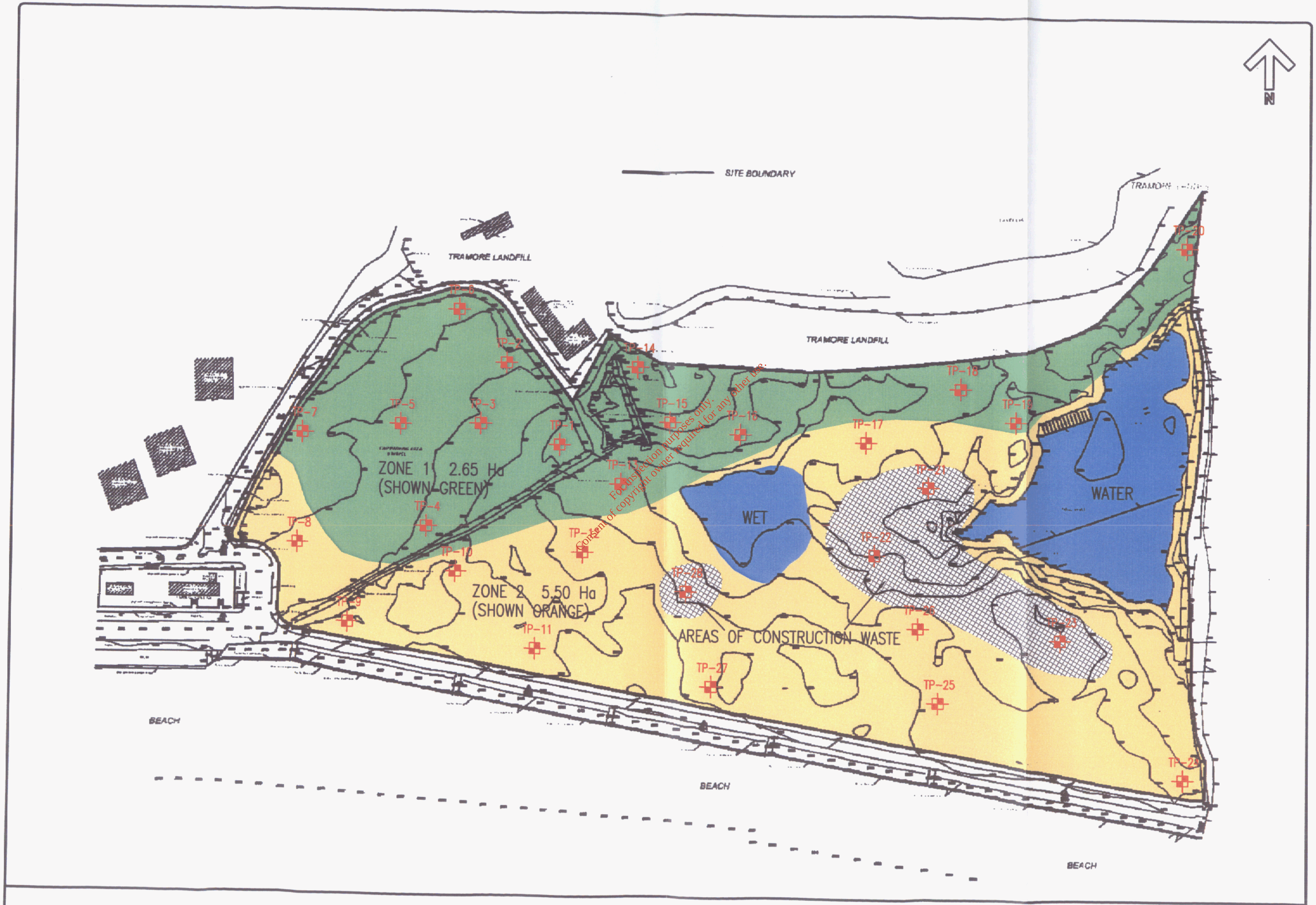


FIG. 3.2 – CONCENTRATIONS OF WASTE MATERIAL N.T.S.

ENVIRONMENTAL REPORT
TRAMORE LEISURE PARK
JOB NR. A9361
DRG NR. A9361-FG03

Table 3.5 Groundwater Level Details

| | BH-1 | BH-2 | BH-3 | BH-4 | BH-5 |
|---|---|---|---|---|---|
| Water Level (mbtc) | 1.43 | 2.02 | 1.29 | 1.85 | 2.58 |
| Total Depth (mbtc) | 5.97 | 6.10 | 5.60 | 6.11 | 6.23 |

| | | | | | |
|---|---|---|---|---|---|
| Description | Slightly murky grey/brown, s/s, slight odour | Murky brown, s/s, no apparent odour | Dark grey, s/s, strong odour | Murky grey, s/s, slight odour | Murky brown, s/s, no apparent odour |

| | BH-1 | BH-2 | BH-3 | BH-4 | BH-5 |
|---|---|---|---|---|---|
| Water Level (mbtc) | 1.43 | 2.02 | 1.29 | 1.85 | 2.58 |
| Cover Level (mOD) | 3.73 | 3.95 | 3.56 | 3.38 | 3.72 |
| Ground Level (mOD) | 3.01 | 3.29 | 2.89 | 2.71 | 3.05 |
| Cover height (aGL) | 0.72 | 0.66 | 0.67 | 0.67 | 0.67 |
| Water Level (mOD) | 2.30 | 1.93 | 2.27 | 1.53 | 1.14 |

**Table 3.6 Laboratory Results**
**Sample Type: Ground Water**

| Sample Identity | BH-1 | BH-2 | BH-3 | BH-4 | BH-5 | Dutch (D) List | Dutch (I) List | EU DW Standard* |
|---|---|---|---|---|---|---|---|---|
| Units | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| Dissolved Antimony | <0.001 | 0.004 | <0.001 | <0.001 | <0.001 | 0.00015 | 0.2 | 0.01 |
| Dissolved Arsenic | 0.005 | 0.007 | 0.002 | 0.006 | 0.008 | 0.0072 | 0.06 | 0.05 |
| Dissolved Barium | 0.912 | 0.02 | 0.337 | 0.151 | 0.013 | 0.2 | 0.625 | 0.5 |
| Dissolved Beryllium | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.00005 | 0.015 | NE |
| Dissolved Boron | 1.43 | 0.424 | 0.467 | 1.114 | 0.38 | NE | NE | 2.0 |
| Dissolved Cadmium | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.00006 | 0.006 | 0.0 |
| Dissolved Calcium | 90.74 | 73.06 | 193.1 | 85.71 | 230.6 | NE | NE | 200 |
| Dissolved Chromium | 0.02 | 0.008 | 0.017 | 0.024 | 0.013 | 0.0025 | 0.03 | 0.05 |
| Dissolved Cobalt | <0.001 | 0.001 | 0.003 | 0.002 | <0.001 | 0.0007 | 0.1 | NE |
| Dissolved Copper | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | NE | NE | 0.5 |
| Dissolved Iron | <0.002 | <0.002 | <0.002 | <0.002 | 0.012 | NE | NE | 0.2 |
| Dissolved Lead | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | NE | NE | 0.05 |
| Dissolved Magnesium | 91.61 | 36.46 | 47.41 | 93.95 | 56.04 | NE | NE | 50 |
| Dissolved Manganese | 0.671 | 0.364 | 2.74 | 0.946 | 0.348 | NE | NE | 0.05 |
| Dissolved Mercury | <0.00005 | <0.00005 | <0.00005 | <0.00005 | <0.00005 | 0.00001 | 0.0003 | 0.0001 |
| Dissolved Molybdenum | 0.04 | 0.012 | 0.005 | 0.014 | 0.007 | NE | NE | NE |
| Dissolved Nickel | 0.005 | 0.004 | 0.006 | 0.008 | 0.006 | 0.0021 | 0.075 | 0.05 |
| Dissolved Phosphorous | 0.015 | 0.116 | 0.071 | 0.146 | 0.013 | NE | NE | 5 |
| Dissolved Selenium | 0.002 | 0.003 | 0.002 | 0.01 | 0.003 | 0.00007 | 0.16 | 0.01 |
| Dissolved Silicon | 4.55 | 6.16 | 5.52 | 5.08 | 3.11 | NE | NE | NE |
| Dissolved Silver | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | NE | 0.04 | NE |
| Dissolved Tellurium | 0.001 | <0.001 | <0.001 | 0.003 | <0.001 | NE | 0.07 | NE |
| Dissolved Thallium | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.007 | NE |
| Dissolved Tin | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.0022 | 0.05 | NE |
| Dissolved Titanium | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | NE | NE | NE |
| Dissolved Uranium | <0.001 | 0.002 | <0.001 | <0.001 | 0.002 | NE | NE | NE |
| Dissolved Vanadium | 0.005 | 0.005 | 0.006 | 0.008 | 0.006 | 0.0012 | 0.07 | NE |
| Dissolved Zinc | 0.035 | 0.015 | 0.019 | 0.017 | 0.019 | 0.024 | 0.8 | 1 |

