Deepwater Block KG-DWN-98/3 (KG-D6) located in Krishna Godavari basin off the East coast, N-W boundary of block about 40-60 km from Kakinada with water depth ranging from 400 m to 2700 m.

RIL had started field investigations and studies in the year of 2002. The first objective was to isolate and understand Natural Challenges put forth in the KG-D6 Development with concept of Full Subsea Production System with Onshore Processing and a Control & Riser Platform (CRP). This was supposed to be First Deepwater gas field development in India.

The development area from Deepwater well locations to the Onshore Terminal comprised of distinct sections on the basis of various ranges of water depths.

- A deep-water section-1300m water depth down to 600 m water depth
- A mid-water pipeline corridor from 600 m to Control raiser platform at 100 m water depth
- A shallow-water section of 25 km length from the CRP at 100 m water depths to the landfall point passing through Estuary of River Godavari, one of the largest rivers in India.

Master Planning of Integrated Studies and Field Investigations- After sectionalizing the development area into various zones, an initial study was done in-house to understand key issues in these zones looking at then available data by conducting various investigations/ surveys like 3-D Seismic data and bathymetry of Deepwater areas, Metocean data collected during drilling boreholes in the Estuary, initial coarser geophysical survey lines from Deepwater to Landfall point (LFP), Pre-drilling Survey including 2D HIRES data in Deep Water at the exploratory well locations and some Historical data collected such as flooding of Godavari river in 1986 & known cyclones such as 1996 and High water marks near Onshore Terminal sites & villages / pillars / homes during peak floods of 1986 & 1996.

Based on the initial study it was decided to carry out various studies in an integrated manner keeping an eye on data gaps & needs. Field Investigation Program was tailor made to fill those data gaps of these MASTER study needs. From overall Risk point of view additional studies were planned such as Site specific earthquake study and Tsunami Risk study for entire site etc.

Challenges in River Section and Field Investigations- The pipelines pass through a 10 km long river section of Godavari. This river is India’s one of the biggest river meeting the Bay of Bengal at our KG-D6 site. There is a barrage on Godavari river 80 km upstream of our jobsite at Dowaleshwaram near Rajahmundry. We have undertaken a huge data gathering program and understood that river is subject to huge discharge of 40000 cumecs. Pipeline corridor within the river is subject to heavy scour & siltation.

The site specific data was considered necessary such as Bathymetry- 2-3 years’ pre & post monsoon data, which gives knowledge on sediment transport & also HFL bank levels, cross section of the Godavari Estuary upto river banks at every 2 kms from Dowaleshwaram Barrage to the rivermouth meeting Bay of Bengal etc.

Challenges in deepwater areas were:
- Careful selection of fair weather window for installation activities as East Coast of India is subject to cyclones/ depressions.
- Possibility of slope instability and the other Geohazards.
- Already known events of TSUNAMI-2004

Hydrodynamic model and calibration of river section- Based on the concurrent measurements of waves, currents & tides at different locations along the river Godavari-Estuary and the field investigations, 2 hydrodynamic models were developed at 2 separate specialist companies-CWPRS, Pune, India and H.R. Wallingford, UK. CWPRS used linear model, whereas HR Wallingford worked on 2D Finite Elements model: “TELEMAC”, a 2-D model, was considered more specific & appropriate considering sediment transport & flow function. Therefore, the scour values provided by HR Wallingford were adopted with design after brainstorming within RIL. Other than scour values, most other parameters worked by both approaches yielded similar results on flooding, currents within the river.
Model Study and Results - Having calibrated the hydrodynamic model, it was used to predict normal currents, waves during installation, peak currents, waves & water levels during floods, during cyclones & different cases of river discharges. Therefore these studies were quite essential and useful for design and safe installation of pipelines.

