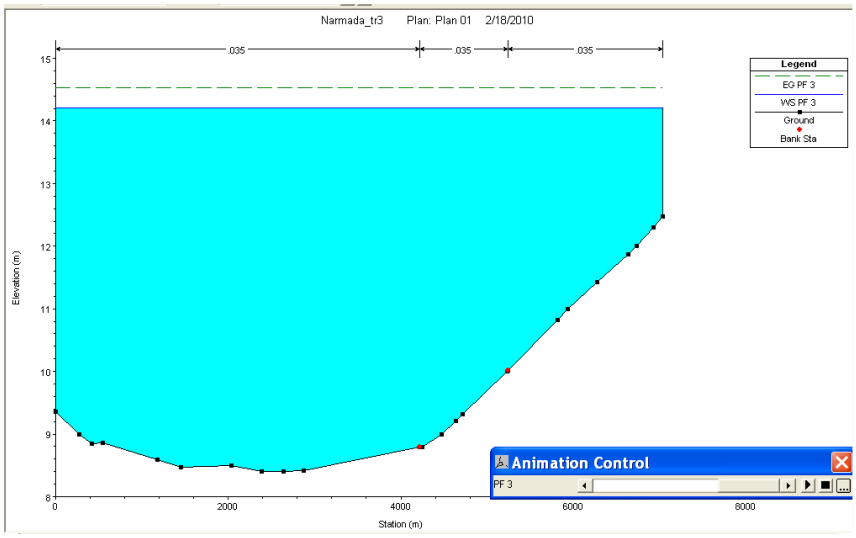
### B.1.2. Profile 2 at the 33975.86 Cross section

Profile 2 at the 33975.86 Cross section



### B.1.3. Profile 3 at the 33975.86 Cross section

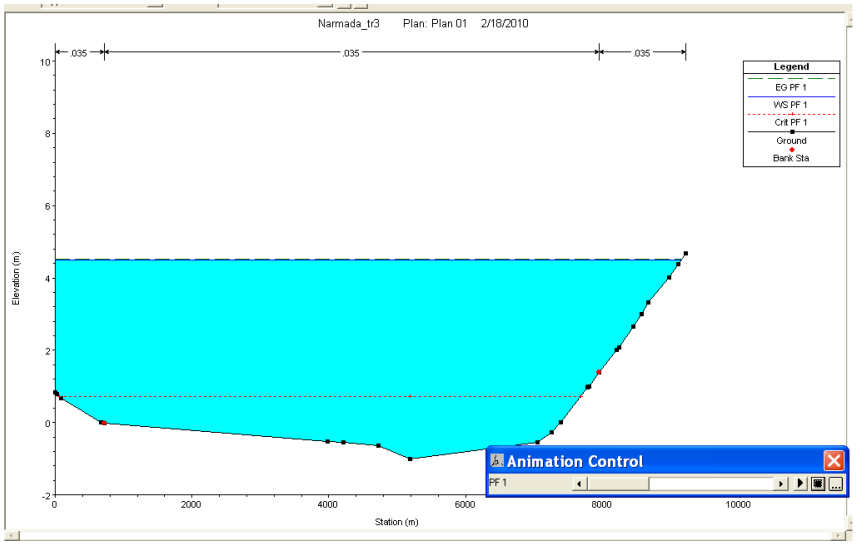
Profile 3 at the 33975.86 Cross section




Source: MM

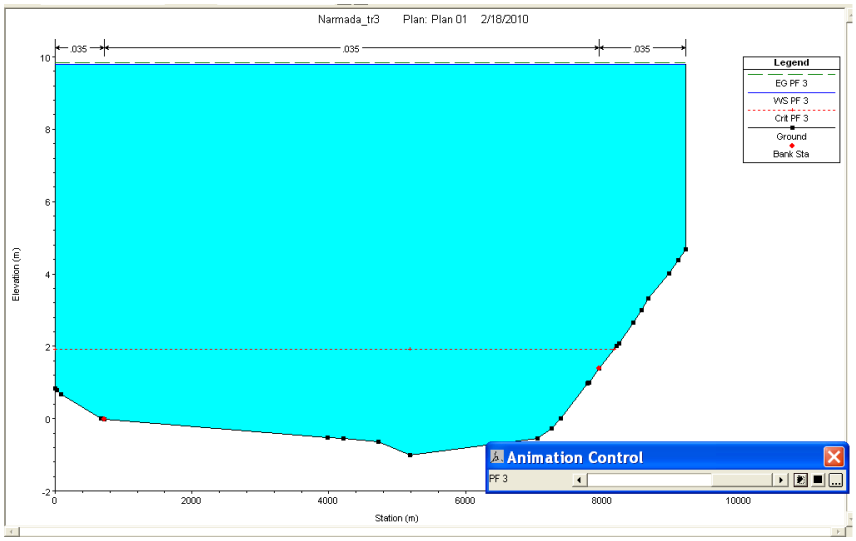
### B.1.4. Profile 1 at the 1332.568 Cross section

Profile 1 at the 1332.568 Cross section



### B.1.5. Profile 3 at the 1332.568 Cross section

Profile 3 at the 1332.568 Cross section




Source: MM

## B.2. Basic Results of the HEC_RAS analysis for Fluvial Floods

| Profile Output | Table - Standard Table 1 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HEC-RAS Plan: | Plan 01 | River: | Narmada | Reach: | Upper Reach | | | | | | | |
| # Rivers | 1 | | | | | | | | | | | |
| # Hydraulic Reaches = 1 | | | | | | | | | | | | |
| # River Stations | 16 | | | | | | | | | | | |
| # Plans | 1 | | | | | | | | | | | |
| # Profiles | 3 | | | | | | | | | | | |

| Reach | River Strata | Pf | Profile No | Q Total | Min Ch El | W.S. Elev | Crit W.S. E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (m3/s) | (m) | (m) | (m) (m) | (m/m) | (m/s) | (m2) | (m) | |
| Upper Reach | 33975.86 | PF | 1 | 27410 | 8.79 | 11.61 | 11.77 | 0.000966 | 1.53 | 15816.35 | 6418.47 | 0.32 |
| Upper Reach | 33975.86 | PF | 2 | 75534 | 8.79 | 13.89 | 14.2 | 0.000879 | 2.32 | 31643.03 | 7038.68 | 0.35 |
| Upper Reach | 33975.86 | PF | 3 | 82854.02 | 8.79 | 14.21 | 14.53 | 0.000851 | 2.39 | 33870.91 | 7038.68 | 0.35 |

| Profile Output | Table - Standard Table | | 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Reach | 31984.66 | PF | 1 | 27410 | 6.53 | 9.18 | 9.38 | 0.001673 | 2.03 | 14451.84 | 7336.2 | 0.43 |
| Upper Reach | 31984.66 | PF | 2 | 75534 | 6.53 | 12.91 | 13.07 | 0.000386 | 1.86 | 42182.8 | 7453.4 | 0.24 |
| Upper Reach | 31984.66 | PF | 3 | 82854.02 | 6.53 | 13.24 | 13.42 | 0.000384 | 1.92 | 44678.3 | 7453.4 | 0.24 |
| Upper Reach | 29784.9 | PF | 1 | 27410 | 2.01 | 8.81 | 8.84 | 0.000092 | 0.9 | 36099.11 | 8586.7 | 0.12 |
| Upper Reach | 29784.9 | PF | 2 | 75534 | 2.01 | 12.65 | 12.71 | 0.000088 | 1.23 | 69091.63 | 8586.7 | 0.13 |
| Upper Reach | 29784.9 | PF | 3 | 82854.02 | 2.01 | 12.98 | 13.05 | 0.000093 | 1.29 | 71893.98 | 8586.7 | 0.13 |
| Upper Reach | 26471.74 | PF | 1 | 27410 | 2.26 | 8.32 | 8.38 | 0.00018 | 1.17 | 25528.29 | 5887.69 | 0.16 |
| Upper Reach | 26471.74 | PF | 2 | 75534 | 2.26 | 12.14 | 12.27 | 0.000179 | 1.67 | 48276.66 | 5957.44 | 0.18 |
| Upper Reach | 26471.74 | PF | 3 | 82854.02 | 2.26 | 12.43 | 12.57 | 0.000192 | 1.77 | 50000.67 | 5957.44 | 0.18 |
| Upper Reach | 24287.27 | PF | 1 | 27410 | 3 | 7.86 | 7.93 | 0.000282 | 1.33 | 24834.27 | 7370 | 0.2 |
| Upper Reach | 24287.27 | PF | 2 | 75534 | 3 | 11.8 | 11.9 | 0.000169 | 1.55 | 53852.55 | 7370 | 0.17 |
| Upper Reach | 24287.27 | PF | 3 | 82854.02 | 3 | 12.06 | 12.18 | 0.00018 | 1.64 | 55810.96 | 7370 | 0.18 |
| Upper Reach | 22273.3 | PF | 1 | 27410 | 1.23 | 7.44 | 7.48 | 0.000163 | 1.18 | 30319.43 | 8250.12 | 0.16 |
| Upper Reach | 22273.3 | PF | 2 | 75534 | 1.23 | 11.54 | 11.61 | 0.000108 | 1.37 | 64163.69 | 8250.12 | 0.14 |
| Upper Reach | 22273.3 | PF | 3 | 82854.02 | 1.23 | 11.78 | 11.87 | 0.000118 | 1.46 | 66191.64 | 8250.12 | 0.15 |
| Upper Reach | 20281.37 | PF | 1 | 27410 | 1 | 7.2 | 7.23 | 0.000097 | 0.87 | 35876.51 | 8848.36 | 0.12 |
| Upper Reach | 20281.37 | PF | 2 | 75534 | 1 | 11.37 | 11.42 | 0.000077 | 1.13 | 72960.24 | 8892.25 | 0.12 |
| Upper Reach | 20281.37 | PF | 3 | 82854.02 | 1 | 11.6 | 11.66 | 0.000085 | 1.21 | 75006.38 | 8892.25 | 0.12 |
| Upper Reach | 18283.65 | PF | 1 | 27410 | 1.74 | 6.96 | 7 | 0.000144 | 0.88 | 31711.49 | 8876.59 | 0.14 |
| Upper Reach | 18283.65 | PF | 2 | 75534 | 1.74 | 11.2 | 11.26 | 0.00009 | 1.11 | 70212.44 | 9090.6 | 0.12 |
| Upper Reach | 18283.65 | PF | 3 | 82854.02 | 1.74 | 11.41 | 11.48 | 0.000099 | 1.19 | 72146.57 | 9090.6 | 0.13 |
| Upper | 16371.4 | PF | 1 | 27410 | 1.57 | 6.66 | 6.71 | 0.00017 | 0.99 | 29780 | 8790.0 | 0.1 |