**Table 3.7 Laboratory Results**
**Sample Type: Ground Water**

| Sample Identity | BH-1 | BH-2 | BH-3 | BH-4 | BH-5 | Dutch (D) List | Dutch (I) List | EU DW Standard* |
|---|---|---|---|---|---|---|---|---|
| Units | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| Potassium | 88 | 22 | 33 | 71 | 21 | NE | NE | 12 |
| Sodium | 280 | 250 | 150 | 540 | 195 | NE | NE | NE |
| Chloride | 475 | 433 | 278 | 766 | 404 | 100 | NE | 250 |
| Fluoride | 0.3 | 0.3 | 0.3 | 0.6 | 0.3 | 0.5 | NE | 1 |
| Nitrite | <0.05 | 0.48 | <0.05 | <0.05 | <0.05 | NE | NE | 0.1 |
| TON | 1.1 | 3.1 | <0.3 | <0.3 | <0.3 | NE | NE | NE |
| ortho Phosphate | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | NE | NE | NE |
| Sulphate | 10 | 15 | 79 | 4 | 243 | NE | NE | 250 |
| Ammonical Nitrogen | 56.1 | 3.4 | 18.3 | 40.6 | 0.6 | NE | NE | 0.23 |
| Free Cyanide | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.005 | 1.5 | NE |
| Total Cyanide | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | NE | NE | 0.05 |
| Total Alkalinity | 870 | 340 | 660 | 910 | 440 | NE | NE | 30 |
| TPT | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | NE | NE | NE |
| TBT | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | NE | NE | NE |
| DBT | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | NE | NE | NE |
| Mineral Oil | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.05 | 0.6 | 0.01 |
| Total Coliforms (cfu/100ml) | 3300 | >30000 | 3600 | 13700 | 4800 | NE | NE | 20 |
| E.Coli (cfu/100ml) | 2500 | 1700 | >30000 | 2900 | 800 | NE | NE | 0 |
| Total Solids | 1355 | 973 | 1043 | 2317 | 1471 | NE | NE | NE |
| Total Phenols | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.2 | 2000 | NE |
| TOC | 16 | 10 | 11 | 28 | 10 | NE | NE | No Abnormal Change |
| Conductivity (mS/cm) | 2.881 | 1.831 | 2.003 | 3.753 | 2.312 | NE | NE | 2.5 |
| DO | 2.6 | 4.3 | 3.6 | 3.4 | 4.5 | NE | NE | NE |
| pH | 7.64 | 7.81 | 7.16 | 7.8 | 7.43 | NE | NE | NE |

* EU Drinking Water Standards 2000
**Refer to Value for Mineral Oil
NE denotes Not Established

### *3.5.1 Introduction to Landfill Gas*

Landfill gas is produced during the breakdown of waste within a landfill. It is a by-product of the digestion, by bacteria, of the organic component of the waste. It comprises a mixture of different gases; methane and carbon dioxide (in the ratio of 3:2) are the main components, with small concentrations of a wide variety of compounds. The number and ratio of gases at any one time depends on the breakdown process which occurs in stages and which is subject to controlling factors. These factors include: -

- Type and input rate of waste deposited;
- Waste age;
- Moisture content, pH, temperature and density of wastes; and
- Application of cover, compaction and capping.

Landfill gas generation typically occurs in a number of stages. When the biodegradable waste is placed in the landfill it contains oxygen. The time frame of the stages varies depending on type and rate of waste inputs and landfill design. Typically, the aerobic stage lasts less than one month to be replaced by the hydrolytic stage, which can last up to 4 months. The acetogenic stage can be reached within 12 months following the commencement of waste filling. The methanogenic stage can be reached within two years of the placement of the waste and can continue for up to twenty years following which declining levels of methane may continue to be generated for another 30 years. At any one time a landfill is, based on the age of the waste, likely to present more than one of these stages of gas production.

Methane is flammable in air in the range of 5 to 15% by volume. A confined mixture of methane and air in this range will explode if ignited. Carbon dioxide is a non-flammable toxic gas. The long-term human exposure level for carbon dioxide is 0.5% by volume.

Biologically stabilised means the landfill is at the end of Stage IV (methanogenic) of the biodegradation process and is no longer a source of landfill gas.



If an investigation establishes that methane levels are greater than 1% and carbon dioxide levels are greater than 0.5% the Guidelines stipulate that specialised solutions are required to develop the site. The scope of such solutions will be based on the scale of landfill gas generation and the proposed end use but may include: -

- Provision of gas barriers; and
- Provision of active and passive abstraction systems.

In addition to risks presented to on-site development landfill gas can also present a risk to off-site properties, via migration.

The United Kingdom Department of The Environment Waste Management Paper 27, 2000, concludes that carbon dioxide can stem from a variety of sources, including microbial activity associated with the roots of vegetation, which can result in up to 7% of carbon dioxide at shallow levels (2 metres). Ground conditions reported in the borehole and trial pit logs identified some naturally occurring organic material (roots), hence it is possible that the carbon dioxide concentrations detected could be partially due to naturally occurring causes as well as residual landfill gas.

perhaps, the presence of other more dangerous pathogens. Exposure to such pathogens (by contact or ingestion) may cause illness (for example, gastroenteritis or hepatitis). Total coliforms ranged from 3,300 cfu/100ml in BH-1 to greater than 30,000 cfu/100ml in BH-2. E.Coli levels ranged from 800 cfu/100ml in BH-5 to greater than 30,000 cfu/100ml in BH-3. It should be noted that BH-2 and BH-5 are located directly adjacent to the new sewer pipe.

Pesticide (organochlorine and organophosphorus) levels were all below the method detection limit of 0.01 µg/l in the 5 groundwater monitoring wells.

Nitrogen Compounds

Reduced forms of nitrogen include total ammonia, un-ionised ammonia ($NH_3$) and organic nitrogen. Ammonia, an inorganic form of nitrogen, is an oxygen consumer and an indicator of water health. Organic nitrogen hydrolyses to ammonia. Un-ionised ammonia is toxic to various aquatic species and is regulated. The sum of ammonia plus organic nitrogen is another indicator, Total Kjeldahl Nitrogen (TKN). Major sources of TKN include wastewater discharges and rotting plants.

Oxidised nitrogen species include nitrate ($NO_3$) and nitrite ($NO_2$). Nitrate and ammonia are common forms of dissolved inorganic nitrogen (DIN). Nitrite oxidises rapidly to nitrate. Also, ammonia is oxidised to nitrate. Sources of ammonia include sewage treatment plants, animal waste and decaying organic matter.

Nitrite was detected in one of the monitoring wells above the method detection limit of 0.05mg/l (BH-2 at 0.48mg/l). There are no Dutch limits specified for nitrite.

TON was detected in BH-1 at 1.1mg/l and BH-2 at 3.1mg/l and was below method detection limits of 0.3mg/l in BH-3 to BH-5.

Ammoniacal Nitrogen levels ranged from 0.6mg/l in BH-5 to 56.1mg/l in BH-1. There are no Dutch limits specified for ammoniacal nitrogen. Although there are no comparable limits, many of the samples are elevated above what would be expected for uncontaminated water.



Mineral Oil

All of the five monitoring well samples were below the method detection limit (MDL) of 10 µg/l and also below the Dutch (D) limit of 50 µg/l / Dutch (I) limit of 600 µg/l.

Volatiles

Volatile organic compounds (VOC) and semi-volatile organic compounds (sVOC) were below method detection limits of 1 µg/l and the Dutch (D) limits in all five of the monitoring wells. 2,6- Bis (Tert-butyl)-Phenol was reported on the sVOC tentatively identified compounds (TIC) list at concentrations of 3 µg/l in BH-4 and BH-5 and 8 µg/l in BH-1. There is no comparative limit (Dutch List) for this parameter.

