12 Geology, Soils and Geomorphology

12.1 Introduction and Methodology

12.1.1 *General*

Information on the physical environment was obtained from the following sources:

- a wide range of published information (Appendix F);
- borehole information;
- conceptual geological model developed by Halcrow (see Figure 12.1 which shows the stratigraphy between Lepe Country Park and West Gurnard); and
- site visits in 2004/2005.

12.2 Baseline Conditions

12.2.1 *Designated Geological Sites*

The following geological/geomorphological designations lie within the study area:

(a) North Solent SSSI; designated partly for the geological exposures at Stone Point (quaternary stratigraphy) and Calshot cliffs. The deposits at Stone Point provide an important and rare datum-point to determine the age of the widespread gravel terraces in the southern New Forest and along the shores of Southampton Water.

The sequence of deposits present at Stone Point (Hampshire) on the foreshore and in the backing cliff comprises: -

- A lower gravel unit occupying a depression cut in tertiary bedrock
- Peat and estuarine clays of Ipswichian Interglacial Zone II Age containing fossil molluscan fauna, pollen and plant macrofossil remains
- An upper gravel unit forming part of a terrace at 7.6m above sea level extensively preserved along the north side of the Solent.

(b) Gurnard Cliff West SINC; partly designated for its parallel slumped cliffs.

(c) Gurnard Geological Conservation Review (GCR) site; this GCR site (No 796) lies at NGR SZ462 943 and was designated for its important palaeo-entomological (fossil record of the insects from the emergence of the group during the Devonian period) characteristics.

12.2.2 *Regional Geological Setting*

The Isle of Wight and adjacent mainland have been subjected to a number of phases of folding. Gentle monoclinal folding took place along NW–SE trending axes during the Lower Oligocene period, based on evidence from the Isle of Wight where the Bembridge Limestone has been observed to rest unconformably on an eroded surface. A later period of folding took place along similar axes and the study area is identified as being located on the northern limb of the Thorness Bay syncline. This has resulted in the regional dip of the strata being towards the south or south-west at one or two degrees. The dip of the strata interpreted from the marine geophysical survey for the outfall at Woodvale, to the north of Gurnard, was consistent with this regional interpretation.

12.2.3 *Stratigraphy*

<u>Solid Geology</u>

Throughout the study area, the strata are of Middle to Late Eocene age. The oldest Formations that are likely to be encountered are present at the Lepe landfall site beneath the drift deposits and also at depth beneath the Solent. These Formations belong to the Barton Group and comprise a thick sequence of predominantly silty fine sands (Becton and Charma Sand Formations) overlying the Barton Clay Formation.

Resting unconformably on the Barton Group are beds belonging to the Solent Group. Within the study area, three Formations within the Solent Group are likely to be encountered in any deep crossing:

- Bouldnor Formation
- Bembridge Limestone
- Headon Hill

The most distinctive unit within the Solent Group is the Bembridge Limestone. At Gurnard Point and Thorness Bay (to the west of Gurnard), it can be observed at outcrop and comprises an upper and lower limestone horizon, both ca. 1m in thickness, separated by ca. 3m of mudstone.

Overlying the Bembridge Limestone is the Bembridge Marls Formation consisting of a thick sequence (>20m) of multi-coloured silty clays and mudstones.

Between the Bembridge Limestone Formation and the older beds of the Barton Group is a thick sequence belonging to the lowest Formation within the Solent Group, the Headon Hill Formation. At Gurnard, six members within the Headon Hill Formation have been tentatively recognised, totalling approximately 90m in thickness. The thickest members, namely the Osborne Marl, Cliff End and Colwell Bay Members each consist of 20 – 30m of multi-coloured stiff over-consolidated clays, marls and mudstones with subordinate sand horizons. On the mainland, the Colwell Bay Member corresponds to the Lyndhurst Member.

Between the Osborne Marl and Cliff End Members is the Lacey's Farm Limestone Member, a thin (<7m) horizon that comprises a sequence of pale green calcareous sandy marls, marly limestones, sandy limestones and calcareous quartz sandstones. At Gurnard, the Lacey's Farm Limestone Member is believed to thin to 1 – 1.5m.

Between the Cliff End and Colwell Bay Members is the Linstone Chine Member, a thin but distinctive unit. The lowest beds usually comprise interbedded pale grey fine sands, silty sands and sandy silts, overlain by grey sands and silty sands. The unit is believed to be between 1.5 and 3.0m thick at Gurnard.