| Profile Output | Table - Standard Table | | 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach | 8 | | | | | | | 9 | | .97 | 4 | 5 |
| Upper Reach | 16371.48 | PF | 2 | 75534 | 1.57 | 11.02 | 11.08 | 0.000096 | 1.17 | 68099.13 | 8790.04 | 0.13 |
| Upper Reach | 16371.48 | PF | 3 | 82854.02 | 1.57 | 11.21 | 11.28 | 0.000107 | 1.25 | 69795.98 | 8790.04 | 0.14 |
| Upper Reach | 14295.42 | PF | 1 | 27410 | 0.69 | 6.33 | 6.38 | 0.000174 | 0.97 | 27660.65 | 6765.17 | 0.15 |
| Upper Reach | 14295.42 | PF | 2 | 75534 | 0.69 | 10.78 | 10.87 | 0.000119 | 1.31 | 57740.7 | 6765.17 | 0.14 |
| Upper Reach | 14295.42 | PF | 3 | 82854.02 | 0.69 | 10.94 | 11.04 | 0.000135 | 1.41 | 58834.83 | 6765.17 | 0.15 |
| Upper Reach | 11201.74 | PF | 1 | 27410 | 0 | 5.69 | 5.74 | 0.000176 | 1.01 | 28704.08 | 7831.94 | 0.15 |
| Upper Reach | 11201.74 | PF | 2 | 75534 | 0 | 10.42 | 10.49 | 0.00009 | 1.18 | 67232.88 | 8149.81 | 0.13 |
| Upper Reach | 11201.74 | PF | 3 | 82854.02 | 0 | 10.54 | 10.61 | 0.000104 | 1.28 | 68143.14 | 8149.81 | 0.13 |
| Upper Reach | 9226.935 | PF | 1 | 27410 | -2.34 | 5.38 | 5.43 | 0.000138 | 1 | 29760.27 | 7426.94 | 0.14 |
| Upper Reach | 9226.935 | PF | 2 | 75534 | -2.34 | 10.26 | 10.32 | 0.00008 | 1.19 | 69172.2 | 8143.85 | 0.12 |
| Upper Reach | 9226.935 | PF | 3 | 82854.02 | -2.34 | 10.34 | 10.42 | 0.000093 | 1.29 | 69861.72 | 8143.85 | 0.13 |
| Upper Reach | 7230.222 | PF | 1 | 27410 | -4 | 5.09 | 5.14 | 0.000147 | 0.98 | 29528.4 | 7478.16 | 0.14 |
| Upper Reach | 7230.222 | PF | 2 | 75534 | -4 | 10.1 | 10.16 | 0.000075 | 1.14 | 71432.63 | 8487.33 | 0.12 |
| Upper Reach | 7230.222 | PF | 3 | 82854.02 | -4 | 10.16 | 10.23 | 0.000089 | 1.24 | 71920.45 | 8487.33 | 0.13 |
| Upper Reach | 5203.961 | PF | 1 | 27410 | -3 | 4.8 | 4.84 | 0.000143 | 0.89 | 32191.07 | 8694.85 | 0.14 |
| Upper Reach | 5203.961 | PF | 2 | 75534 | -3 | 9.97 | 10.02 | 0.000061 | 0.99 | 79069.94 | 9088.52 | 0.1 |
| Upper Reach | 5203.961 | PF | 3 | 82854.02 | -3 | 10 | 10.06 | 0.000073 | 1.09 | 79372.07 | 9088.52 | 0.11 |
| Upper Reach | 3211.781 | PF | 1 | 27410 | -3 | 4.63 | 4.65 | 0.000065 | 0.69 | 42091.84 | 9243.21 | 0.1 |
| Upper Reach | 3211.781 | PF | 2 | 75534 | -3 | 9.88 | 9.92 | 0.00004 | 0.86 | 90610.31 | 9243.21 | 0.09 |
| Upper Reach | 3211.781 | PF | 3 | 82854.02 | -3 | 9.9 | 9.94 | 0.000048 | 0.95 | 90761.2 | 9243.21 | 0.09 |
| Upper Reach | 1332.568 | PF | 1 | 27410 | -1 | 4.5 | 4.52 | 0.000073 | 0.7 | 40268.8 | 9159.84 | 0.1 |

| Profile Output | Table - Standard Table | | 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Reach | 1332.568 | PF | 2 | 75534 | -1 | 9.8 | 1.779.84 | 0.000042 | 0.87 | 89131.23 | 9220.54 | 0.09 |
| Upper Reach | 1332.568 | PF | 3 | 82854.02 | -1 | 9.8 | 1.929.84 | 0.000051 | 0.96 | 89131.23 | 9220.54 | 0.1 |

