Carrick District Council
Environmental Protection Act 1990, Part2A – Section 78B
Record of Determination of Wheal Maid Tailings Lagoons,
Gwennap, Cornwall as Contaminated Land

1 Introduction and site location

Paragraph B.52 of the Statutory Guidance (Defra Circular 01/2006) requires local authorities to prepare a written record of determination that particular land is contaminated land for the purposes of Part2A of Environmental Protection Act 1990 (EPA). This document outlines why Carrick District Council (CDC) has determined land at Wheal Maid Tailing Lagoons (the site) to be Contaminated Land.

The site is located approximately 1km east of St Day, the national grid reference of its centre is SW 74722 42229. A location plan and site boundary are shown in Figure 1. The extent of the land (the site) has been defined by CDC with due consideration of the requirements of Paragraph B.32 of the statutory guidance.

Brief site description
The site is approximately 8ha in area, it is a valley infill consisting of two lagoons separated by three dams and contains approximately 220000m³ of tailings. It was operated during the 1970s and 1980s, taking fine-grained mineral processing wastes (tailings) from the mill facilities at the former Mount Wellington tin mine.

A section of the Mineral Tramways footpath runs along the southern boundary of the site. There is also a footpath that runs along the western boundary of the site. Gwennap Parish Council owns the site; there is no right of access onto the site. Despite this, the site is regularly used by motorcyclists, four wheel drives (becoming less frequent), mountain bikers and walkers/dog walkers.

The St Day stream, a tributary of the Carnon River, flows from west to east through a 1200mm diameter culvert beneath the site. A branch of the County Adit runs north to south beneath the site and the culverted watercourse, it discharges into the Carnon River, to the east of the site, at Twelveheads.

The site overlays Devonian Mylor and Porthtowan formations (metamorphosed siltstones and sandstones). There is extensive faulting and previously worked mineralisation, with numerous shafts and adits in the vicinity. The site geology is classified as Minor Aquifer and there are no licensed groundwater supplies nearby.

2 Description of Significant Pollutant Linkages

There are 26 Significant Pollutant Linkages (SPLs) forming the basis of this determination. For the purposes of this description the SPLS have been grouped, which gives four groups of SPL, as shown in Table 1.
Table 1 – Significant Pollutant Linkages

<table>
<thead>
<tr>
<th>SPL number</th>
<th>Significant pollutant</th>
<th>Migration and exposure pathways</th>
<th>Receptor</th>
<th>Basis of determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>Arsenic</td>
<td>Ingestion, dermal contact and inhalation of contaminated soils</td>
<td>Site users- child mountain bikers</td>
<td>Significant possibility of significant harm</td>
</tr>
<tr>
<td>3 - 10</td>
<td>Arsenic, cadmium, chromium, copper, iron, lead, nickel, zinc</td>
<td>Leaching from contaminated soils through the lower dam</td>
<td>Controlled Waters - St Day Stream</td>
<td>Pollution of controlled waters is being caused</td>
</tr>
<tr>
<td>11 - 18</td>
<td>Arsenic, cadmium, chromium, copper, iron, lead, nickel, zinc</td>
<td>Leaching from contaminated soils through culvert walls</td>
<td>Controlled Waters - St Day Stream</td>
<td>Pollution of controlled waters is likely to be caused</td>
</tr>
<tr>
<td>19 - 26</td>
<td>Arsenic, cadmium, chromium, copper, iron, lead, nickel, zinc</td>
<td>Leaching from contaminated soils</td>
<td>Controlled Waters - groundwater in the minor aquifer</td>
<td>Pollution of controlled waters is likely to be caused</td>
</tr>
</tbody>
</table>

3) Summary of the evidence on which the determination is based

Monitoring data suggested that the site could be causing a failure of Environmental Quality Standards (EQS) (Dangerous Substances Directive 76/464/EEC) in the St Day Stream. Because of this Carrick District Council asked the Environment Agency to carry out the inspection. The Environment Agency contracted consultants to carry out the desk study and the intrusive site investigation and did the majority of the risk assessment work themselves. The evidence on which the determination is based is in the following documents and summarised below.