The Totland Bay Member is the lowest member of the Solent Group. On the mainland, it corresponds to the Lower Headon Member. The Totland Bay Member consists of approximately 10m of grey, green or brown silts and sands with subordinate limestones, marls, lignitic muds and ironstones.

Drift Deposits

At Lepe, the drift deposits are of glacial origin; outcrops of Upper Gravel, predominantly sandy flint gravel, are exposed in the low cliffs along the foreshore and at the rear of the lower car park. In the intertidal zone, a deposit of estuarine mud and peat has been identified as an interglacial deposit, resting on a Lower Gravel deposit. The thickness of the underlying Lower Gravel deposit is not known.

Beneath the Solent, and on the basis of rather limited data, it appears that the seabed is characterised by a rather thin cover of unconsolidated granular sediments (sands, gravels and shells), which rarely exceeds 2m in thickness.

Recent drift deposits encountered at Gurnard comprise beach gravels underlain by alluvial deposits forming Gurnard Marsh and, possibly extending to the adjacent shoreline.

12.2.4 *Geomorphology and Coastal Processes*

The West Solent represents a submerged and enlarged segment of a previous Pleistocene river system and has been strongly influenced by Holocene sea-level transgression, which caused submergence, widening, and deposition of sediments by the relatively rapid tidal currents and wave action.

Main channel sediments within the Solent are very mobile and therefore only coarse materials are stable on the bed for any length of time. There is a complex pattern of tidal currents within the West Solent however generally tidal currents transport sediment offshore from Stone Point and Gurnard into the central section of the channel, where it meets tidal currents transporting material in an easterly direction towards the mouth of Cowes harbour and Brambles Bank in the east. The proposed twin pipeline crosses surface currents up to 5 knots (2.5m/s).

Littoral drift on both the Hampshire and Isle of Wight (between Newtown Harbour and West Cowes) transports material in an easterly direction along the coastline within the study area.

The Hampshire coastline within the study area has a small tidal range (see Table 12.1) although there are high water movements due to the variation in range between the spits of Hurst and Calshot (from slower currents in the lee of the two spits, to the more rapid currents in between them). The proposed twin pipeline crossing involves water depths to -22mOD and maximum wave heights in the order of 2 to 3m.

The predicted tide levels for Stansmore Point (Lepe) and for Cowes in accordance with the Admiralty tables and relative to chart datum are shown in Table 12.1 (Ordnance Datum is 2.44m and 2.59m above chart datum for Lepe and Cowes respectively).

Table 12.1 *Predicted tide levels at Lepe and Cowes*

Tide	Lepe	Cowes
Lowest astronomical tide (LAT)	0.0m	0.1m
Mean low water springs (MLWS)	0.7m	0.8m
Mean low water neaps (MLWN)	1.6m	1.8m
Mean high water neaps (MHWN)	3.3m	3.5m
Mean high water springs (MHWS)	3.9m	4.2m
Highest astronomical tide (HAT)	4.3m	4.6m

12.2.5 *Coastal Erosion*

Active erosion has occurred along some stretches of the coastline at Lepe, which has formed a distinctive series of retreating cliffs up to 6m high cut into Tertiary sands capped by Pleistocene river terrace gravels (www.SCOPAC.org.uk). Cliff erosion has resulted in a limited line of retreat in front of the Cadland Estate. It is considered that the interruption of longshore drift further west may be removing beach material and accelerating the rate of erosion (Hampshire County Council 2005). Historical maps (Appendix G) show the retreat of the shoreline over the past 140 years within the study area on the Hampshire side.

The eroding cliffs formerly extended further eastward to Stone Point, but a series of timber and rock revetments in combination with groynes have protected the toes so that the cliffs are now inactive and vegetated (Hampshore County Council, 2003). Map comparisons covering the period 1868 to 1977 revealed recession of the High Water Mark at a rate of 0.22-29ma^{-1} (Hooke and Riley, 1987; Posford Duvivier, 1997; Lock, 1999 as cited in www.scopac.org.uk). Posford Duvivier (1994) propose a higher figure of 0.4ma^{-1}, sustained since the early 1890s. Current erosion yield is calculated at 2,000m^{3} a^{-1}, one half of which is coarse (gravel) sediment. Shoreface erosion, at a calculated rate of 0.2mma^{-1} over an area some 800m in width, may yield approximately 1800-2500m^{3}a^{-1} (Posford Duvivier, 1999).