# Appendix C. Pluvial Flood Analysis

## C.1. Depth intensity Curves for Pluvial Floods

| Depth Intensity curves | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sr.No | Duration (Minutes) | Duration (hr) | 2-yr | | 10-yr | | 100-yr | | 200 -yr | |
| | | | Depth (mm) | Intensity (mm/Hr) | Depth (mm) | Intensity (mm/Hr) | Depth (mm) | Intensity (mm/Hr) | Depth (mm) | Intensity (mm/Hr) |
| 1 | 5 | 0.08 | 1.05 | 7.75 | 2.44 | 19.58 | 4.94 | 36.52 | 5.62 | 41.63 |
| 2 | 10 | 0.17 | 1.68 | 7.05 | 3.93 | 17.81 | 7.95 | 33.22 | 9.06 | 37.87 |
| 3 | 15 | 0.25 | 2.23 | 6.64 | 5.19 | 16.78 | 10.50 | 31.29 | 11.96 | 35.67 |
| 4 | 20 | 0.33 | 2.71 | 6.35 | 6.32 | 16.04 | 12.79 | 29.92 | 14.58 | 34.11 |
| 5 | 30 | 0.50 | 3.58 | 5.94 | 8.35 | 15.01 | 16.90 | 27.99 | 19.26 | 31.90 |
| 6 | 40 | 0.67 | 4.37 | 5.65 | 10.18 | 14.27 | 20.59 | 26.62 | 23.47 | 30.34 |
| 7 | 50 | 0.83 | 5.09 | 5.42 | 11.87 | 13.70 | 24.01 | 25.56 | 27.36 | 29.13 |
| 8 | 60 | 1.00 | 5.77 | 5.24 | 13.45 | 13.24 | 27.21 | 24.69 | 31.01 | 28.14 |
| 9 | 120 | 2.00 | 9.29 | 4.54 | 21.65 | 11.47 | 43.81 | 21.39 | 49.92 | 24.38 |
| 10 | 180 | 3.00 | 12.27 | 4.13 | 28.61 | 10.44 | 57.88 | 19.46 | 65.96 | 22.17 |
| 11 | 240 | 4.00 | 14.95 | 3.84 | 34.86 | 9.70 | 70.53 | 18.09 | 80.37 | 20.61 |
| 12 | 300 | 5.00 | 17.43 | 3.61 | 40.64 | 9.14 | 82.21 | 17.03 | 93.69 | 19.40 |
| 13 | 360 | 6.00 | 19.76 | 3.43 | 46.06 | 8.67 | 93.18 | 16.16 | 106.19 | 18.41 |
| 14 | 420 | 7.00 | 21.96 | 3.27 | 51.20 | 8.28 | 103.59 | 15.43 | 118.05 | 17.57 |
| 15 | 480 | 8.00 | 24.07 | 3.14 | 56.12 | 7.94 | 113.54 | 14.79 | 129.40 | 16.85 |
| 16 | 540 | 9.00 | 26.10 | 3.02 | 60.85 | 7.64 | 123.11 | 14.23 | 140.30 | 16.21 |
| 17 | 600 | 10.00 | 28.06 | 2.91 | 65.42 | 7.37 | 132.35 | 13.73 | 150.83 | 15.64 |
| 18 | 660 | 11.00 | 29.96 | 2.81 | 69.85 | 7.13 | 141.31 | 13.28 | 161.04 | 15.12 |
| 19 | 720 | 12.00 | 31.81 | 2.73 | 74.15 | 6.90 | 150.01 | 12.86 | 170.96 | 14.65 |
| 20 | 780 | 13.00 | 33.60 | 2.65 | 78.34 | 6.70 | 158.49 | 12.48 | 180.63 | 14.21 |
| 21 | 840 | 14.00 | 35.36 | 2.57 | 82.44 | 6.51 | 166.77 | 12.13 | 190.06 | 13.81 |
| 22 | 900 | 15.00 | 37.07 | 2.50 | 86.44 | 6.33 | 174.87 | 11.80 | 199.29 | 13.44 |
| 23 | 960 | 16.00 | 38.76 | 2.44 | 90.36 | 6.17 | 182.79 | 11.49 | 208.32 | 13.08 |
| 24 | 1020 | 17.00 | 40.40 | 2.37 | 94.20 | 6.02 | 190.57 | 11.20 | 217.18 | 12.76 |
| 25 | 1080 | 18.00 | 42.02 | 2.32 | 97.97 | 5.87 | 198.20 | 10.93 | 225.88 | 12.45 |
| 26 | 1140 | 19.00 | 43.61 | 2.26 | 101.68 | 5.73 | 205.70 | 10.67 | 234.43 | 12.15 |
| 27 | 1200 | 20.00 | 45.18 | 2.21 | 105.32 | 5.60 | 213.08 | 10.43 | 242.83 | 11.87 |
| 28 | 1260 | 21.00 | 46.72 | 2.16 | 108.91 | 5.48 | 220.34 | 10.20 | 251.11 | 11.61 |
| 29 | 1320 | 22.00 | 48.23 | 2.11 | 112.45 | 5.36 | 227.50 | 9.98 | 259.27 | 11.36 |
| 30 | 1380 | 23.00 | 49.73 | 2.07 | 115.94 | 5.24 | 234.55 | 9.77 | 267.31 | 11.11 |
| 31 | 1440 | 24.00 | 51.20 | 2.03 | 119.38 | 5.14 | 241.51 | 9.56 | 275.24 | 10.88 |

## C.2. Pluvial flood Analysis

**Snyder Unit Hydrograph**

Need:

- Snyder's Standard Lag ($T_p$): Hours
- Snyder's Storage Coefficient ($C_p$)

The Snyder method does not define a complete unit hydrograph, so the hydrologic model (HEC-1 or HEC-HMS) completes the hydrograph using a trial and error procedure. With the given input parameters, $T_p$ and $C_p$, the program uses hydrologic model to determine the optimal Clark parameters based on the Snyder coefficients. Bedient and Huber (1992) present equations to determine $T_p$ and $C_p$:

$$T_p = C_t\left(LL_c\right)^{0.3}$$, where

$T_p$ = Snyder's standard lag (hr)
$L$ = length of channel (outflow to basin boundary) (mi)
$L_c$ = length along channel to centroid of area (mi)
$C_t$ = coefficient usually ranging from 1.8 to 2.2 ($C_t$ has been found to vary from 0.4 in mountainous regions to 8.0 along the Gulf of Mexico)

$C_p$ is the storage coefficient that normally ranges from 0.4 to 0.8, where larger values of $C_p$ are associated with smaller values of $C_t$. $C_p$ can also be estimated in the peak flow from the unit hydrograph is known:

$$C_p = \frac{Q_p T_p}{640A}$$, where

$Q_p$ = peak discharge of unit hydrograph (cfs)
$A$ = drainage area ($mi^2$)

**Stream Routing**

There are numerous methods of modeling stream routing for each stream segment in a hydrologic model. We will present two of the more common methods, Modified Puls (Storage-Outflow) Routing and Muskingum Routing. Further discussion on both methods is presented in Hoggan (1997) and Bedient and Huber (1992).

**Muskingum Routing**

Need:
Muskingum K (Travel Time): hr
Muskingum X (Storage Routing)
Time Steps (or sub reaches)

Muskingum K is the travel time for the reach, and is determined by dividing the mean velocity by the reach length. Velo hydraulic model, such as HEC-2 or HEC-RAS, or performing a simple open-channel flow calculation using Manning's e can also be assumed,
using the rule-of-thumb presented in the previous section.

Muskingum X is the only means represent storage for the routing step using this routing procedure. Muskingum X rang used for smooth uniform channels with a pure translation of the flood wave. A value of 0.2 is generally used for natural is used for most improved urban channels.
The number of time steps is the time it takes a drop of water to travel the entire length of the routing reach divided by t hydrologic model. To estimate the time it take a drop of water to travel the length of the reach, a hydraulic model shoul water in a stream can travel 2 mi/hr, although in channelized streams, the rate can increase to 10 mi/hr, or even greate slope and channel roughness.

**Figure** shows the effect of Muskingum K and X coefficients on the routed hydrographs.

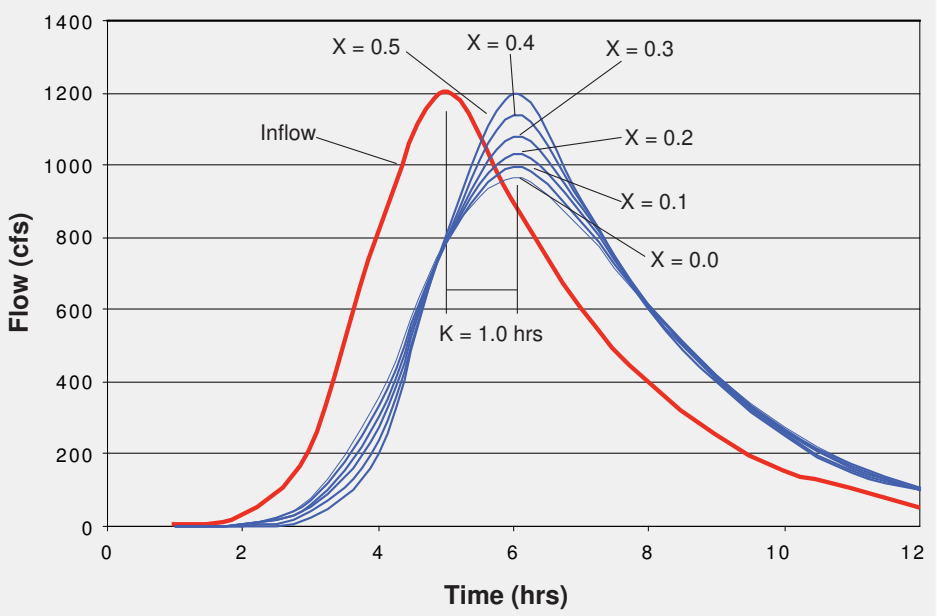



Figure: Muskingum Routing

**Loss Rates**
The loss rate used in this project is the simple Initial-Constant Loss Method. Under this method, an initial amount of r evaporates) and a constant rate of rainfall is lost per hour. This depends on the soil type and the rainfall pattern in the

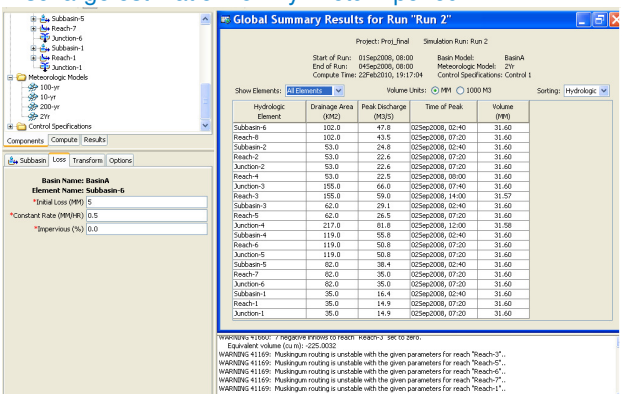
The parameters used in the study area are as under

- Snyder's Standard Lag ($T_p$): Hours 6 hrs
- Snyder's Storage Coefficient ($C_p$): 0.6
- Initial loss: (mm) 5
- Constant loss (mm/hr) 0.5
- Impervious( Initial) % 0.0
- Routing Muskingum
- Muskingum (k) 6.0
- Muskingum (x) 0.2

The above parameters have been selected finally keeping in view the topography, area, drainage pattern and the soil of trails have been conducted before finalizing the basic parameters. It is also observed that the marginal variations in the overall results.