Desk study

The desk study was completed in October 2006. It collected and assessed documentary information to establish a conceptual model for the site. The information assessed included:

- 13 previous site investigation reports
- historic maps
- government guidance and policy
- published geological information
- previous water quality monitoring data
- aerial photographs
The study concluded that there were 111 possible pollutant linkages. At this stage there was not sufficient information to establish with enough certainty which linkages were present and causing unacceptable risk. Therefore the study made recommendations for further investigation and assessment. These recommendations included intrusive investigation.

**Intrusive investigation**

This work began in January 2007 and finished in October 2007. The consultants reviewed the desk study and used the information to design the site investigation so that the linkages could be fully evaluated and the conceptual model refined. The following activities were carried out:

- Collection of 53 surface soil samples to assess the concentrations of heavy metals exposed at the surface and therefore available for exposure to site users;
- Drilling of four boreholes and installation of groundwater monitoring wells to obtain deeper soil samples from the tailings and to obtain samples of groundwater from within the tailings and underlying bedrock;
- Collection of surface water samples from the St Day Stream up and downstream of the site, within standing water on the lagoons and water seepage at the northern toe of the lower lagoon;
- Analysis of soil samples for metals, pH, sulphate, sulphide and chloride and particle size analysis. Leaching tests and bioaccessibility testing on selected samples. Water samples were analysed for the same chemicals, and;
- Flow measurement in the St Day Stream up and downstream of the site and estimation of groundwater seepage flows at the lower lagoon.

The Environment Agency carried out monthly surface water sampling around the site. Analysis showed elevated concentrations of metals and metalloids in the St. Day Stream, the groundwater below the site and water within the tailings.

The investigation identified four main soil types at the site:

- **Mine waste** – granular material of varying particle size that is present around the perimeter of the lagoons. This was used for the construction of the dams. High, but variable, concentrations of metals including arsenic. Leachable metals are generally copper and zinc with some chromium.

- **Granular capping material** – this material was used to cover the tailings in the upper lagoon. High, but variable, concentrations of metals and similar leaching characteristics to the mine waste.

- **Marbled tailings** – fine grained red/brown/yellow material within the lower lagoon. Although arsenic concentrations are high, arsenic does not appear to be readily leached. Copper and zinc leach from these tailings, but to a lesser extent than the other materials on the site. Perched groundwater encountered within these strata contains high concentrations of copper, nickel and zinc, but the copper and zinc concentrations are lower than in the underlying bedrock groundwater.

- **Grey Tailings** – fine to medium grained sand with visible yellow pyrite mineral crystals. Total metals concentrations are comparable with the other three material types. These tailings contain a high proportion of sulphide minerals, which weather to their metal constituents and sulphuric acid. This results in low pH (acidic) soil and water conditions. Testing of the grey tailings has identified a high leaching potential for
arsenic, cadmium, copper, lead, nickel and zinc. The exposure, erosion and weathering of this material within the lower lagoon is regarded as the main contributing factor for the very poor, acidic water quality within the lower lagoon and associated seepages to the St Day Stream via the toe of the lower retaining dam. The grey tailings are the most significant materials of the four identified in terms of contamination risk.

The URS site investigation collected water quality data from groundwater beneath and within the site and surface water data. The Environment Agency carried out monthly surface water quality monitoring for a year at eight locations in and around the site. Historic monitoring data was also acquired from the Environment Agency.

A survey of the culvert was carried out using mobile CCTV equipment. It was not possible to assess the entire length of the culvert, however, it did show that water from the tailings is entering the culvert.

4 Summary of assessment of the evidence on which the determination is based

The desk study, site investigation and subsequent assessment considered the likely receptors at the site in light of those set out in Tables A and B of the Statutory Guidance. It was concluded that the only receptors that may be present are human beings and controlled waters. Therefore they were taken forward for detailed consideration.