### 3.4 Site Investigation (Landfill Gas)

Based on the observations during the trial pit survey it appeared that the waste contains biodegradable material (such as putrescible material, woody material, paper and cardboard) with the potential to generate landfill gas. Landfill gas monitoring was carried out during the excavation of the trial pits and on the five gas wells (refer to Figure 2.3). The groundwater monitoring wells are also suitable for landfill gas monitoring and monitoring was carried out in these wells following installation.

and as a deworming agent in poultry. It is also a metabolite (breakdown product) of TBT. Both TBT and DBT were below the method detection limits of 0.05mg/l and 0.02mg/l respectively.

Total Organic Carbon (TOC) is an important water quality indicator. Carbon affects biogeochemical processes, nutrient cycling, bioavailability, chemical transport and interactions. TOC is a measurement of the carbon dioxide released by chemical oxidation of the organic carbon in a sample. Levels ranged from 10mg/l in BH-2 and BH-5 to 28mg/l in BH-4.

Dissolved oxygen (DO) analysis measures the amount of gaseous oxygen ($O_2$) dissolved in an aqueous solution. Levels range from 2.6mg/l in BH-1 to 4.5mg/l in BH-5.

An important indicator of water quality is the amount of solids in the water column - both dissolved (filterable) solids and undissolved (suspended) solids. TDS is the term used to describe the inorganic salts and small amounts of organic matter present in a water sample. The principal constituents are usually cations of calcium, magnesium, sodium, and potassium, and anions of carbonate, hydrogencarbonate, chloride, sulphate, and nitrate anions. The common method of determining TDS is to measure conductivity with a probe that detects the presence of ions in water. Total solids range from 973mg/l in BH-2 (south westerly portion of the site) to 2,317mg/l in BH-4 (northern margin of the site, adjacent to the existing landfill).

Conductivity is measured as millisiemens per meter (mS/cm) and is a measure of the ability of an aqueous solution to carry an electrical current. Conductivity is a measurement used to determine a number of applications related to water quality. These include determining mineralisation (this is commonly called total dissolved solids - used to determine the overall ionic effect in a water source) and noting variation or changes in natural water and wastewaters. Conductivity levels were lowest in BH-2 at 1.831 mS/cm (south westerly portion of the site, furthest location hydraulic down gradient of the landfill) and highest in BH-4 at 3.753 mS/cm (northern margin of the site, adjacent to the existing landfill).



Sulphate levels range from 4mg/l in BH-4 to 243mg/l in BH-5. Sulphate ($SO_4$) is a divalent anion that occurs naturally in water as a result of the weathering of rocks but can also have anthropogenic sources. Although sulphate is a natural and necessary constituent for humans, sulphate salts may cause adverse health effects (such as diarrhœa). Also, sulphate has been linked to animal toxicity.

Ortho-Phosphate was below the method detection limit of 0.03mg/l in all five of the monitoring wells. Orthophosphate is water soluble. Sources include runoff, soil weathering, sewage discharge and atmospheric deposition.

pH units ranged from 7.16 to 7.81 across the site. Typically soil pH would fall within the region of 5 - 9 pH units.

Total phenols were not detected above the MDL of 0.01mg/l in any of the five groundwater monitoring wells.

Free cyanide and total cyanide were not detected in any of the monitoring wells (i.e. levels were below method detection limit of 0.05mg/l).

Total and fæcal coliforms measure sanitary quality in terms of bacterial counts within a given sample volume. High fæcal coliform levels indicate the presence of faeces in a waterway and,

**Metals**

Beryllium, cadmium, lead, mercury, silver, thallium, tin and titanium were not detected in any of the five groundwater samples (i.e. samples were below the method detection limit (MDL)). Boron, calcium, copper, iron, magnesium, manganese, molybdenum, nickel, phosphorus, silicon, tellurium and uranium were either below Dutch (D) limits or no limits have been established for these parameters.

Antimony was detected in BH-2 at 0.004mg/l above the Dutch (D) limit of 0.00015mg/l but well below the Dutch (I) limit of 0.2mg/l. Arsenic was detected in BH-5 at 0.008mg/l marginally above the Dutch (D) limit of 0.0072mg/l. Barium was detected in BH-3 at 0.337mg/l above the Dutch (D) limit of 0.2mg/l and in BH-1 at 0.912mg/l above the Dutch (I) limit of 0.625mg/l.

Chromium was detected in BH-1 to BH-5 at levels ranging from 0.008mg/l to 0.024mg/l above the Dutch (D) limit of 0.0025mg/l but below the Dutch (I) limit of 0.03mg/l. Cobalt was detected in BH-2 to BH-4 at levels ranging from 0.001mg/l to 0.003mg/l above the Dutch (D) limit of 0.0007mg/l but below the Dutch (I) limit of 0.1mg/l.

Selenium was detected in BH-1 to BH-5 at levels ranging from 0.002mg/l to 0.01mg/l above the Dutch (D) limit of 0.00007mg/l but below the Dutch (I) limit of 0.16mg/l. Vanadium was detected in BH-1 to BH-5 at levels ranging from 0.005mg/l to 0.008mg/l above the Dutch (D) limit of 0.0012mg/l but below the Dutch (I) limit of 0.07mg/l. Zinc was detected in BH-1 at 0.035mg/l (above the Dutch (D) limit of 0.024mg/l but well below the Dutch (I) limit of 0.8mg/l).

**General Parameters**

Potassium was detected in all five monitoring wells at levels ranging from 21mg/l (BH-5) to 88mg/l (BH-1). Sodium levels ranged from 150mg/l (BH-3) to 540mg/l (BH-4). There are no Dutch list limits for potassium or sodium.

Chloride levels ranged from 278mg/l in BH-3 to 766mg/l in BH-4. This is consistent with elevated sodium levels which would be expected in coastal regions. Fluoride was detected in all five of the monitoring wells, ranging from 0.3mg/l in BH-1,2,3 and 5 and 0.8mg/l in BH-4). Dutch (D) limits are available for chloride and fluoride (100mg/l and 0.5mg/l respectively). The Dutch (D) limit for chloride is exceeded in all of the wells.

Alkalinity ranges from 340mg/l in BH-2 (south westerly portion of the site) to 910mg/l in BH-4 (northern margin of the site, adjacent to the existing landfill). The total Alkalinity is a measure of the acid-neutralising (buffering) capacity of a water sample. High alkaline waters essentially absorb excess $H^+$ ions and prevent occurrence of significant pH fluctuations in a water body. Sewage effluent often increases the natural alkalinity of a water body

Triphenyltin (TPT), an organotin which have been used in the past as algicides and molluscicides in antifouling products, is a persistent organic pollutant and is strongly adsorbed to sediment and soil. TPT was not detected above the method detection limit of 0.05mg/l in any of the five groundwater monitoring wells.

TBT is the active ingredient of many products that act as biocides against a broad range of organisms. It is primarily used as an antifoulant paint additive on ship and boat hulls, docks, fishnets, and buoys to discourage the growth of marine organisms such as barnacles, bacteria, tubeworms, mussels and algae. Dibutyltin (DBT) is used as a stabilizer in plastic products,

### *3.4.3 Landfill Gas Results*

Methane

During the monitoring period methane was detected in four of the gas wells (GS-1, GS-3, GS-4 and GS-5) and three of the groundwater monitoring wells (BH-1, BH-3 and BH-4) ranging from 0.1% to 69% by volume. The Department of the Environment (DOE) Guideline limits on the Protection of New Buildings from Landfill Gas (methane 1.0% v/v) was exceeded in four of the ten wells (GS-1, GS-3, GS-4 and GS-5). GS-3 presented the highest concentration of methane ranging from 56% to 69% by volume. From the trial pit investigation, similar waste material (in the area where GS-3 was located) was identified along the boundary with the existing landfill (refer to Figure 2.3 for details), hence taking the precautionary principle it must be assumed that this area has the potential to generate landfill gas volumes with similar methane concentrations. As methane is flammable in air in the range of 5 to 15% by volume, this presents a significant risk to any development.

Carbon Dioxide

Carbon dioxide was detected in all ten of the monitoring wells with the exception of BH-2 and BH-5 for the final monitoring period (19/12/05) and ranged in concentration from to 0.1 to 23% by volume. The Department of the Environment (DOE) Guideline limits on the Protection of New Buildings from Landfill Gas (carbon dioxide 0.5% v/v) was exceeded in nine of the ten wells (i.e. all monitoring wells with the exception of BH-2). GS-3 presented the highest concentration of methane ranging from 13% to 23% by volume. From the TP investigation, similar waste material (in the area where GS-3 was located) was identified along the boundary with the existing landfill (refer to Figure 2.3 for details), hence taking the precautionary principle it must be assumed that this area has the potential to generate landfill gas volumes with similar carbon dioxide concentrations. As prolonged and elevated carbon dioxide concentrations have the potential to cause health problems, this presents a significant risk to any development.