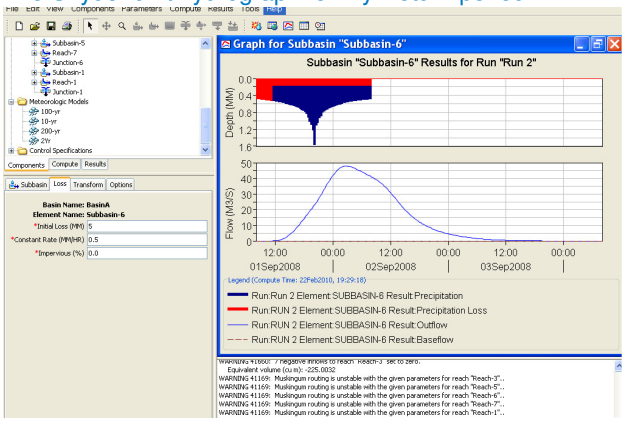
## C.3. Discharge Estimations for 2 yr, 10 yr and 100 yr Return period

### Discharge estimation for 2 yr Return period



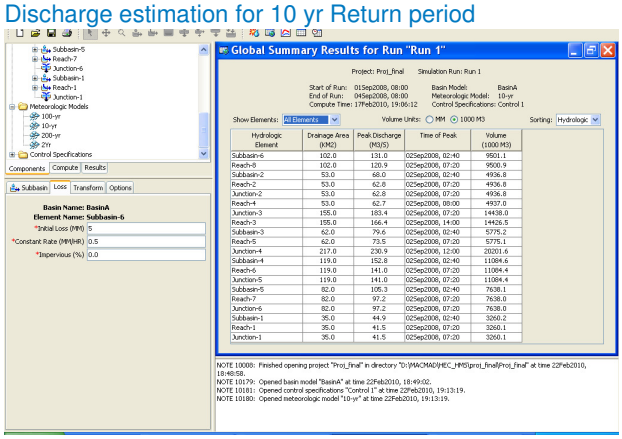

Source: MM

### The Snyder unit hydrograph for 2 yr-return period



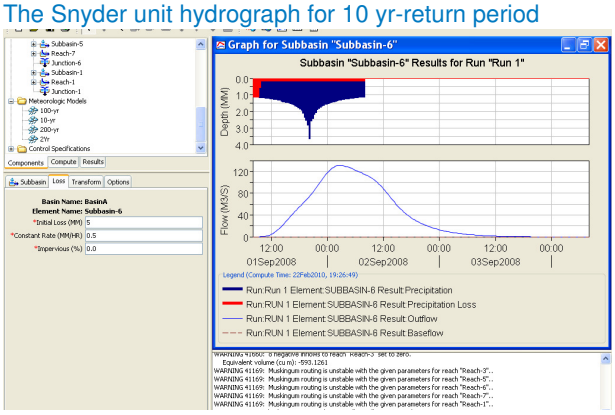

Source: MM

### Discharge estimation for 10 yr Return period



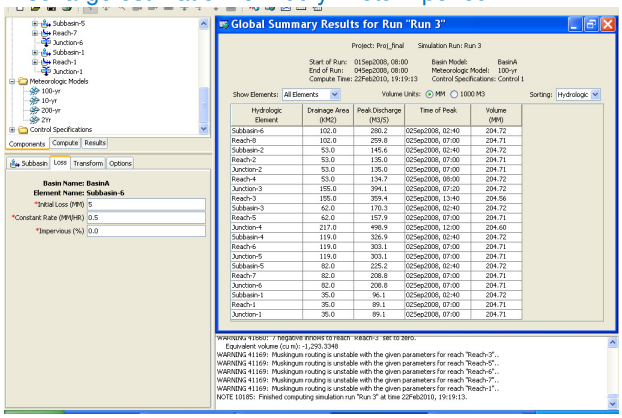

Source: MM

### The Snyder unit hydrograph for 10 yr-return period



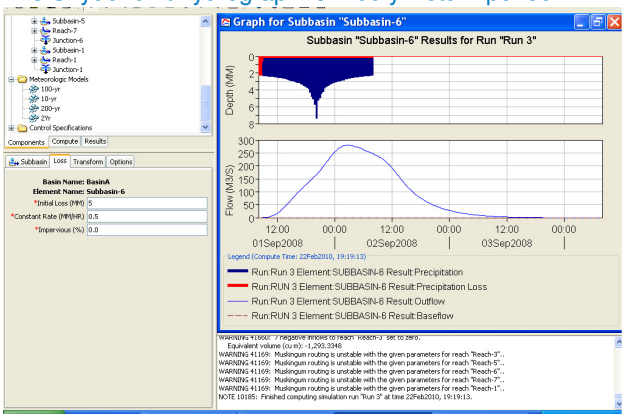

Source: MM

## Discharge estimation for 100 yr Return period




Source: MM

## The Snyder unit hydrograph for 100 yr-return period




Source: MM

# Appendix D. List of Industries

In this section the supportive tables of Chapter 3, has been put chronologically as follows:

- Allotment Details of Dahej 1
- Allotment Details of Dahej SEZ
- Allotment Details of Dahej II
- Allotment Details of Vilayet
- Industry Survey Sheet

Table D.1: Allotment detail of Dahej I estate

| Name of the Company | Plot No. | Area (in Ha.) | Sector | Products | Sub sector | Scale of Industries |
|---|---|---|---|---|---|---|
| Reliance Industries Limited (earlier I.P.C.L.) | 1 | 681.610 | Chemical / Petrochemical | 1) VCM, PVC, Chlor-Alkali Plant<br>2) Ethane, Propylène, Butadiene etc (petrochemical complex) | Petrochem | Large |
| Reliance Dahej Marine Terminal (RDMT) – Jageshwar Jetty | NA | NA | Chemical / Petrochemical | Container terminal and captive jetty of Reliance Industries Limited (IPCL) | Logistics | Large |
| Gujarat Alkalis and Chemicals Limited | 3, CH-17 | 140.950 | Chemical / Petrochemical | Caustic Soda (lye, flakes, prills), Sodium hypochloride, liquid chlorine, compressed hydrogen gas, HCL, caustic Potash (lyes, flakes), Potassium Carbonate, Polyaluminum Chloride, Phosphoric Acid, Hydrogen peroxide, Aluminum Chloride anhydrous etc. | Inorganic chem | Large |
| Oil and Natural Gas Corporation Limited | 7/D | 55.000 | Petroleum | Petroleum, Oil refining | Petrochem | Large |
| L.G. Polymer | 12/B | 26.000 | Chemical / Petrochemical | Polystyrene, expandable polystyrene (EPS), ABS (acrylonitrile-butadiene-styrene) and SAN (styrene acrylonitrile). | Polymer | Large |
| NOCIL | 12/A/1, 13/B/1 | 20.450 | Chemical / Petrochemical | Rubber chemical | elastomer | Large |
| Sterling Auxilaries | 12/A/2 | 11.190 | Chemical / Petrochemical | Fatty Alcohols, Fatty Acids, Alkyl Phenol, Fatty Amines, Esters, Stearic Acid Ethoxylates, Ethoxylates of Other Vegetable Oils – Castor oil, Phenoxyl Ethanol, Sulphanated Products Emulwet – BUT, HPWD –A1, Esters, Amides & Betains, Phosphatized and Anti-oxidants products | Specialty Chemicals | Large |
| Gujarat Florochem. Ltd. | 12/A | 41.050 | Chemical / Petrochemical | PTFE- PT-PTFE & TFE, Chloro Methane, Caustic Soda | Inorganic chemicals, Polymer | Large |
| The Sarashwati Industries | 13/B | 19.720 | NA | NA | NA | NA |
| Mahipal Chemical | E/532 | 0.120 | Chemical / Petrochemical | NA | Chemical | Medium |
| Chloride India | E/533, 534 | 0.223 | Chemical / Petrochemical | Calcium Chloride, Ammonium Chloride concentrate | Inorganic chemical | Medium |
| Meghmani Organics Ltd. | CH 1, 2 | 65.000 | Chemical / Petrochemical | Caustic Soda Lye and Flacks, Chlorine Gas, Hydrogen Gas, 78% Dilute Sulphuric Acid, 30% HCL, Sodium Hydrochlorite | inorganic chem | Large |

