

GLENDALOUGH VALLEY

Background information

Mine Name: Glendalough Valley

Mine District: Glendalough

Alternative Names:

Elements of interest:

Pb, Zn, Cu, Cd

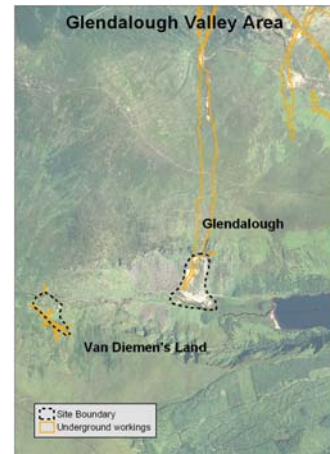
Project Prefix: GLD-

County:
Wicklow

Townland:
Camaderry
Lugduff

Grid Reference:

E308964, N196346 (Glendalough)
E307695, N196116 (Van Diemen's)



Site Description and Environmental Setting

The Glendalough site is at the head of the Upper Lake in Glendalough Valley (photo, right). Van Diemen's Land is an isolated site further up the valley, on high ground between Camaderry Mountain in the north and Lugduff in the south (photo, below). Glendalough was developed on the southern end of the Luganure Lode that runs through Camaderry Mountain. On the northern side of the mountain the Luganure mine was developed on the same lode. Van Diemen's mine was developed on an entirely separate lode. The sites as defined for the HMS-IRC project cover a total of over 17 ha, of which 11.8 ha is accounted for by Glendalough and 5.5 ha by Van Diemen's.



The Luganure Lode was the first to be exploited in the district outside of Glenmalur, where mining began in the late 18th century. The Luganure mine was begun on the north side of Camaderry, possibly as early as 1800, and large-scale mining in the district in the 1820s and 1830s initially centred on the Luganure Lode. Some workings are known to have occurred in Glendalough Valley as early as

1812, at least, but it does not seem that major exploration took place until the 1840s or 1850s. By 1855 Van Diemen's was being explored and adits were being driven into Camaderry Mountain from Glendalough Valley. In 1857 a crusher plant was built in the valley and in 1859 the Glendalough adits were driven through to connect with

the Luganure adits. Subsequently, ore produced in Luganure was brought to the Glendalough site for processing. Mining ceased in Glendalough, as elsewhere in the district, by the 1880s but between 1913 and 1925 a small operation was run to recover Pb from the waste rock in the valley.

The Glendalough site has a significant quantity of extant adits and mine buildings as well as large volumes of solid waste (Fig. 1). The First, Second and Third Adits are all open and accessible to some degree, especially the First Adit. The lowermost Third Adit issues a steady if small flow of mine water (photo, right). Mine buildings include the ruins of the Roll Mill house (photo, below), forge and offices as well as a stone hopper (ore bin/chute) and cobbled dressing floor. A small 20th-century roll crusher presumably dates from the period between 1913 and 1925 when waste was reworked to extract Pb.



The Van Diemen's site (Fig. 2) is much less extensive but contains numerous small waste heaps, the remains of some mine buildings, several extant shafts and a collapsed adit that discharges a low flow of mine water. The shafts are generally filled with water so that their exact state is not readily ascertained – presumably most have either collapsed and/or been blocked up but this is not known with certainty. The mine

buildings include the footprint of a crusher house and the somewhat more substantial remains of an office.

Because it was a major processing area the Glendalough site has a variety of solid waste not seen anywhere else in the Glendalough District apart from at the Old Hero site in Glendasan. Waste types identified on site include unprocessed spoil, crushed waste, stamps waste (photo, right), buddle waste and tailings. A small tailings lagoon is located at the eastern end of the site (TA04 on Fig. 1). The calculated area and volume of waste heaps are given in Table 1.