Human Beings
The Environment Agency carried out a detailed assessment of the risks, within the context of Part 2A, posed by the site to human health. This was done in consultation with the health Protection Agency and the Primary Care Trust. It considered a large amount of information including:

- Results of all investigations to date
- How the land is used by local people and likely patterns of site use that might bring them into contact with soils at the site.
- The spatial variation in soil types and associated concentrations of substances across the site and how this might impact on the people’s exposure to them.
- The likely intake of substances present in the soil by people regularly using the site.
- Toxicological, physical and chemical properties of the contaminants.
- Published guidance and research.

The assessment is reported in the following documents, and summarised below.

- Environment Agency memo reference 44382747/SJC/CRME0002, dated 16 August 2007

Analysis of the monitoring data in URS October 2007 showed that Arsenic is the dominant contaminant present in the soils at the site. Recorded surface soil concentrations of arsenic exceed the Soil Guideline Value (SGV) for residential land without plant uptake at all 59 locations sampled. The SGV is exceeded by over two orders of magnitude at twelve locations. Concentrations of other contaminants (metals and metalloids) in the soil were also analysed. This showed that they were not of concern compared to the arsenic.
The first stage of the assessment was the development of a conceptual exposure model. This is shown in Table 2 below.

**Table 2 – Conceptual exposure model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical receptor</td>
<td>Young children using the site for BMX/mountain biking</td>
</tr>
<tr>
<td>Exposure frequency</td>
<td>130 days/year</td>
</tr>
<tr>
<td>Exposure duration</td>
<td>6 years (ages 6 to 12)</td>
</tr>
<tr>
<td>Body weight</td>
<td>As quoted in CLR10 for each age class</td>
</tr>
<tr>
<td>Inhalation rate</td>
<td>Active breathing rates as quoted as a function of body weight in CLR10</td>
</tr>
<tr>
<td>Exposed skin surface area</td>
<td>Function of body weight for each age class, assuming exposed face, hands, forearms and lower legs</td>
</tr>
<tr>
<td>Skin-soil adherence factor</td>
<td>0.08mg/cm²</td>
</tr>
<tr>
<td>Soil ingestion rate</td>
<td>50mg/day</td>
</tr>
<tr>
<td>Outdoor dust concentration</td>
<td>Modelled based on default CLR10 approach of fugitive dust emission from surface wind erosion only; site size is approximated at 10ha with a maximum of 25% vegetation cover</td>
</tr>
<tr>
<td>Pollutant linkage to be assessed</td>
<td>Accidental ingestion (pathway) of arsenic contaminated soil and dust (source) by children cycling on the site (receptor)</td>
</tr>
<tr>
<td>Pollutant linkage to be assessed</td>
<td>Dermal contact (pathway) with arsenic contaminated soil and dust (source) by children cycling on the site (receptor)</td>
</tr>
<tr>
<td>Pollutant linkage to be assessed</td>
<td>Inhalation (pathway) of arsenic contaminated fugitive dust (source) by children cycling on the site (receptor)</td>
</tr>
</tbody>
</table>

The site has several different soil types which contain varying ranges of arsenic. In order to arrive at a representative concentration for use in the assessment statistical analysis of the arsenic concentration data recorded by URS was carried out. The analysis looked at the spatial distribution of arsenic by soil type and location and time spent on site by the critical receptor. This resulted in the range of calculated upper confidence limits of arsenic concentrations (UCL (95%)) shown in Table 3 below.