| Name of the Company | Plot No. | Area (in Ha.) | Sector | Products | Sub sector | Scale of Industries |
|---|---|---|---|---|---|---|
| Jash Chem | Ch-3 | 1.000 | Chemical / Petrochemical | NA | NA | NA |
| Borex Morarji Ltd. | CH-4 | 9.010 | | NA | NA | NA |
| Hemani Intermediates Pvt. Ltd. | CH-5 | 4.000 | Chemical / Petrochemical | NA | fine chemicals | Medium |
| Universal Chem Ind. | CH-5/A (CH-5D) | 9.350 | Chemical / Petrochemical | KMNo4, KOH | inorganic chem | Medium |
| Luna Chem Ind Ltd. | CH-6,7,8,9 | 6.894 | Chemical / Petrochemical | Aniline oil, Nitro Aromatics, Nitro Benzene | specialty chem | Large |
| Expanded Incorporation (Expanded Polymer Systems P. Ltd.,) | CH-10 | 5.000 | Chemical / Petrochemical | NA | polymer | Medium |
| Alex Industries | CH-11 | 1.100 | NA | NA | NA | NA |
| Agrasen Impex Private limited (Sajjan Ind. Ltd) | CH-12 | 16.000 | NA | NA | NA | NA |
| Indocat Pvt Ltd | CH-15 | 10.500 | Chemical / Petrochemical | Manufacturing & marketing of FCC (fluidised catalytic cracking) catalysts and additives. | specialty chem | Large |
| Vishal Organics | CH-18&19 | 2.500 | NA | NA | NA | Medium |
| Insecticides (India)Limited | CH-21 | 15.000 | Chemical / Petrochemical | NA | fine chem | Large |
| Stephan (India) Pvt. Ltd (Surfactant Project) | CH-23 | 20.000 | Chemical / Petrochemical | Surfactants and specialities which include anionics, non-anionics cationics and amphoterics | specialty chem | Medium |
| Astral Biochem Pvt. Ltd | CH-25 | 6.421 | Chemical / Petrochemical | Ethanol | chemical | Medium |
| Siris Crop Sciences Ltd. | CH-44/1 | 11.403 | Chemical / Petrochemical | NA | fine chemicals | Large |
| BASF Styrenics Ltd. (Earlier Pushpa Polymers) | H-6/1 (4) | 0.240 | Chemical / Petrochemical | Polymers of Styrene | petrochem | Large |
| Ganesh Oleo Chem Limited | S/120 | 1.000 | Chemical / Petrochemical | NA | specialty chemicals | Medium |
| Organic Industries Ltd. (M/s Surfactant Specialities Ltd.) | S/163 | 17.158 | Chemical / Petrochemical | Potassium Permanganate, Boric Acid Powder | Specialty Chemicals | Medium |
| Metro Pharma Chem Mfg Co. | S-165 | 1.000 | Chemical / Petrochemical | | Fine Chemicals | Medium |
| Hindalco (Indo Gulf) | 2, 10,11,43 | 356.350 | Engineering | Copper Cathodes, Power, Oxygen, Sulphuric acid etc. | Metallurgical | Large |
| Sitaram Energy & Logistics limited | E-206, E-207 | 1.523 | Engineering | Packing of DAP/NPK fertilisers for Birla Copper | Logistics | Medium |
| Standard Engineering (Enterprise) | E/339 | 0.239 | Engineering | Motor Winding | Electrical | Medium |
| Snehal Engineering | S/125 | 0.085 | Engineering | NA | Not defined | NA |

| Name of the Company | Plot No. | Area (in Ha.) | Sector | Products | Sub sector | Scale of Industries |
|---|---|---|---|---|---|---|
| Birla AT&T Communication Ltd. | S-11 | 0.059 | Engineering | NA | Communication | Medium |
| Shiv Engineering | S-12 & 13 | 0.232 | Engineering | NA | NA | NA |
| Shiv Engineering | S/15 | 0.230 | Engineering | NA | NA | NA |
| Swami Steel | S/136 | 0.350 | Engineering | NA | NA | NA |
| Blast Abrasives Processing Ind. (M/s. Jolly Abrasives) | S/153 | 2.191 | Engineering | NA | NA | NA |
| Deepthy Engineering Works | S/155 | 0.480 | Engineering | NA | NA | NA |
| Narmada Packaging | S/164 | 0.670 | Engineering | NA | Packaging | Medium |
| Varun Engineering | S-52/1 | 0.085 | Engineering | NA | NA | Medium |
| ISGEC | NA | NA | Engineering | High pressure vessels, Boilers, Heat exchangers | NA | Large |
| Walchandnagar Industries Ltd. | | NA | Engineering | Developing an offshore platform fabrication | NA | Large |
| Petronet LNG Ltd. | CH-14, 7/A/1 | 82.500 | Natural Gas Infrastructure | Import of LNG, Regassification of LNG & Export of Natural Gas etc. | Gas Infra | Large |
| Petronet LNG & M/s GSPC Gas Company Ltd. | CH-14 7/A/1 | NA | NA | Import of LNG regasification | Gas Infra | Large |
| IOC Ltd. – Terminal | 7/A | NA | NA | NA | Logistics | Large |
| GCPTCL | 8 | 150.000 | Chemical handling port | Commercial port and storage terminal for dedicated for handling Liquid & Gaseous Chemicals | Logistics | Large |
| GSPL | 8/- 1 | 0.901 | Natural Gas Infrastructure | Developing natural gas transportation for Dahej-Vijaipur Pipeline network | Gas Infra | Large |
| GEB | 31 | 14.233 | Electricity Board | NA | power infra | |
| A.B.G. Shipyard | RS. No. 701/A,B and 39 + 40/1&2 | 17.990 | Port and related Industries | NA | NA | Large |
| GMB – site for Ro-Ro Terminal | NA | NA | Port | NA | NA | Large |
| Adani Petronet (Dahej) Port P. Ltd. | NA | NA | Port and related Industries | NA | port | Large |
| Telephone Exchange | S/65 to 67 | 0.546 | Others | NA | NA | NA |
| Y.A. Matadhar | S/81 | 0.118 | Others | NA | NA | NA |
| B.K. Solanki | RS. No. 225/B | 1.221 | Others | NA | NA | NA |

| Name of the Company | Plot No. | Area (in Ha.) | Sector | Products | Sub sector | Scale of Industries |
|---|---|---|---|---|---|---|
| Smt. Vimalaben K. Patel | E/340 | 0.180 | Others | NA | NA | NA |
| D.M. Chaudhury | E/531 | 0.120 | Others | NA | NA | NA |
| Disaster Management | 23/-1 | 0.100 | | NA | NA | NA |
| M/s. Vijaykumar Nandlal Upadhyay (Hotel Shalin) | S-13 & 14 | 0.300 | Others | NA | NA | NA |
| Smt. Sangeetaben J. Tapiawala | S/18 | 0.210 | Others | NA | NA | NA |
| Shri Rajesh R. Tapiawala | S/55 | 0.750 | Others | NA | NA | NA |
| Shri S.B. Kulchandani | S/31 (S-131) | 0.320 | Others | NA | NA | NA |
| Smt. Vanitaben Yogeshbhai Shah | S/113 | 0.250 | Others | NA | NA | NA |
| Dahej Police Station | S/117 | 0.098 | Others | NA | NA | NA |
| M/s. Deep Enterprise | S/156 | 0.270 | NA | NA | NA | NA |
| M/s Raj Enterprise | S/157 | 0.475 | NA | NA | NA | NA |
| M/s Aashish and Co. | S/158 | 0.530 | NA | NA | NA | NA |
| M/s. Narmada Industries | S/159 | 0.890 | NA | NA | NA | NA |
| Smt. Priti Tarak Mamlatdama | S/1 | 0.900 | NA | NA | NA | NA |
| M/s Aarav Enterprise | S/51 | 0.830 | NA | NA | NA | NA |
| Shri Y V Modi | S-236 | 0.890 | NA | NA | NA | NA |
| GIDC Office | NA | NA | NA | NA | NA | NA |