Landfill Gas Production at the Site

The actual gas measurements indicate that the fill is actively generating significant volumes of methane and carbon dioxide. This indicates that the biodegradable material (organic/putrescible fraction of the domestic type waste), which is the source of the landfill gas, is still undergoing bacterial digestion.

Significant volumes of landfill gas were detected in the car park and along the northern margins of the site close to Tramore Landfill. The levels detected were significantly higher than in the central and southern area of the site (with the exception of GS-5). For example in TP-16, where depths of domestic waste extend to below 3.3m bgl and in the vicinity of GS-3 where the highest methane levels were noted (both located at the landfill boundary), significant gas volumes were noted during the excavation of the pit and installation of the gas well. It is likely that landfill gas generation in this area originates from such wastes alleged to have been historically disposed in this area, but could also be attributed to vertical migration from the adjacent landfill.

The highest levels were consistently recorded at GS-3, where the fill is deepest containing dense deposits of domestic waste. The levels appear to be associated with areas where biodegradable materials have been deposited.

Fly-tipped waste is also present primarily along the northern margins of the site. Because these materials are at the surface they do not present a risk in the context of landfill gas.

In the southern portion of the site where the fill is shallow with low percentages of waste material, methane was not detected or was detected at low levels (with the exception of GS-5 where methane concentrations of 9.5% were recorded). Elevated carbon dioxide levels are however present, possibly indicating the migration of gas from the central and northern area or the presence of pockets of biodegradable waste. Here in the southern portion of the site the subsurface comprises mainly construction material overlying natural sandy/silty deposits (refer to trial pit logs in Appendix 4 for details). There were no major sources of material identified during the trial pitting investigation with the potential to generate significant volumes of landfill gas in the southern portion of the site.

The 2004 AER indicated that the leachate has impacted the groundwater with high iron and ammonia levels since 1999 although no toxic effects from same were expected. Leachate volumes for 2000 were reported in the region of 14,600 tonnes per annum. Relatively high levels of landfill gas were recorded within the site. The methane percentages at the landfill ranged up to similar levels encountered within the proposed development site.

# 4. DISCUSSION

## 4.1 Fill Material

A total of 28 no. trial pits were excavated across the fill area during the investigations on the 14th & 15th November 2005. In Pettit's investigation, fill material was encountered in all of the trial pits. The thickness of the fill ranges from 0.4m to an excess of 3.3 m. The minimum thickness of the fill is along the southwestern boundary of the site (TP-9). The deepest pocket of fill is in the northern portion of the site in the vicinity of TP-16. The majority of the trial pits terminated just below groundwater level which ranged from 0.7 m below ground level in TP-21 to 3.0m in TP-23. Groundwater levels were recorded from 1.14mOD (BH-5) in the south eastern portion of the site to 2.30mOD (BH-1) in the northern portion of the site (car park).



The previous analytical results (June 2005) for sediment samples reported elevated lead and PAHs indicating considerable contamination.

The findings of this investigation are consistent with the observations made during the geotechnical assessment carried out in July 2005 by Geotech Specialists Limited. The fill typically comprises a matrix of sandy and silty clays with quantities of miscellaneous and construction waste, including mainly plastics, scrap metal, construction rubble, wood, ceramics, glass, textiles and domestic waste. Significant quantities of household/putrescible type wastes were encountered at the northern margins of the site (adjacent to the existing landfill). With the exception of TP-3 (1.2-1.4m) Pettit did not encounter any discrete layers of oil-contaminated soils, materials, or containers. Pettit did not observe any evidence which would suggest the presence of asbestos material on-site.

The extent of contamination detected in the solid samples was as follows:

- **Car Park Area** (TP-1 to TP-8) – with the exception of PAH and lead in TP-3, all detected parameters were below the intervention levels for contaminated land (i.e. below the *Dutch List* (I) Limit);
- **Landfill Boundary Area** (TP-13 to TP-20) - all detected parameters were below the intervention levels for contaminated land; and
- **Remainder of the Site** (TP-9 to TP-12 and TP-21 to TP-28) – with the exception of copper and lead in TP-10, all detected parameters were below the intervention levels for contaminated land;

## 4.2 Waste Categorisation

Pettit classified the fill based on the materials found and the analytical results in the context of the requirements of The Waste Management Act 1996. The 1996 Act defines hazardous waste as "waste for the time being mentioned in the list prepared pursuant to Article 1 (4) of Council Directive 91/689/EEC of 12th of December 1991, being either: -

- Category 1 waste that has any of the properties specified in part I of the Second Schedule of the Act, or
- Category 2 waste that: -
  - Contains any of the constituents specified in part II of the Second Schedule, and
  - Have any of the properties specified in part III of the said Schedule.

The EPA has issued guidelines on the methods of determining if a particular waste has the properties which render it hazardous. These are included in the EPA's publication titled Waste Catalogue and Hazardous Waste List (EWC and HWL) 2002 and were used by Pettit in the evaluation of the materials.

The fill material does not contain Category 1 waste (which is waste specified in *Part I* of the *Second Schedule*, namely *paragraphs 1* to *18*). The material does include Category 2 waste (which is *Part I* of the *Second Schedule*, namely *paragraphs 19-40)* but does not contain any of the substances specified in the Second Schedule of the Act at the concentrations that would render the material a hazardous waste. Pettit considers, based on the observations made during the trial pit investigation and the laboratory results, that the fill material encountered in the trial pits does not constitute a hazardous waste.

Based on the site observations and the laboratory analyses it appears that the waste deposited at the site comprises a mix of domestic and construction waste as defined in the EWC/HWL. Contaminants can be leached out from the waste material; however analytical results demonstrate that these do not exceed the comparable thresholds. The investigations did not identify the presence of hazardous waste.



## 4.3 Soil and Groundwater Impacts

One mechanism by which waste can cause pollution is the migration of contaminated surface water run-off and leachate. Leachate is formed by water (either infiltrating rainwater, surface water or groundwater) entering the waste and leaching out contaminants. Leachate escaping from the waste can be a major cause of pollution to underlying soils, adjacent watercourses and groundwater. The significance of the pollution depends on the quality of the leachate and the sensitivity of the receiving environment. The quality of the leachate depends on the type, volume and age of the waste.

In sites (such as the northern portion of the study area and the adjacent landfill) that have been historically in-filled with various materials, leachate generation would be expected to occur. Because the fill at the adjacent landfill was unlined there is unrestricted groundwater movement into and out of the area. It is likely that that a significant portion of contaminating material that would have been present in the fill has been leached out as a result of constant throughput of rainfall, groundwater and tidal movement. This would also depend on other variable factors such as length of time the site was infilled, height of ground water, etc.

Domestic waste material and building rubble was discovered during the trial pit investigation. While CEN leachate analysis of the fill indicated that this waste material has the potential to leach contaminants to water, the detected levels are not currently exceed their comparative limits.

# 5. CONCLUSIONS & RECOMMENDATIONS

## 5.1 Conclusions

Based on the findings of the site investigations and laboratory analysis, Pettit considers the fill material can be classified as non-hazardous waste (mainly domestic and mixed construction waste). The main concentrations of the waste material are illustrated on Figure 3.2.

With the exception of lead and PAH, contamination in the fill material was identified as not exceeding the recommended intervention levels across the site. Because these two parameters have been exceeded, there is a requirement to address this issue. Once soil has become contaminated with lead, which is not biodegradable, it remains a long-term source of lead exposure. Many PAH species are known or suspected carcinogens, yet many are also known to be biodegradable by bacteria and fungi indigenous to native and contaminated soils. These compounds are poorly soluble in water and their biodegradation can be limited by the extent to which they become available to the micro-organisms. 15mg of PAH/kg of soil is the cut-off criteria that indicates the level at which all contact with soil should be cut off if the land use of the area is sensitive (Soil Contamination Division, Danish EPA, 2005).



Results for heavy metals, TPH and general parameters are below the threshold limits. However, these results should not detract from the presence of dense volumes of domestic waste primarily along the northern margin of the site and construction/miscellaneous wastes across the remainder site. Evidence of groundwater contamination from the adjacent landfill (elevated levels detected in BH-4, hydraulically up-gradient, at the landfill boundary) and existing waste at the site has been identified (refer to the trial pits and groundwater laboratory analytical results) for a number of parameters (such as barium, ammoniacal nitrogen, total and faecal bacteria, total dissolved solids and alkalinity).