Between Stansore Point and Stone Point at Lepe Country Park, the coastline is dominated by low-lying land (and associated sandy cliffs) and pebble beaches. Although the cliffs extend to no more than 7m above OD, historical cliff toe recession and sub-aerial mass movement has produced a locally important sediment supply to beaches due to their dominant gravel composition. These cliffs are not inactive and partially vegetated due to the effects of coast protection at Stone Point and the accretion of a wide protective gravel beach along the southern half of Stanswood Bay. Hooke and Riley (1987) calculated that 17m of net accretion of the foreshore between Stone and Stansore Point occurred between 1865 and 1985 thus isolating cliffs from marine erosion.

Map comparisons for Stone Point to Bourne Gap covering the period 1868-1994 reveal cliffline retreat of between 0.20 and 0.27ma^{-1} (Halcrow, 1998) although cliff recession would have ceased well before 1994. Cliffs 7m high over a frontage of 1km retreating at this latter rate would have yielded a maximum of 1900 m^3a^{-1} of sediment. Of this approximately only 50% would be sufficiently coarse to remain on the beach, so maximum supply of less than 1,000 m^3a^{-1} would have been likely prior to their protection. The shallow shoreface, which narrows to a little over 400m, may yield approximately 800m^3a^{-1} of suspended sediment as a result of wave and tidal current abrasion (Posford Duvivier, 1999).

At Gurnard, a combination of relatively non-resistant rock material and exposure to waves and currents has resulted in an eroded coastline. Posford Duvivier (1997) cited in www.scopac.org.uk estimated that the eroding cliffs and platforms between Sconce Point and Gurnard Bay currently yield 150-200,00 m^3a^{-1} of fine sediment, very little of which is available to littoral transport, but which may provide (or provided) a source of supply to estuarine mudflats and saltmarshes in the Western Solent. By contrast, the annual yield of coarse sediment is considered to be less than 500m^3. Some basal protection afforded by Bembridge Limestone ledges at Gurnard Ledge, and to the east, results in some increased cliff stability and slower retreat rates slower to the northeast of the Ledge compared to the cliffs to the south. Historical map comparisons by Halcrow (1997) indicate long-term (1909-1995) mean cliff top recession of 0.48ma^{-1} for the cliffs to the south of the Ledge and 0.18ma^{-1} for those to the northeast (www.scopac.org.uk).

12.2.6 *Turbidity/Suspended sediment*

Background measurements of turbidity levels recorded within the study area are described in section 7.2.5 'Water'.

12.2.7 *Waste*

It is estimated that approximately 600m^3 of soil arisings (predominantly clay, silt and sand) from the directional drilling operations will require disposal on the mainland and 1250m^3 of waste on the island (more on the island due to a larger bore diameter for a sleeve).

All waste (including construction waste and other materials e.g. from temporary site compounds) generated by the proposed scheme will be inert and will be disposed of at a suitably licensed tip. The licensed tip will be identified at a later stage in the scheme's development.

It will not be possible to recover the material for beneficial use. The waste arisings from the directional drilling will be silty sandy clay, which after passing through the soil separation plant will be in solid form but still with a high moisture content and plastic nature that has very little potential for re-use.

Traffic impacts associated with the disposal of waste are discussed in section 16 'Traffic and Transport'.

12.3 Impact Assessment and Mitigation

12.3.1 *Construction Impacts: New Forest*

I.1. The proposed pipeline will drill at a depth of more than 10m beneath the North Solent SSSI and would therefore have **no significant impact** on this nationally designated geological site or on the existing cliff erosion that is experienced along the coastline.

12.3.2 *Construction Impacts: Isle of Wight*

I.2. The proposed pipeline will drill at a depth of more than 10m beneath the Gurnard Cliff West SINC and would have **no significant impact** on this locally designated geological site or on the existing cliff erosion that is experienced along the coastline.

I.3. The proposed pipeline at Gurnard will be drilled beneath a derelict farm building at an approximate depth of 15m. The cover over the pipeline here consists of stiff over consolidated silty clays and Bembridge Limestone. Accordingly, there will be **no significant settlement issues** associated with the pipeline installation.

12.3.3 *Construction Impacts: Marine*

I.4. Turbidity impacts associated with the proposed jetting activities are discussed in section 7.3.3 'Water'.

12.3.4 *Operational Impacts*

I.5. The scheme will have no permanent impacts on geological features upon completion.