Table D.2: Allotment detail of Dahej SEZ

| Name of the Company | Plot No. | Area (sq.mt) | Area in Ha. | Sector / Products | Present Status | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|---|
| ONGC Petro Additions Ltd. | Z-1 | 50530047.000 | 526.00 | Petrochemical | Under Construction | | Large |
| ONGC Petro Additions Ltd. | Z-83 | | | Petrochemical | Under Construction | | |
| ONGC Petro Additions Ltd. (C2-C3-C4 project) | Z-7/D (Z/7) | 598574.000 | 230.000 | Petrochemical | Under Construction | | |
| DIC Fine Chemicals Private Ltd. | Z-3 | 20000.000 | 2.000 | Petro chemical | Under Construction | chem | medium |
| M/s.Pidilite Industries Limited | Z-2 | 204135.000 | 20.414 | Petrochemical - Synthetic | Under | specialty | Large |

| Name of the Company | Plot No. | Area (sq.mt) | Area in Ha. | Sector / Products | Present Status | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|---|
| | | | | Elastomer | Construction | | |
| M/s. Neesa Infrastructure India Pvt Ltd. | Z-88 | 140648.000 | 14.065 | Petro chemical | Proposed Site | infra | |
| M/s. Chemetall Lithium India P. Ltd. | Z/12/2 | 17900.000 | 1.790 | Chemical / petrochemical - inorganic, organic, hydraides, alkoxides, amides etc. | NA | chem | Medium |
| M/s. Indofil Chemicals Co. | Z-8, Z/7/1 | 98700.000 | 9.870 | Petrochemical | Operational | chem | Large |
| M/s. Firmenish Aromatics Prod. (I) Ltd. | Z-10 | 197300.000 | 19.730 | Petrochemical | Under Construction | | Medium |
| M/s. Sarju Impex Ltd. | Z-13 | 24878.000 | 2.488 | Petrochemical | Under Construction | textile | Large |
| M/s. Prasar Chem Pvt. Ltd. (M/s Aries Colorchem Pvt. Ltd.) | Z/29 & Z/30 | 32200.000 | 3.220 | Petrochemical | Proposed Site | chem | Medium |
| M/s James Robinson India Pvt. Ltd. | Z/33 | 20058.000 | 2.006 | Chemical / petrochemical - specialty chemicals and Intermediates like photography chemicals, hair dyes intermediates, flourescent pigments | NA | specialty | Medium |
| M/s. Meghmani Chemtech Ltd. | Z/31 & Z/32 | 84428.000 | 8.443 | Chemical / petrochemical | Proposed Site | | Large |
| M/s. Meghmani Speciality Chemical Ltd. | Z-6 | 75415.000 | 7.542 | Chemical / petrochemical | Proposed Site | Fine Chemicals | Large |
| M/s Meghmani Unichem Pvt. Ltd. | Z/34 | 53831.000 | 5.383 | Chemical / petrochemical | Proposed Site | Fine Chemicals | medium |
| Sun Pharmaceutical Ind Ltd. | Z/15 | 87480.000 | 8.748 | Chemical / petrochemical | NA | Fine Chemicals | Large |
| M/s.Sigachi Cellulos Pvt Ltd. | Z-16 | 10822.000 | 1.082 | Chemical / petrochemical - Heavy Chemicals, Cellulose and Chlorine based products | Proposed Site | Speciality Chemicals | Large |
| M/s.Gujarat Dyestuff Industries | Z-25, 26, 27 & 28 | 76689.000 | 7.669 | Chemical / petrochemical | Proposed Site | Fine Chemicals | Large |
| M/s.P&J Cretechem (P) Ltd. | Z-17 & 18 | 20695.000 | 2.070 | Chemical / petrochemical - Constrution Chemical & Intermediates | Proposed Site | Speciality Chemicals | Medium |
| Ramdev Chemicals Industry | Z/19, Z/20 | 20000.000 | 2.000 | Petrochemical | NA | NA | NA |
| M/s.Chemorge (Jain). | Z-22 | 9375.000 | 0.938 | Chemical | Proposed Site | NA | NA |

| Name of the Company | Plot No. | Area (sq.mt) | Area in Ha. | Sector / Products | Present Status | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|---|
| M/s. Panama Petrochem Ltd. | Z-23 | 9375.000 | 0.938 | Chemical / Petrochemical - Petroleum speciality | Proposed Site | Speciality Chemicals | Medium |
| M/s. Sajjan Speciality Ltd. | Z-106 | 89505.000 | 8.951 | Petrochemical | Proposed Site | Fine Chemicals | Medium |
| M/s. Rallis India Ltd. | Z-110 | 80004.000 | 8.000 | Petrochemical | Proposed Site | Fine Chemicals | Large |
| M/s. P.I.Industries Ltd. | Z-97/P | NA | NA | Chemical / petrochemical | Proposed Site | Speciality Chemicals | Large |
| M/s. Borregaard Kelkar Chemicals Pvt Ltd. | Z-109/B | NA | NA | Chemical / petrochemical | Proposed Site | NA | NA |
| M/s.Sun Pharmaceutical Industries Ltd. | Z-105 | NA | NA | Petrochemical | Proposed Site | Fine Chemicals | Large |
| M/s.Bajaj Eco-Chem Products Pvt Ltd. | Z-108 | NA | NA | Chemical / petrochemical | Proposed Site | | Medium |
| M/s. Bajaj Hindustan Limited | Z-107 | NA | NA | Chemical / Petrochemical - Sugar and Ethanol Manufacturing Company | Proposed Site | Chemicals | Large |
| M/s. Choksi Colours Pvt.Ltd. | Z-109/A | NA | NA | Petrochemical | Proposed Site | Fine Chemicals | Medium |
| M/s Torrent Pharmaceutical Ltd. | Z/104, Z/105 | 164400.000 | 16.440 | Petrochemical | NA | Fine Chemicals | Large |
| Aetgen Pharma Pvt. Ltd. | Z/101/2 | 50000.000 | 5.000 | Petrochemical | NA | Fine Chemicals | Large |
| Sterling Auxiliaries Pvt. Ltd. | Z/109 | 50100.000 | 5.010 | Chemical / Petrochemical | NA | Speciality Chemicals | Medium |
| M/s. Shankar Packaging Ltd. | Z-12 | 50000.000 | 5.000 | Engineering - others | Proposed Site | Packaging | Medium |
| M/s. Torrent Energy Ltd., | Z-9 | 1107158.000 | 110.716 | Power | Proposed Site | | Large |
| M/s. Torrent Energy Ltd., | Z/21, Z/101/1 | 65434.000 | 6.543 | Power | NA | | Large |
| M/s.Roxul-Rockwool Insulation India Pvt Ltd. | Z-111/B (Z/4/1) | 94163.000 | 9.416 | Stone wool insulation | Proposed Site | Ceramic | Large |
| M/s Godrej & Boyee Mfg.Co.Ltd. | Z-90 | 235030.000 | 23.503 | Engineering | Proposed Site | | Large |
| M/s.Saraswati Industrial Syndicate Ltd. | Z-89 | 238020.000 | 23.802 | Engineering - manufactures bars & rods, metal, machine tool parts & accessories, steel and sugar products. | Proposed Site | | Medium |
| Tiong Woon Project and Contracting Pte. Ltd. | Z/88 (P/3) | 10000.000 | 1.000 | Engineering - specialists and solution providers of infrastructure businesses, supporting mainly the Oil & Gas, as well as | NA | Logistics | Large |

| Name of the Company | Plot No. | Area (sq.mt) | Area in Ha. | Sector / Products | Present Status | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|---|
| | | | | Petrochemical, Power and Construction sectors - providing possesses heavy lift, heavy haulage, marine transport and fabrication yard resources | | | |

Table D.3: Allotment detail of Dahej II

| Name of the Company | Plot No. | Area (Ha.) | Sector | Product | Present Status | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|---|
| Growmore Enterprises | NA | NA | Chemical | Sodium Silicate, Ceramics Frit | Operational | Ceramics | Medium |
| Nahar Paints & Chemicals Limited | NA | NA | Chemical | Ceramic Tile Glaze | Operational | Speciality Chemicals | Medium |
| GNFC – TDI-Aniline Complex | D-II/8 | 279.72 | Chemical / Petrochemical | TDI, MDI and related product | Under Construction | Speciality Chemicals | Large |
| First Carbon Technologies Private Limited | D-II/4, D-II/12, D-II/12/A, D-II/13 | 100.04 | Chemical | Project of Cokonyx produced by Carbon Alloys Synthesis Plant | Under Construction | metal | Large |
| M/s Action Peroxide Pvt.Limited | D-II/7A | 32 | Chemical | Caustic soda, Chlorine gas and Hydrochloric acid | NA | Inorganic Chemicals | Large |
| Gujarat Alkalies and Chemicals Limited | D-II/6 | 113.83 | Chemical / Petrochemical | Project of Phenol, Bis phenol-A, Poly Carbonate, Elstomer group products EDC/PVC | NA | NA | Large |
| M/s. SRF Limited, | D-II/1 | 45.9933 | Chemical / Petrochemical | Polymer, Monomer, refrigerant gases, trichloroethylene and perchloroethylene, caustic / chlorine | NA | NA | Large |
| M/s GACL | D-II/9 | 65.7095 | Chemical / Petrochemical | Caustic Soda, Chlorine, hydrogen, Hydrochloric Acid, Sodium Hypochlorite and other products based on chlorine and hydrogen and power for above plants | NA | Inorganic Chemicals | Large |
| M/s GSFC | D-II | 225 | Chemical / Petrochemical | MMA/PMA complex biodegradable plastics derivatives capralaction nylon fibre complete offiside facilities | NA | Polymer | Large |
| Kaneria Granito | NA | NA | Others | Vitrified tiles | Operational | Ceramics | Large |
| Pavit Ceramics | NA | NA | Others | Paving/Exterior Tiles | Operational | Ceramics | Large |

| Name of the Company | Plot No. | Area (Ha.) | Sector | Product | Present Status | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|---|
| Shiv Shakti Industries | NA | NA | | NA | Operational | | |
| Daya Glass India Private Limited | NA | NA | Others | Ceramic Industry | Not in operation since last 20 days | Ceramics | Medium |
| Welspun Stahl Rohren Gujarat Limited | NA | NA | Engineering | Saw Pipes, Plates and Coils | Operational | NA | Large |
| M/s. Adani Power Dahej Limited | D-II/2, D-II/5 | 211.6076 | Engineering | Generation of Electricity | NA | Power | Large |
| M/s. Bharat Forge Limited | D-II/11 | 66.61 | Engineering | Castings, Heavy forgings, Turbine and generator for power plants, balance of plants, nuclear power plants equipment other capital goods | NA | NA | Large |