Significant volumes and concentrations of landfill gas (namely methane and carbon dioxide) have been identified across the site, particularly adjacent to the existing landfill. These pose a significant risk to safety and health and also present significant limitations to development design and construction on the site. The extent of gas levels detected at the site indicates that specialist measures are necessary in advance of and as part of the development of the site. At a minimum this will involve the removal to an appropriately licensed facility of materials which are significant sources of landfill gas, specialist barriers for buildings meeting the requirements Department of the Environment Guidelines 'The Protection of New Buildings and Occupants from Landfill Gas' and where removal off-site is not feasible, the use of gas ventilation trenches.

Pettit recommend that technically for any structural development to proceed, the removal off-site of the organic fraction of the fill material should be actioned to eliminate the sources of landfill gas generation on-site. If this type of waste were removed from the site, the risk presented by landfill gas (from the fill material in the study area) would be reduced or even eliminated. By backfilling the Zone 1 area with granular material, and the provision of landfill gas venting at the boundary, the risk for lateral landfill gas migration (any potential gas generated from the adjacent landfill) should be reduced. In addition, the provision of gas barriers should be incorporated into the design of any development on the site, albeit of the final landfill gas levels.

### 5.2 Development Considerations

A number of development options for the site have been addressed in this report. Examples of remediation measures that may be required to allow the development to proceed are discussed below. Pettit will be in a position to formulate a detailed scope of works with associated costs to remediate the site to suitable end use conditions.

The three main options for the development area are as follows:

**Option 1 - Development of Entire Site (Zone 1 and Zone 2)**
**Disposal of waste material in Zone 1 and implementation of remediation measures for Zone 2**

- Removal and disposal to landfill of the waste material in Zone 1
- Granular infill of Zone 1
- Additional gas well installation and monitoring
- Trenching (incl. granular fill) and installation of gas ventilation pipes in areas of elevated methane and/or carbon dioxide
- Segregation and disposal of waste material from trenches in Zone 2
- Monitoring of vents and gas wells to determine if methane and carbon dioxide levels have been reduced to acceptable levels
- Maintain a number of gas wells and vents if deemed necessary following construction.



Recorded and potential landfill gas levels and concentrations in northern portion of the site have flammable/explosive properties. It is recommended that the domestic fill material in this area be removed to an authorised landfill. This is likely to be costly (average costs for disposal are typically in the range of €120-€140 per tonne) and could potentially be a limiting factor to the development. Pettit recommend that areas from which such fill material is removed be back-filled with granular material to maximise venting of residual landfill gas.

Other areas of miscellaneous waste where landfill gas generation is elevated, processing and removal of the problematic material should be undertaken (particularly where elevated lead and other parameters were identified). This may involve the excavation of the fill, removal of the large items using a mechanical grab or shovel and screening to remove the plastic, scrap metal and timber and smaller items. The waste material extracted from the fill should be segregated from the residue and stored pending removal to an off site licensed landfill. Based on Pettit's observations it is considered that the materials are unlikely to be suitable for recovery/recycling.

Waste materials removed from the fill should be disposed at an appropriately licensed landfill and the Resident Engineer is requested to confirm the regulatory position in relation to the need for a permit. In the event that the characteristics of the fill material significantly change to extent that material pose significant risk, it is recommended that the Local Authority is re-notified and the licensing/permit status is reconfirmed.

In areas where removal off-site is not feasible, venting trenches and/or trial pits should be installed across the fill to reduce the levels of landfill gas present at the site. Venting trenches could be installed by excavating 0.5 - 1.0 m wide trenches using a long-reach excavator to prove the base of the deposits. The trenches should be back filled with hardcore gravel larger than 20 mm. The larger the grain size the higher degree of venting can be achieved.

The trenches should be installed primarily across the areas of concern in Zone 2 outlined on Figure 3.2 with some trenching along the areas where slight elevations of landfill gas were detected. The trenches should be installed at approximately 10 metre centres. Several trenches should be installed at right angles to the main orientation to maximise venting capability. Slotted vertical PVC riser pipes (minimum area 25% to allow for residual gas entry from the trench) should be installed along each trench at 10 metres centres. The frequency of riser pipe installation can be altered depending on field conditions but the pipes should be installed to the base of the fill i.e. at the natural alluvial deposits. It is possible that these trenches would be left in place during foundation development. The Consulting Engineer should therefore assess the potential impact such trenches could have on the foundation design.

Once the methane levels have been reduced to acceptable levels and in order to address any residual risk associated with carbon dioxide a gas membrane should employed. Pettit recommend that as a factor of safety a gas membrane should be incorporated in the foundations of the buildings to be placed on the development site. This membrane can also function as a radon barrier. The design for the gas membrane should be in keeping with the specification in the Department of the Environment Guidelines 'The Protection of New Buildings and Occupants from Landfill Gas'.

*Disposal Costs*
Waste disposal costs alone are estimated at €10million. This does not include costs that would be expected for example haulage, specialist contractors, granular backfill, disposal of fly tipped material, landfill gas venting, gas barriers etc.



**Option 2 – Development of Zone 2 Only**
**Implementation of remediation measures for Zone 2 (same as that for Option 1)**

- Construction of a ventilation trench between Zone 1 and Zone 2 to reduce any potential lateral migration of landfill gas
- Should Zone 1 remain in Tramore Leisure Parks ownership, the hot spot in the vicinity of TP-3 (elevated lead and PAHs) should be excavated and removed to a suitably licensed landfill. This should be conducted under the supervision of a suitably qualified engineer/environmental scientist.
- Additional gas well installation and monitoring across Zone 2
- Trenching (incl. granular fill) and installation of gas ventilation pipes in areas of elevated methane and/or carbon dioxide
- Segregation and disposal of waste material from trenches in Zone 2
- Monitoring of vents and gas wells to determine if methane and carbon dioxide levels have been reduced to acceptable levels
- Maintain a number of gas wells and vents if deemed necessary following construction.

With significant levels of landfill gas generation in the domestic waste material and the proximity of the site to the Tramore Landfill, the possibility exists for lateral migration of this gas in the direction of Zone 2. Construction of a ventilation trench between these two areas would help reduce the risk of any migration between the zones.

Once the methane levels have been reduced to acceptable levels and in order to address any residual risk associated with carbon dioxide a gas membrane should employed. Pettit recommend that as a factor of safety a gas membrane should be incorporated in the foundations of the buildings to be placed on the development site. This membrane can also function as a radon barrier. The design for the gas membrane should be in keeping with the specification in the Department of the Environment Guidelines "The Protection of New Buildings and Occupants from Landfill Gas'.

*Disposal Costs*

Waste disposal costs are estimated at €0.6million. This does not include costs that would be expected for example haulage, specialist contractors, granular backfill (including disposal of the material from the Zone1/Zone2 boundary trench), disposal of fly tipped material, landfill gas venting, gas barriers etc.

**Option 3 – No Development**

**Alternative usage**

If neither of the preceding options are considered feasible, it may be necessary to devise alternative uses for the 30 acre site. This could include for example capping the site and conversion to a recreation park.



### 5.3 Recommendations

Tramore Leisure Park will need to determine the feasibility of all options and make a decision on how to proceed (taking into consideration the economic and time constraints associated with each). Should Option 1 be selected it would be prudent to note that the cost of remediation could place severe limitations on the development (i.e. cost of disposal per tonne, haulage, specialist contractors, timeframes and continuous monitoring).

1. It is recommended that prior to developing the planning strategy, Pettit are consulted regarding:
   - the options for development; and
   - the decision to consult with and present the findings of this report to the Local Authority.

   On becoming aware of a pollution problem the individual responsible (i.e. the owner of the site) must notify the appropriate Local Authority without delay (Section 14 of Local Government (Water Pollution) Act 1977). As the material identified during this investigation poses a risk to groundwater, it will be necessary to present the findings of this report to the Local Authority.

2. From the documents received and the verbal advice from the client, the position of the boundary on the ground may not be reflective of the legal boundary. In view of the fact that significant liability is attached to the presence of waste on site, we recommend legal advice is obtained regarding the boundary position. A request could also be made to the Local Authority for a copy of the drawings for the Tramore Landfill so that the boundary line between this and the study area can be compared.

3. Should a decision be taken to proceed with the development, Pettit recommend that all fly tipped municipal type waste at the surface of the site be removed from site and disposed to landfill. As cursory examination of the site, it has been estimated that this may involve up to 40 tonnes of material.