Geohazard Study - Master Planning - Reliance conceptualized a working model to carry out studies & field investigation. Data-gathering & desktop studies began at 4 places such as within Reliance, for Geohazards at NGI, a Workshop held for brainstorming at Reliance with experts including NGI and at HR Wallingford / BGS to look at TSUNAMIS & likely effects. Continuous Participation of key Team members during end to end process lead to very positive energy of creative working apart from seamless & online decision making during the course of Geohazard Studies and field data collection.

Tsunami Study - On ‘boxing day’ of 26th December 2004, the whole Indian Ocean had shaken like never before due to a magnitude of 9.0 Earthquake in deepwater offshore Indonesia with a major loss of lives. Reliance learnt from initial studies with NGI that effect of TSUNAMI are more pronounced in the shallow water sections, hence Reliance contracted HR Wallingford to undertake a comprehensive TSUNAMI risk assessment to re-evaluate already carried out Hydrodynamic model study. HR Wallingford developed TSUNAMI impact study with BGS looking at Geology & Tectonics. Current speeds, runoff & water elevations during Tsunami were evolved. Use of recorded water levels at jobsite within Godavari River & 3 locations near river mouth was done to co-relate projected & measured water levels.

Desktop Geohazard study prior to field investigations - As a part Geohazards study, the various Key Observations were made. Reliance / NGI therefore concentrated on analysis of potential trigger force i.e. Design Basis Earthquake & the key seabed soil parameters – Shear and pore pressures with the help of Fugro who carried out 8 boreholes about 125 m deep.

Deepwater Geotechnical Investigations - Fugro carried out Deepwater Geotechnical investigations work between June & August 2005 by drilling 8 boreholes in water depths between 530 m and 900 m with the help of MV Bavenit DP class vessels in 2 modes such as, Seabed Mode and Downhole Drilling Mode. Extensive shear strengths & pore pressure data was obtained from seabed to right down to approx 125m depth with the use of various tools in seabed and downhole mode of drilling. Each borehole meant actually 5-6 different sets of data holes/ equipment drives. Various tests like Pore pressure dissipation tests, Temperature equilibrium tests carried out one the samples collected from these boreholes for Geohazard assessment. Field investigation includes near seabed logging for Geohazards assessment.

Post Field Investigation Conclusions on Geohazards - Slope instability beyond 8° seabed slope is most significant risk as Geohazard. Seismicity is generally low in the area. There are relatively over-consolidated layers on the shelf. There are none or negligible Geohazards within the region up to the shelf edge. The sea floor morphology of the continental slope is characterized by a relatively gentle slope of 2° to 3° intersected by channels. The most striking feature of the deepwater area as a whole are the channel systems. The channels show signs of possible present turbidity current activity. Otherwise, there are no signs of erosional activities. Less than 8° gradients have a sufficient high safety factor even during Earthquake triggered cases. Based on these results of the site response analyses, idealized seabed response spectra were developed for the seismic structural design of the offshore facilities and the location planning of seabed structures was done in order to avoid proximity to steep slopes. Pipeline routing was also done to avoid slopes steeper than 8°.

Key Engineering outcomes and resulting design decisions -

- Safe grade elevations arising out of flooding studies resulting into rising of entire Onshore Terminal site by 5 m. A gigantic task performed by RIL. Geohazard Evaluation allowed Safe / Stable design and installation of manifold, PLEMs & pipelines.
- Areas of Turbidities were avoided based on Geohazard study and pipelines were trenched to deeper depths where these turbidity areas could not be avoided along the route. Based on results of seabed slope stability, pipeline route was planned along alignment less than 8 degree seabed slope.
- The river section pipelines were laid in a trench with Engineered Backfill and rock armor.
- The design Earthquake Ground Acceleration was revised upwards compared to National Code BIS 1893 for KGD6 based on Site Specific Earthquake Study.
- The entire sub-sea architecture comprising of suction anchor foundations, manifolds, PLEMs, sub-sea flow-lines and trunk-lines, CRP Platform and the entire Onshore Terminal installation was executed almost as planned and within the planned program.