Table D.4: Allotment detail of Vilayet Estate

| Name of the Company | Plot No. | Present Status | Area (in Ha.) | Sector | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|
| M/s Grasim Industries | 1 | Proposed Site | 222.63 | Petrochemical | Textile | Large |
| M/s. Biotor Industries Ltd. (formerly Jayant Oil & Derivatives Ltd.) | 2 | Proposed Site | 122 | Agrochemical | Fine Chemicals | Large |
| M/s Century Pulp and Paper | 3 | Proposed Site | 100 | Chemical / petrochemical | Chemicals | Large |
| M/s. Colourtex Ind. Pvt. Ltd., Surat | 3/A | Proposed Site | 40 | Chemical / petrochemical | Fine Chemicals | Large |
| M/s Jubilant Organosys Limited | 4 | Proposed Site | 20.23 | Chemical / petrochemical | Specialty | Large |
| M/s Jubilant Infra. Pvt. Limited | 5 | Proposed Site | 107.24 | Chemical / petrochemical | Fine Chemicals | Large |
| M/s. Gujarat Hydrocarbon and Energy SEZ Limited, C/o. M/s Assam Company Limited | 6 | Proposed Site | 315 | Petrochemical | NA | Large |
| M/s. Indra Steel Pvt. Ltd. | E/56 | Proposed Site | 0.5004 | Engineering | Metallurgical | Large |
| M/s. Anupama Saigal | E/58 | Proposed Site | 0.5004 | Others | NA | NA |
| Shri Shashi Kapoor | E/54 | Proposed Site | 0.5004 | others | NA | NA |
| NareshKumar Khanna | E/55 | NA | 0.5004 | others | NA | NA |
| M/s. Dinesh Enteerprise | E/52 | NA | 0.5004 | others | NA | NA |
| Shushma Agrawal | E/53 | NA | 0.5004 | others | NA | NA |
| Ritu Jain | E/48 | NA | 0.5004 | others | NA | NA |
| Sukhmal Jain | E/50 | NA | 0.5004 | others | NA | NA |

| Name of the Company | Plot No. | Present Status | Area (in Ha.) | Sector | Subsector | Scale of Industries |
|---|---|---|---|---|---|---|
| Smt. Hamal Preet Honey | E/41 | NA | 0.5004 | others | NA | NA |
| Rakeshkumar | E/42 | NA | 0.5004 | others | NA | NA |
| Mardul R. Jjain | E/43 | NA | 0.5004 | others | NA | NA |
| Tarun Jain | E/44 | NA | 0.5004 | others | NA | NA |
| Shri Shiv Enterprise | E/45 | NA | 0.5004 | others | NA | NA |
| Amit Rakesh Jain | E/46 | NA | 0.5004 | others | NA | NA |
| Trishla D. Jain | E/47 | NA | 0.5004 | others | NA | NA |
| Ritu Jain | E/48 | NA | 0.5004 | others | NA | NA |
| Sukhmal Jain | E/50 | NA | 0.5004 | others | NA | NA |
| AIK Packaging | E/50 | NA | 0.5004 | others | NA | NA |
| Dinesh Enterprise | E/52 | NA | 0.5004 | others | NA | NA |
| Shushma Agraval | E/53 | NA | 0.5004 | others | NA | NA |
| M/s. Sapana Gupta | E/8 | NA | 0.4989 | others | NA | NA |
| Gurudatt R Juneja | E/9 | NA | 0.96 | others | NA | NA |
| Vijaykumar R. Bhavatia | E/10 | NA | 0.96 | others | NA | NA |
| Chandreshkumar Behal | E/11 | NA | 0.96 | others | NA | NA |
| Shital M. Sachde | E/12 | NA | 1.18 | others | NA | NA |
| Heenaben R. Keshwani | E/13 | NA | 1.05 | others | NA | NA |
| Sarojben Bhupandra Kapadia | E/15 | NA | 0.96 | others | NA | NA |
| Abhinav Industrial | E/16 | NA | 0.96 | others | NA | NA |
| Jahida Jain Patel | E/17 | NA | 0.96 | others | NA | NA |
| Chandrajit Singh Vadatia | E/18 | NA | 0.96 | others | NA | NA |
| Harshad P. Patel | E/19 | NA | 0.96 | others | NA | NA |