4. Pettit recommend that Tramore Leisure Park continue to monitor the gas wells across the site to sample for the presence of methane and carbon dioxide prior to submission of any planning application.

5. It is also recommended that additional gas monitoring wells are installed particularly in areas where waste removal or remedial measures have not been proposed, to confirm the need, if any, for further ventilation/remedial measures.

6. Pettit recommend that further gas monitoring be undertaken on a weekly basis for a minimum of two months. The two-month time span would allow an evaluation of potential gas generation at a greater number of sampling points, during a range of atmospheric pressure conditions and would confirm that significant volumes of landfill gas is consistently being generated beneath the site. There is also the possibility that there may be trapped gas beneath the surface at locations which are not actively generating methane or carbon dioxide. Monitoring over the two month period would facilitate this distinction.

7. In the event that the levels are below 1.0 % methane and 0.5 % carbon dioxide (meeting the requirements of the department of the Environment Guidelines), it should be possible to proceed with the commercial/residential development (assuming the lead and PAH contaminated areas, along with the dense domestic fill areas have been suitably addressed). However if they exceed these levels, the site will require specialised solutions such as those mentioned above to meet the requirements of the guidelines.



8. Pettit also recommend additional groundwater sampling is carried out at the borehole locations to monitor the water quality, at the hydraulically up-gradient (BH-1 and BH-4), middle (BH-2 and BH-3) and down-gradient (BH-5) wells. This will confirm the extent of ongoing pollution from up-gradient sources and also facilitate identifying the contribution of the study area to contamination of the groundwater.

9. Pettit recommend that where possible gas probes and boreholes be retained for monitoring purposes to assess the effectiveness of any remedial measures until the gas levels have been reduced to acceptable levels.

### *3.4.2 Landfill Gas Well Installation and Monitoring*

The well pipe was slotted from the base to 0.5 m below the surface. A gravel pack was placed around the well pipe and a bentonite seal was placed above the pack.

A gas tight seal with a sampling port was fitted on the top of the well pipe. A concrete seal was placed around the probes and borings at the ground surface to prevent escape of gases to atmosphere along the annular space between the probe and the boring into which it was installed.

The wells were left to allow stabilisation of subsurface conditions to ensure representative measurements were obtained. Gas monitoring was undertaken using a Landfill Monitoring System G-3 gas analyser for methane, carbon dioxide, oxygen and barometric pressure.

Monitoring was undertaken on four occasions (29/11/05, 09/12/05, 13/12/05 and 19/12/05) during the initial investigation programme and the data is presented in Table 4.1 to Table 4.4 below. The data is compared to the Department of the Environment (DOE) Guideline limits on the Protection of New Buildings from Landfill Gas. The guidelines stipulate that where carbon dioxide or methane is present at a site at 0.5% v/v and 1% v/v respectively specialist measures are required in the construction of buildings.

Guidelines published by the Department of the Environment "Protection of New Buildings and Occupants from Landfill Gas" 1994, contains guidance in relation to development on sites impacted by landfill gas. The guidance recommends that when assessing a site for development purposes the following should be seriously considered: -

> *'until a landfill site is biologically stabilised the site use should be restricted to agriculture, or where proper landfill gas and leachate control measures are in place, to open public space'.*

**Table 4.1 Gas monitoring on 29/11/05**

| | Atmospheric Reading | GS-1 | BH-1 | GS-2 | BH-2 | GS-3 | BH-3 | GS-4 | BH-4 | GS-5 | BH-5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ (%) | 0.0 | 4.3 | 0.7 | 0.0 | 0.0 | 56.0 | 0.7 | 2.9 | 0.3 | 0.0 | 0.0 |
| LEL (%) | 0.0 | 87.1 | 11.8 | 0.0 | 0.0 | >>> | 13.9 | 60.2 | 7.6 | 0.0 | 0.0 |
| $CO_2$ (%) | 0.0 | 3.0 | 0.8 | 0.5 | 0.1 | 23.0 | 2.7 | 2.8 | 0.7 | 2.1 | 1.1 |
| $O_2$ (%) | 20.3 | 3.4 | 10.7 | 19.2 | 19.6 | 0.0 | 18.9 | 14.1 | 19.8 | 12.0 | 19.2 |
| Flow (L/hr) | N/A | 0.3 to -0.3 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 to 2.1 | 0.0 to 0.2 | 0.0 | 0.0 to 0.3 | 0.0 |

**Table 4.2 Gas monitoring on 09/12/05**

| | Atmospheric Reading | GS-1 | BH-1 | GS-2 | BH-2 | GS-3 | BH-3 | GS-4 | BH-4 | GS-5 | BH-5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ (%) | 0.0 | 4.0 | 0.4 | 0.0 | 0.0 | 60.0 | 0.9 | 2.9 | 0.4 | 0.0 | 0.0 |
| LEL (%) | 0.0 | 82.9 | 6.3 | 0.0 | 0.0 | 21.0 | 16.7 | 58.9 | 9.1 | 0.0 | 0.0 |
| $CO_2$ (%) | 0.0 | 2.6 | 0.6 | 0.6 | 0.2 | 19.0 | 2.8 | 2.9 | 0.8 | 1.9 | 0.9 |
| $O_2$ (%) | 20.2 | 5.3 | 19.1 | 19.4 | 19.5 | 0.0 | 17.8 | 14.0 | 19.8 | 12.4 | 19.3 |
| Flow (L/hr) | N/A | 0.1 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 to 0.2 | 0.0 | 0.0 | 0.0 |

**Table 4.3 Gas monitoring on 13/12/05**

| | Atmospheric Reading | GS-1 | BH-1 | GS-2 | BH-2 | GS-3 | BH-3 | GS-4 | BH-4 | GS-5 | BH-5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ (%) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 64.0 | 0.2 | 0.9 | 0.1 | 2.7 | 0.0 |
| LEL (%) | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 | >>> | 4.1 | 12.3 | 2.9 | 51.2 | 0.0 |
| $CO_2$ (%) | 0.0 | 0.2 | 0.5 | 0.6 | 0.1 | 14.0 | 0.7 | 3.0 | 0.5 | 3.0 | 0.1 |
| $O_2$ (%) | 20.1 | 19.1 | 19.3 | 18.3 | 19.6 | 0.8 | 19.9 | 13.1 | 19.9 | 8.3 | 19.9 |
| Flow (L/hr) | N/A | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |

**Table 4.4 Gas monitoring on 19/12/05**

| | Atmospheric Reading | GS-1 | BH-1 | GS-2 | BH-2 | GS-3 | BH-3 | GS-4 | BH-4 | GS-5 | BH-5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ (%) | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 69.0 | 0.0 | 0.0 | 0.0 | 9.5 | 0.0 |
| LEL (%) | 0.0 | 7.0 | 0.0 | 0.0 | 0.0 | >>> | 0.0 | 0.0 | 0.0 | >>> | 0.0 |
| $CO_2$ (%) | 0.0 | 0.2 | 0.6 | 0.4 | 0.0 | 13.0 | 0.4 | 3.8 | 0.1 | 8.8 | 0.0 |
| $O_2$ (%) | 20.1 | 19.0 | 19.2 | 18.6 | 19.6 | 0.6 | 20.1 | 12.0 | 20.0 | 1.6 | 20.1 |
| Flow (L/hr) | N/A | 0.0 to 0.2 | 0.0 | 0.1 | 0.0 | 0.0 to 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |

# APPENDIX 1

Well Survey (Levels & Co-ordinates)

Client: E.G. PETTIT & ASSOCIATES

# Jacobs Babtie Geomatics

## Tramore Bored Well Locations

## Survey Report



December 2005

**Jacobs Babtie** Merrion House, Merrion Road, Dublin 4
Tel 01 269 5666 Fax 01 269 5706

## Tramore Bored Well locations.

**Survey Carried out by:** Jacobs Babtie Dublin
**Date:** December'05

**Key objectives of survey:**

The key objectives of this survey were to co-ordinated and level five Gas wells and seven Boreholes to Local survey grid and Ordnance datum.

**Procedure:**
The approximate location of the 5 gas wells and 7 bore holes in question were shown on the provided mapping issued to Jacobs Babtie by Cardinal Engineering Services, on the 12th December 2005.