**Table 3 – Arsenic concentrations by soil type and location**

<table>
<thead>
<tr>
<th>Soil type/location</th>
<th>As concentration UCL (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole site</td>
<td>1406</td>
</tr>
<tr>
<td>Capping material only</td>
<td>1587</td>
</tr>
<tr>
<td>Mine spoil material only</td>
<td>2301</td>
</tr>
<tr>
<td>Marble tailings only</td>
<td>1229</td>
</tr>
<tr>
<td>Grey tailings only</td>
<td>2050</td>
</tr>
<tr>
<td>Upper lagoon only</td>
<td>1509</td>
</tr>
<tr>
<td>Lower lagoon only</td>
<td>2050</td>
</tr>
<tr>
<td>Whole site weighted by % cover of different soil types</td>
<td>1883</td>
</tr>
<tr>
<td>Critical exposure UCL*</td>
<td>1426</td>
</tr>
</tbody>
</table>

* - Soil type UCLs weighted against the proportion of time exposed to that soil type by children cycling on the site (i.e. – concentrated exposure in areas of jumps etc).
Estimates of reasonable worst-case exposure (defined as an average daily exposure (ADE)) were calculated using CLEA_UK for arsenic, based on the CEM and the critical exposure UCL as described above. The health criteria benchmarks used were those published for arsenic in TOX 1. The modelling made allowances for extra dust generation by the mountain bikers. It also considered the impacts of arsenic bioaccessibility on exposure through the use of the physiologically based extraction test (PBET). This test simulates activity in the human stomach and intestine in order to give an indication of the amount of arsenic that would be taken up in these organs.

The results showed that the risk associated with exposure to arsenic via the inhalation pathway is above the chronic minimal risk level (MRLc) when related the health criteria benchmarks. This means that there is a significant possibility of significant harm to the critical receptor (children using the site for BMX/mountain biking).

When arsenic bioaccessibility is taken into account the risks posed by the oral and dermal routes alone are below the relevant health criteria and can be considered to be acceptable. However, there is uncertainty about the accuracy and repeatability of PBET testing. The Environment Agency’s believes that there is a need for more research to reduce the uncertainty in these tests and their regulatory position is that “given the current uncertainties associated with bioaccessibility testing, we consider its application to be limited”. In light of the Environment Agency’s position a precautionary approach has been taken and the results of the PBET were not used in the final assessment. This results in a risk associated with exposure to arsenic via the ingestion and dermal pathways above the chronic minimal risk level (MRLc) when related the health criteria benchmarks. This means that there is a significant possibility of significant harm to the critical receptor (children using the site for BMX/mountain biking).

Following discussion with local residents the following scenarios were also assessed with DQRA:

- Impacts on a child falling into ponds on the lagoon surface and swallowing water.
- Long term (chronic) impacts on adults and children walking the perimeter of the site on a twice-daily basis resulting from exposure to wind blown dusts (dog walkers).

It was concluded that there is not an unacceptable risk, in terms of Part2A, relating to these receptors.

The conclusions of the human health risk assessment are that on a precautionary, worst case basis, there is a significant possibility of significant harm to young children using the site for BMX/mountain biking from exposure to arsenic through the inhalation, ingestion and dermal absorption pathways (SPL 1 - 2).

**Controlled Waters**

The monitoring data described above was compared against relevant Environmental Quality Standards and upstream quality was compared to downstream quality. This assessment showed that water quality deteriorates downstream of the site, and that groundwater beneath the site has elevated concentrations of metals.

The evidence gained in the site investigation showed that the water emanating from springs beneath the toe of the lower dam is contributing to the elevated concentrations of metals in the St. Day Stream downstream of the site. Hence, it is concluded that pollution of controlled waters is occurring.

The leaching analysis and quality of water within the tailings shows that metals in tailings on the site are a source of contamination for controlled waters receptors. Given the presence of this source, and the fact that there are no barriers to contaminant transport, it
was concluded that the site is likely to cause pollution of groundwater beneath the site. It was also concluded, given the age and condition of the culvert, that the site is likely to cause pollution of the St. Day Stream through the culvert walls.

The conclusions of the controlled waters risk assessment are that the site is causing pollution of controlled waters by leaching of arsenic, cadmium, copper, chromium, iron, lead, nickel and zinc through the toe of the lower lagoon into the St. Day Stream (SPL 3 to 10). It further concludes that pollution of controlled waters is likely to be caused by leaching of the above pollutants into groundwater beneath the site and through the culvert wall into the St. Day Stream (SPL 11 – 19 and 20 – 26).