Table D.5: Industry Survey Sheet

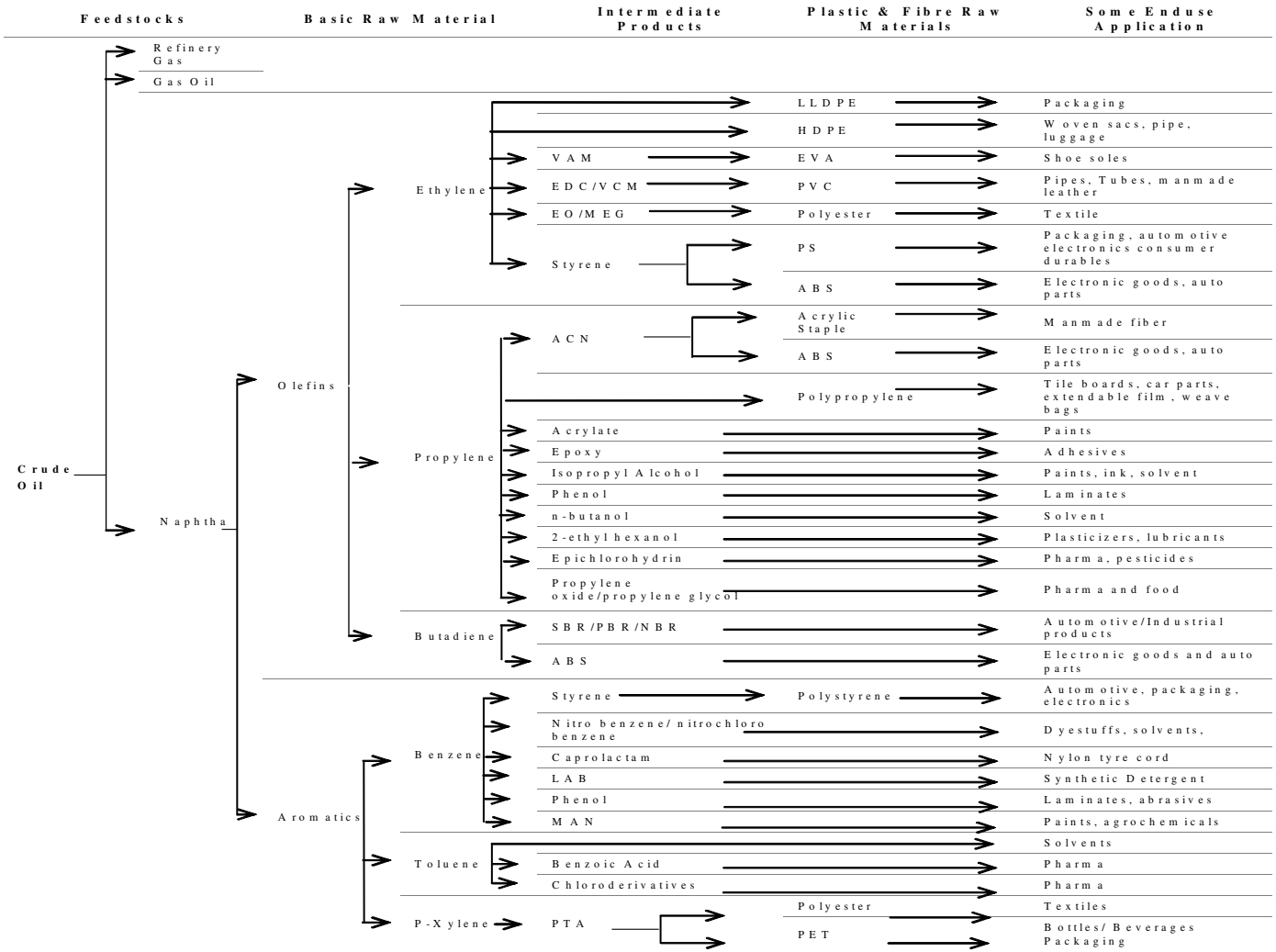
| Units Under Operation | Direct Employee | Pre-production and production | | | | | | | | Post production | | | | | | | Common Services | | | | | Social Infrastructure | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Raw material movement | | | | Availability of industrial infrastructure | | | | Material Despatch | | | | Availability of industrial Infrastructure | | | | | | | | | | | |
| | | Road | Port | Rail | Pipeline | Power | Water | Fuel | Storing | Road | Port | Rail | Pipeline | Sewage Disposal | Effluent Disposal | Solid waste | R&D Centre | Quality certification | ICT infrastructure | Marketing Infrastructure | Truck parking Bay | Housing | Health care | Recreation and Sports | Banks |
| BASF Styrenics Private Limited | 95 | Y | Y | N | N | DGVCL | GIDC | Furnace Oil | Styrene tank | Y | N | N | N | Zero Disposal | NA | Process Waste & ETP sludge to BEIL and Carboise & Spent oil to resale | N | Y | Y | Y | N | N | Y | N | N |
| Gujarat Alkalies & Chemicals Limited | 700 | Y | Y | N | N | Captive plant | GIDC | NG | Open yard and God own | N | N | N | N | Into Sea( 7 km inside the sea) | Into Sea( 7 km inside the sea) | BEIL and Recyclers & reprocessors | N | Y | Y | Y | Y | Y | Y | Y | N |
| Meghmani Finechem Ltd. | 300 | Y | N | N | N | Captive plant | GIDC | Coal | open yard | Y | N | N | N | Septic tank | CETP | To pit and sale to authorized vendor | Y | Y | Y | Y | Y | N | Y | N | N |
| Chlorides India | 16 | Y | N | N | N | DGVCL | GIDC | Firewood | Tank and Open yard | Y | N | N | N | Septic tank | | BEIL | N | N | N | N | Y | N | N | N | Y |
| Sitaram Energy & Logistics Ltd. | 25 | Y | N | N | N | DGVCL | GIDC | NA | | Y | N | N | N | Septic tank | NA | NA | N | N | N | N | N | N | N | N | N |
| Standard Enterprise | 18 | Y | N | N | N | DGVCL | Private Tanker | NA | iron racks | Y | N | N | N | Septic tank | N | N | N | N | Y | Y | NA | Y | Y | N | N |
| Hindalco Industries Limited | 2500 | | N | N | N | Captive plant | GIDC | FO, Naptha, Propane | | | N | N | N | | N | N | N | Y | Y | Y | Y | N | N | N | N |
| Organic Industries Limited | 135 | Y | N | N | N | DGVCL | GIDC | | tanks | Y | N | N | N | Zero Discharge Unit | N | N | N | Y | Y | Y | Y | N | Y | N | N |
| Petronet | 180 | N | N | N | N | DGVCL | GIDC | N | N | N | N | N | Y | Sea | | sell to recyclers | N | Y | Y | Y | N | N | Y | Y | N |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LNG Limited | | | | | | | | | | | | | | disposal | | and BMC | | | | | | | | | |
| Indofil Chemicals Company | 98 | Y | Y | N | N | Torrent Power | GIDC | Coal & LDO | tanks | Y | Y | N | N | Septic Tank | Sea | BEIL,Approved recycler | N | N | Y | Y | Y | N | Y | N | N |
| Luna Chemical Inds. P. Ltd. | 50 | Y | N | N | Y | DGVCL | GIDC | HSD & FO | Not available | Y | N | N | N | Septic tank | CETP | resale | N | Y | Y | Y | Y | N | Y | | |
| ONGC – Gas Gathering Station | 10 | N | N | N | Y | Captive plant | Gandhar WTP | NA | tanks | N | N | N | Y | Septic tank | | | N | Y | Y | Y | N | Y | Y | Y | Y |
| Shoft Shipyard Private Limited | 250 | Y | N | N | Y | DGVCL | Private tankers | | open yard | N | N | N | N | Sea disposal | | Sell for reprocessing | N | Y | Y | Y | Y | Y | Y | N | N |
| Pavit Ceramics Pvt. Ltd. | 60 | Y | N | N | | DGVCL + Captive plant | Private tankers | | Bags in Godown | Y | | N | N | Septic tank | | Resale & Reuse | Y | Y | Y | Y | Y | Y | Y | N | N |
| Welspun Gujarat Stahl Rohren Ltd. | 251-500 | Y | Y | N | N | DGVCL + Captive plant | GIDC | HFO,HSD, NG for Power & NG for heating | Open yard | Y | Y | N | N | Root zone type | | Surat,BEIL & Resale | Y | Y | Y | Y | Y | N | N | N | N |
| GCPTCL | 90 | N | N | | Y | | GIDC | HSD | | Y | N | N | Y | Septic tank | | Sell for reprocessing | Y | Y | Y | Y | Y | N | Y | N | N |
| Grow More / Narmada / Jayson Enterprise (A Group of Kaneria Group of Industries) | 25 | N | N | N | N | DGVCL | Private tankers | NG | solid and open yard | N | N | N | N | Disposed to open space & septic tank | | Sell for reprocessing | N | Y | N | Y | N | Y | N | N | N |
| Gujarat Fluoro Chemicals Limited | | Y | N | N | N | DGVCL + Captive plant | GIDC | Imported coal (250 MT | Open yard and tanker | Y | Y | N | N | Septic tank | Sea | BEIL,GEPIL,Cement Industyry & Recycler | Y | Y | Y | Y | Y | N | N | N | N |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | D) & NG( 0.19 MM SC MD) | | | | | | | | | | | | | | | | |
| ISGEC | 300 | Y | Y | N | N | DGVCL | GFCL | LPG & HS D | open yard and closed godowns | Y | Y | N | N | Septic tank | | Resale | N | Y | Y | Y | Y | N | N | N | N |
| Nahar Colours & Coating Ltd. | 60 | Y | Y | N | N | Captive plant | Private tankers | | Bags in Godown | Y | | N | N | Septic tank | | Resale & Reuse | Y | Y | Y | Y | Y | Y | N | N | N |
| Sterling Auxiliaries Pvt. Ltd. | 98 | Y | Y | N | N | DGVCl | GIDC | LDO & FO | | Y | Y | N | N | Septic tank | Sea | BEll & sell to authorized vendor | Y | Y | Y | Y | N | Y | Y | N | N |
| Kaneria Granito Limited | 350 | Y | N | N | N | DGVCL | Private tankers | NG | Open yard and warehouse | Y | | N | N | Disposed to open space & septic tank | | Sell torecyclers | Y | Y | Y | Y | N | N | N | N | N |
| Universal Chemicals & Industries Pvt. Ltd. | 150 | Y | N | N | N | DGVCL | GIDC | NG | Godown and storage tank | Y | | N | N | Septic tank | | Sell to recyclers | Y | Y | Y | Y | N | N | N | N | N |
| Jolly Abrasives | 15 | | N | N | Y | DGVCL | Private tankers | | Tanks | Y | | N | N | Septic tank | | | N | Y | Y | Y | Y | N | N | N | N |
| Eurostar Crystal Marble | 30 | Y | N | N | N | N | Private tankers | | Open yard and tank | Y | Y | N | N | Septic tank | | | N | N | Y | N | N | N | N | N | N |
| Reliance Industries limited | >500 | Y | N | N | N | N | Captive Facility | NG, Cracker off gas, Mixed slop | | Y | Y | N | N | Mixed with Effluent | Sea | Landfill site,Incenireation and Sell to vendor | Y | Y | Y | Y | Y | N | Y | N | Y |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | oil | | | | | | | | | | | | | | | | | | | |
| ABG Shipyard Ltd. | >500 | N | N | N | Y | DGVCL | Private tankers | HSD | Open yard and sphere | Y | N | N | N | Septic tank | | | N | Y | Y | Y | Y | Y | Y | Y | N | N | |
| Daya Glass Industries Pvt. Ltd. | 93 | N | N | N | | | Private tankers | NG & HSD | N | N | N | N | N | Septic tank | | | N | N | Y | | Y | N | N | N | N | N | |
| ONGC Petro additions Ltd.(OPaL) | >500 | N | N | N | Y | Torrent Power and Captive Facility | Captive Facility | | N | Y | Y | Y | Y | STP | CETP | | N | N | Y | Y | Y | Y | Y | Y | N | N | |

Figure D.1: Co-Siting of petrochemical products




Source: MM desk research