### Tramore Well Locations

| Well Number | Easting (M) | Northing (M) | METAL CAP LEVEL | GROUND LEVEL |
|---|---|---|---|---|
| | | | | |
| BH1 | 1147.059 | 1118.877 | 3.732 | 3.010 |
| BH2 | 1060.123 | 998.134 | 3.950 | 3.290 |
| BH3 | 1242.756 | 1076.893 | 3.555 | 2.890 |
| BH4 | 1345.628 | 1125.289 | 3.382 | 2.710 |
| BH5 | 1380.026 | 961.886 | 3.723 | 3.050 |
| OLD BH3 | 1287.680 | 1072.009 | 2.580 | 2.420 |
| OLD BH5 | 1227.060 | 1022.558 | 3.294 | 3.090 |
| GS1 | 1087.100 | 1059.268 | 3.642 | 3.950 |
| GS2 | 1177.153 | 1017.202 | 4.213 | 3.470 |
| GS3 | 1263.729 | 1122.663 | 4.041 | 3.300 |
| GS4 | 1354.416 | 1076.330 | 3.098 | 2.320 |
| GS5 | 1276.769 | 982.835 | 4.320 | 3.494 |



Note:
All levels were based on a best fit to existing Topographical survey drawings provided.

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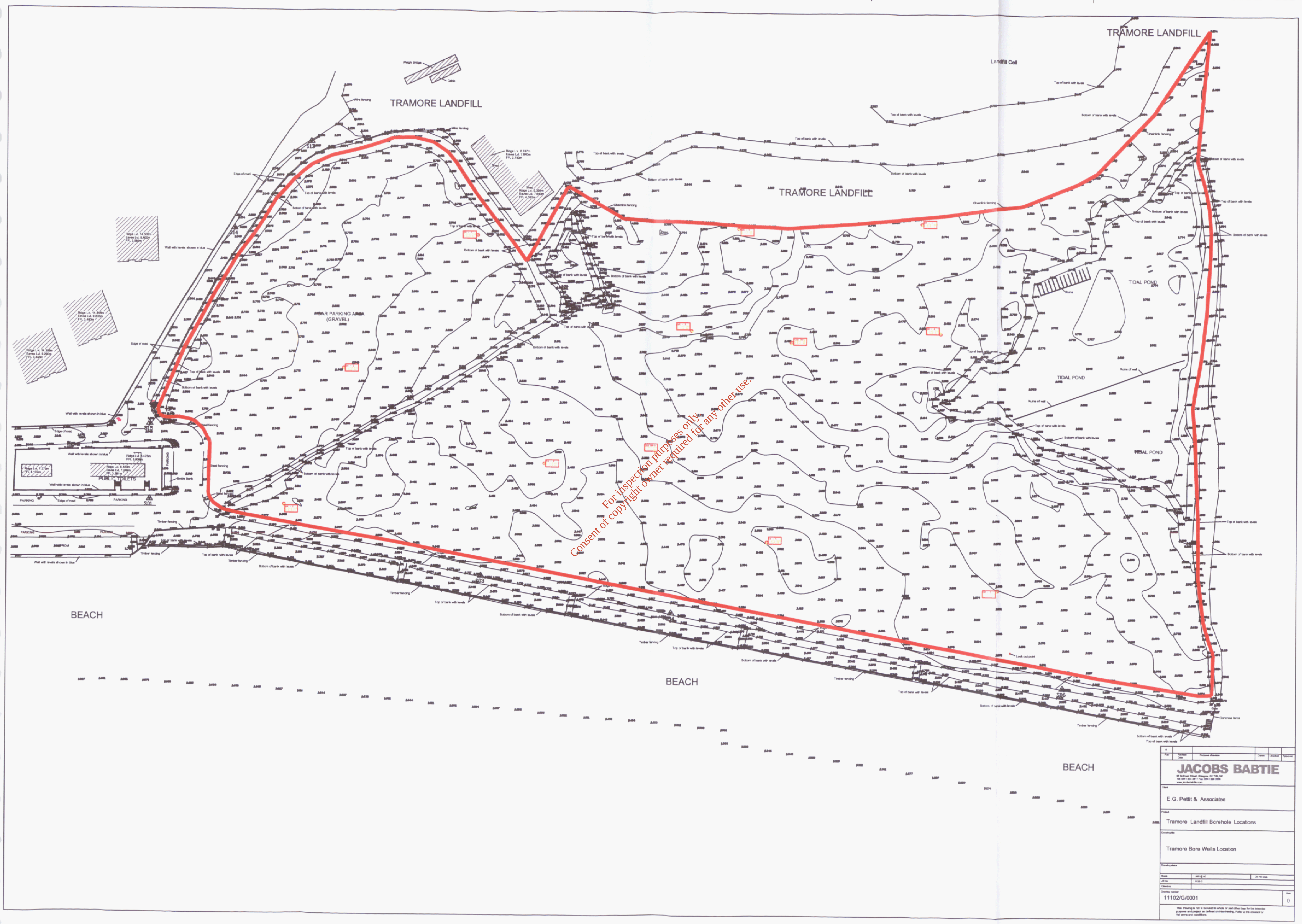
All levels were based on a best fit to existing Topographical survey drawings provided.



TRAMORE LANDFILL
Landfill Cell
TRAMORE LANDFILL
TRAMORE LANDFILL
CAR PARKING AREA (GRAVEL)
PUBLIC TOILETS
PARKING
TIDAL POND
TIDAL POND
TIDAL POND
BEACH
BEACH
BEACH
Top of bank with levels
Bottom of bank with levels
Timber fencing
Concrete fence
JACOBS BABTIE
Client
E.G. Pettit & Associates
Project
Tramore Landfill Borehole Locations
Drawing title
Tramore Bore Wells Location
Drawing status
Scale
Do not scale
Drawing number
11102/G/0001
Rev
0

# APPENDIX 2

GSI Well Search and Quaternary Geology

GEOLOGICAL SURVEY OF IRELAND

GROUNDWATER DATABASE

List of abbreviations

GSIHolename. 1:25,000 sheet Number and number of the well on that sheet

EASTING (E) & NORTHING (N) 5 figure Grid Reference of the well

Grid Acc or Acc Accuracy level, refers to the accuracy of the grid reference.

| | | |
|---|---|---|
| 1 = 10m | 5 = 200m | 9 = 5km |
| 2 = 20m | 6 = 500m | 10 = 10km |
| 3 = 50m | 7 = 1km | |
| 4 = 100m | 8 = 2km | |

Schemename Name of the person or organisation who own the well.

Townland Name of the area where the well is located

Co. County i.e. DO = County Donegal

Six or Six" 1:10,560 sheet number (6" sheet number)

InvType Well Type:

WD = Dug Well WB = Bored Well

WS = Spring WU = Unknown

U Usage:

A = Agricultural use only B = Agricultural & Domestic use

D = Domestic use only G = Group Scheme

I = Industrial use P = Public Supply

O = Other

Y or Yield Class Yield:

F = Failure P = Poor (<40m$^3$/d)

M = Moderate (40 – 100m$^3$/d) G = Good (100 – 400m$^3$/d)

E = Excellent (>400m$^3$/d) U = Unknown

Depth Total depth of the well in metres

DTB Depth to bedrock in metres

Yield Usually yield obtained during initial well testing in m$^3$/day

SpeCap_Abstract Discharge/ Drawdown m$^3$/day/ m (from yield test or abstraction data)

MainAquifer Lith. General description of the geological unit supplying water to the well.