5 Summary of how the relevant requirements of Chapters A and B of Statutory Guidance have been met

Risk Assessment
Para A.11. Contaminants, pathways and receptors have been identified for the site.

Para A.17 and A.19. Twenty-six pollutant linkages have been identified at the site. Two present a significant possibility of significant harm to the identified receptor. Eight are resulting in the pollution of controlled waters, which constitutes the receptor, and sixteen are likely to result in such pollution.

Significant Possibility of Significant Harm
Para A.28, A.29 and A.30. Regard has been given to the significant possibility of significant harm in line with Table B. The nature and degree of harm, susceptibility of the receptors and timescale within which the harm might occur have been taken into account in the risk assessment described in section 4 above.

Para A.33 and A.34. The site has been assessed on its current use – derelict land that is used for recreational purposes by trespassers.

Pollution of controlled waters
Para A.36, A.37 and A.39. Monitoring data shows that metals are present in the soil at high concentrations and they continue to leach. This is a source that continues to enter controlled water. Metals are dissolved in the receiving controlled waters.

Determining whether and appears to be contaminated land
Para B.31. Carrick District Council (CDC) has determined the land to be contaminated land. This decision relied on information provided by the Environment Agency as they carried out the inspection on our behalf.

Physical extent of land
Para B.32, B.33, B.34, B.35 and B.36. The area of land to be determined as contaminated land is shown on Figure 1. It is the whole of the tailings lagoons, but does not include the valley sides. This decision is based on the following factors.

- The significant pollutants, with regard to pollution of controlled waters (POCW), are present within the entire lagoons.
- The nature of remediation, with regard to POCW, is likely to involve work on the entire site.
- It is understood that one company operated the lagoons. The site, in its entirety, is currently owned by one public body.

Should further information become available in the future CDC is prepared to review this decision.
Making the determination

Para B.38. The site is determined on the grounds that
1. there is a significant possibility of significant harm being caused,
2. pollution of controlled waters is being caused, and
3. pollution of controlled waters is likely to be caused

Para B.39. CDC and the Environment Agency have taken all relevant and available information into account. Where the inspection process has highlighted uncertainties and gaps in the information they have been addressed by subsequent stages. The desk study amassed a large amount of previous site investigation and monitoring data. The inspection was carried out according to the requirements of CLR11 – Model Procedures for the Management of Land Contamination, DEFRA and Environment Agency guidance on risk assessment and Environment Agency Policy.

Para B.40. Twenty-six significant pollutant linkages have been identified, all three elements (pollutant, pathway and receptor) are present for each.

Para B.41. Additive/synergistic effects have been considered in the risk assessment; they are not relevant in this case.

Para B.43. CDC has consulted with, and had regard to, the comments of the Environment Agency in making the determination so far as it relates to pollution of controlled waters. The Environment Agency carried out the inspection and recommended the basis for determination.

Para B.45, B.46. A scientific and technical assessment of the risks, according to relevant, appropriate, authoritative and scientifically based guidance, has been carried out. This is described in Para B.39 above and in Section 4 of this document. The assessment shows that there is a significant possibility of harm occurring and there are no suitable and sufficient risk management agreements in place to prevent such harm. The investigation was appropriate for the specific circumstances at the site.

Para B.50 and B.51. A scientific and technical assessment of the risks, according to relevant, appropriate, authoritative and scientifically based guidance, has been carried out. This is described in Para B.39 above and in Section 4 of this document. Based on this assessment CDC is satisfied that, on the balance of probabilities, potential pollutants are present in, on or under the land and that they are entering controlled waters.

Equally, CDC is satisfied that identified pollutants are in a condition such that they are capable of entering controlled waters, pathways are present, the pollutants are more likely than not to enter controlled waters and that there are no suitable and sufficient risk management arrangements present.