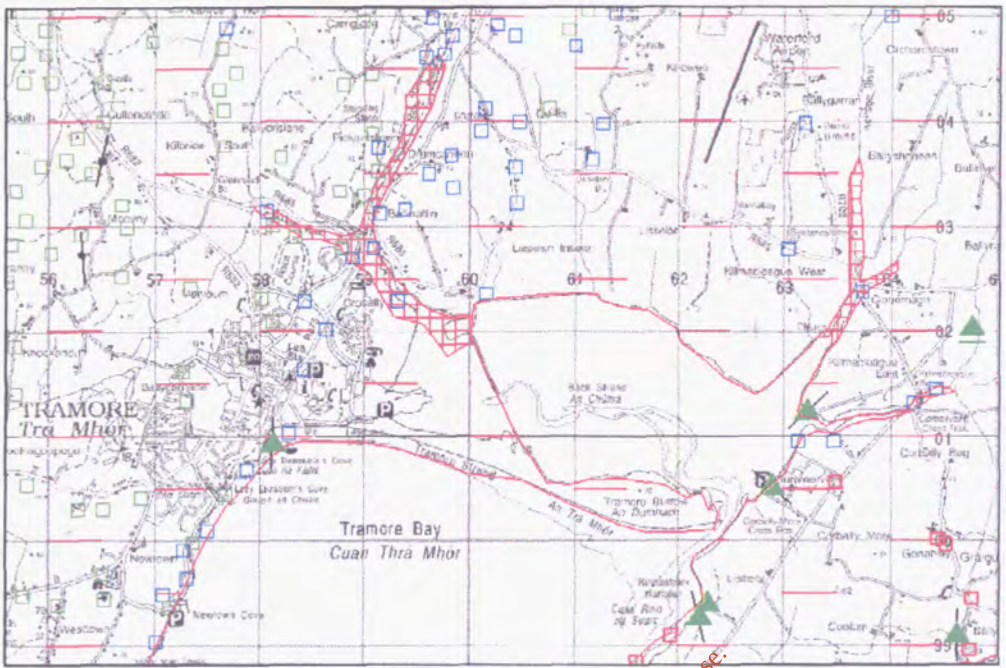
AveDailyAbstract m$^3$/day

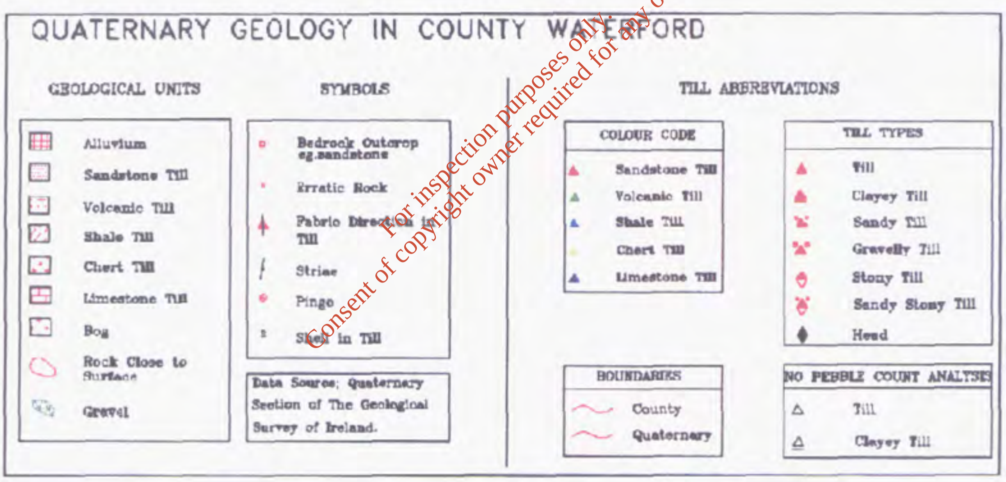
WaterStrike Metres below dipping reference – ground level unless stated otherwise

| GSIHOLENAME | INVTYPE | EASTING | NORTHING | GRID_ACCURACY | TOWNLAND | DTB |
|---|---|---|---|---|---|---|
| 2309NEW072 | WB | 25845 | 10173 | 7 | TRAMORE ROAD | 4.6 |
| 2309NEW077 | WB | 25753 | 10375 | 7 | KILBRIDE SOUTH | 3.7 |
| 2309NEW075 | WB | 25850 | 10136 | 8 | TRAMORE | 11.6 |
| 2309NEW082 | WB | 25850 | 10136 | 7 | TRAMORE ROAD | 11.5 |
| 2309SEW010 | WB | 25663 | 9917 | 7 | WESTTOWN | 1.8 |
| 2309NEW067 | WB | 25785 | 10118 | 7 | TRAMORE WEST | 3.7 |
| 2309NEW069 | WB | 25957 | 10289 | 7 | BALLINATTIN | 5.5 |
| 2309NEW066 | WB | 26000 | 10372 | 7 | DRUMCANNON | 3.7 |
| 2609NWW037 | WB | 26177 | 10297 | 7 | LISSELAN | 4.9 |
| 2309NEW065 | WB | 25889 | 10302 | 7 | PICKARDSTOWN | 9.1 |
| 2309NEW061 | WB | 25893 | 10387 | 7 | PICKARDSTOWN | 3.7 |
| 2609SWW002 | WB | 26206 | 9854 | 7 | BROWNSTOWN | 3.1 |
| 2609NWW039 | WB | 26176 | 10296 | 7 | BALLINVELLA | 15.2 |
| 2309NEW032 | WB | 25944 | 10378 | 7 | DRUMCANNON | 3.7 |
| 2309NEW033 | WB | 25966 | 10391 | 7 | DRUMCANNON | 6.7 |
| 2609NWW006 | WS | 26132 | 10436 | 7 | KILLOWEN | |
| 2309NEW128 | WB | 25832 | 10392 | 6 | BALLYDRISLANE | 22.9 |

| DEPTH | YIELD | YIELDCLASS | WATERSTRIKE_1 |
|---|---|---|---|
| 31.4 | 43.6 | M | |
| 49.7 | 32.7 | P | |
| 25.3 | 54.5 | M | |
| 49.7 | 26.2 | P | |
| 51.8 | 3.3 | P | |
| 101.8 | 6.5 | P | |
| 42.7 | 32.7 | P | |
| 31.1 | 32.7 | P | |
| 31.7 | 43.6 | M | |
| 55.5 | | F | |
| 32.6 | 27.3 | P | |
| 22.9 | 32.7 | P | |
| 56.1 | 32.7 | P | |
| 26.5 | 32.7 | P | |
| 36.6 | 32.7 | P | |
| 106.7 | 16.4 | P | 73.2 |

| GSIHOLENAME | INVTYPE | EASTING | NORTHING | GRID_ACCURACY | TOWNLAND | DTB | DEPTH | YIELD | YIELDCLASS | WATERSTRIKE_1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2309NEW072 | WB | 25845 | 10173 | 7 | TRAMORE ROAD | 4.6 | 31.4 | 43.6 | M | |
| 2309NEW077 | WB | 25753 | 10375 | 7 | KILBRIDE SOUTH | 3.7 | 49.7 | 32.7 | P | |
| 2309NEW075 | WB | 25850 | 10136 | 8 | TRAMORE | 11.6 | 25.3 | 54.5 | M | |
| 2309NEW082 | WB | 25850 | 10136 | 7 | TRAMORE ROAD | 11.5 | 49.7 | 26.2 | P | |
| 2309SEW010 | WB | 25663 | 9917 | 7 | WESTTOWN | 1.8 | 51.8 | 3.3 | P | |
| 2309NEW067 | WB | 25785 | 10118 | 7 | TRAMORE WEST | 3.7 | 101.8 | 6.5 | P | |
| 2309NEW069 | WB | 25957 | 10289 | 7 | BALLINATTIN | 5.5 | 42.7 | 32.7 | P | |
| 2309NEW066 | WB | 26000 | 10372 | 7 | DRUMCANNON | 3.7 | 31.1 | 32.7 | P | |
| 2609NWW037 | WB | 26177 | 10297 | 7 | LISSELAN | 4.9 | 31.7 | 43.6 | M | |
| 2309NEW065 | WB | 25889 | 10302 | 7 | PICKARDSTOWN | 9.1 | 55.5 | | F | |
| 2309NEW061 | WB | 25893 | 10387 | 7 | PICKARDSTOWN | 3.7 | 32.6 | 27.3 | P | |
| 2609SWW002 | WB | 26206 | 9854 | 7 | BROWNSTOWN | 3.1 | 22.9 | 32.7 | P | |
| 2609NWW039 | WB | 26176 | 10296 | 7 | BALLINVELLA | 15.2 | 56.1 | 32.7 | P | |
| 2309NEW032 | WB | 25944 | 10378 | 7 | DRUMCANNON | 3.7 | 26.5 | 32.7 | P | |
| 2309NEW033 | WB | 25966 | 10391 | 7 | DRUMCANNON | 6.7 | 36.6 | 32.7 | P | |
| 2609NWW006 | WS | 26132 | 10436 | 7 | KILLOWEN | | | | | |
| 2309NEW128 | WB | 25832 | 10392 | 6 | BALLYDRISLANE | 22.9 | 106.7 | 16.4 | P | 73.2 |






Area of interest is dominated by Diamicton derived from Volcanic Rocks.
There are numerous rock outcrops of Shale (cyan colour) and Volcanic rocks (green colour).
Undifferentiated alluvial sediments occur north of Tramore.

Sources of information.
GSI Quaternary Field Sheets (1950's & 1960's) (1:10,560)
GSI Bedrock Field Sheets (1900's) (1:10,560)
Field Mapping by I. Quinn.