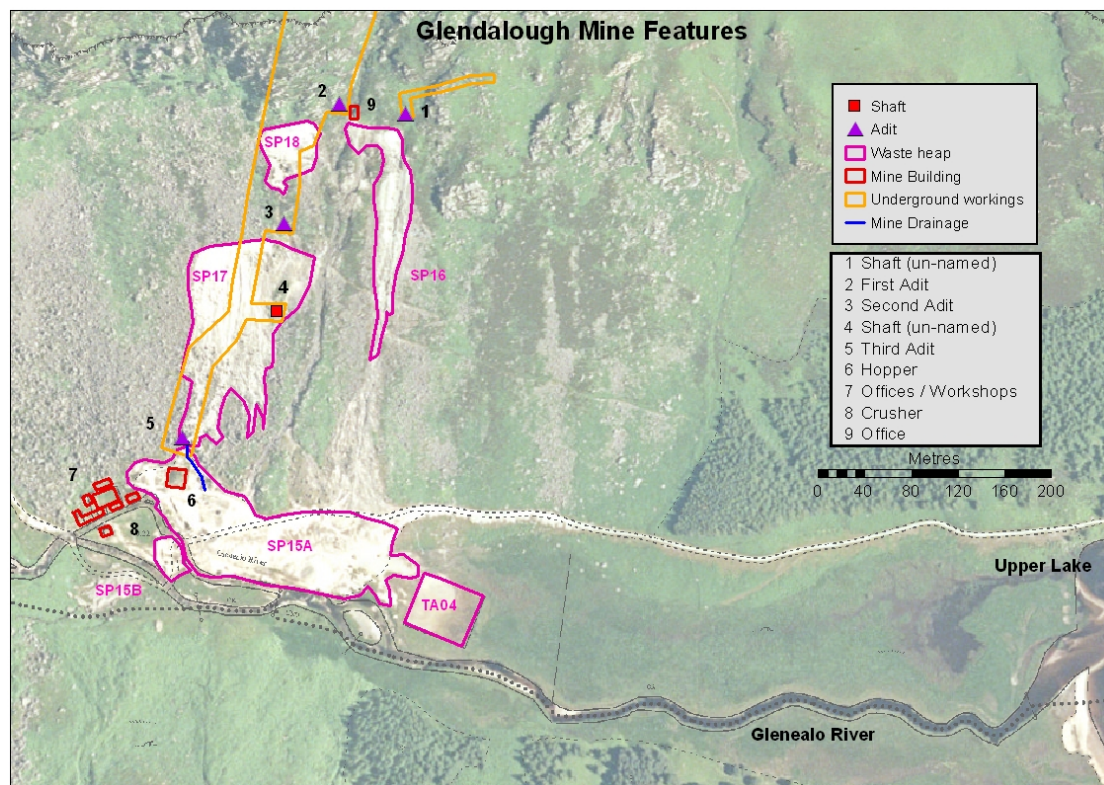


Fig. 1 Glendalough Mine Features

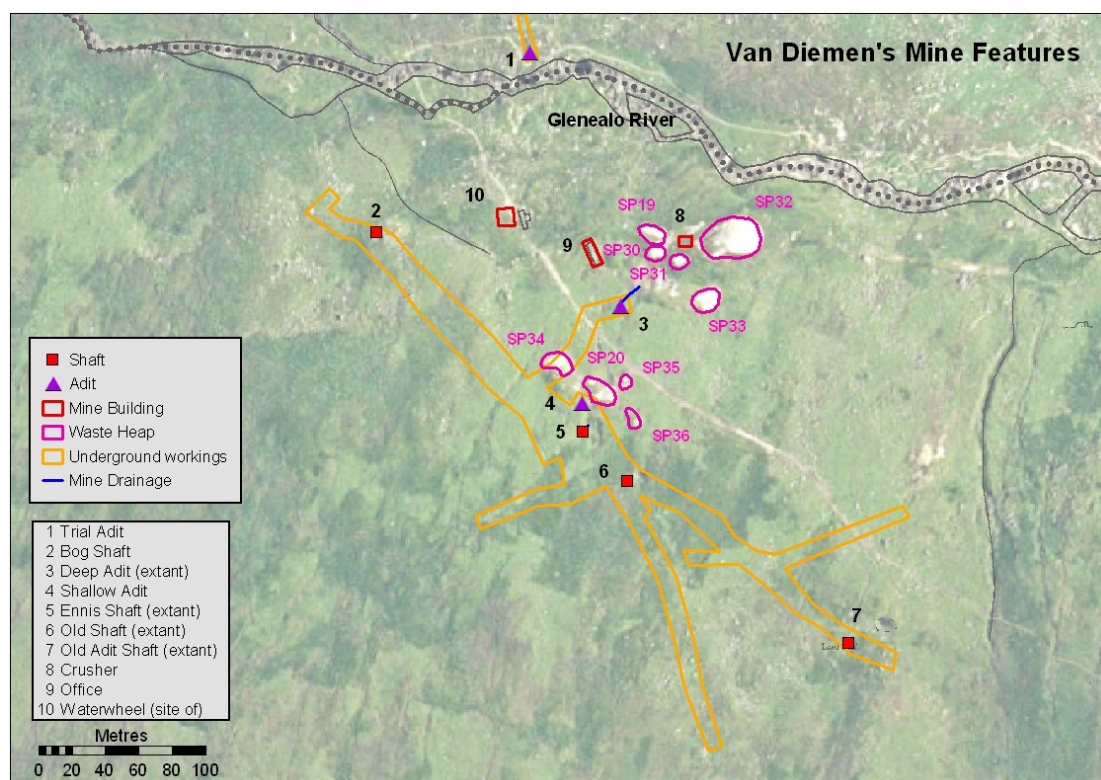


Fig. 2 Van Diemen's Mine Features

Table 1 Area, volume of spoil heaps at Glendalough and Van Diemen's

| Waste ID | Area (m²) | Volume (m³) |
|-----------------|-----------------------------|-------------------------------|
| GLD-SP15a | 14994 | 27187 |
| GLD-SP15b | 746 | 606 |
| GLD-SP16 | 4412 | 361 |
| GLD-SP17 | 12595 | 5829 |
| GLD-SP18 | 2109 | 1078 |
| GLD-TA04 | 2498 | 2498 |
| GLD-SP19 | 134 | 88 |
| GLD-SP20 | 205 | 1201 |
| GLD-SP30 | 82 | 131 |
| GLD-SP31 | 76 | 61 |
| GLD-SP32 | 711 | 147 |
| GLD-SP33 | 182 | 860 |
| GLD-SP34 | 163 | 3011 |
| GLD-SP35 | 49 | 25 |
| GLD-SP36 | 71 | 53 |

Geochemical assessment

No geochemical sampling or analysis was done at Van Diemen's mine. Scoring of waste heaps at Van Diemen's site for the HMS-IRC Site Scoring system is based on the chemistry of spoil from GLD-SP15a at Glendalough.

1. Surface water

Water was sampled at five sites in Glendalough in both winter and summer (Fig. 3). The Third Adit discharges a steady flow of mine water (sample W014) throughout most of the year, measured at 2.3 l/s in July 2007. The flow rate was not measured in winter but was somewhat higher than that in summer. The adit discharge flows onto and beneath the main waste heap. It may contribute to the seepage that emerges from the southern side of this heap close to the river (W012). This seepage flows into the river just above sample site W011. It had a flow rate of 2 l/s in July 2007 and appears to be a year-round phenomenon. Two other sites were sampled, one upstream of all workings in Glendalough (W010) and another downstream of the tailings lagoon (W013). Tables 2 and 3 summarize the data for the winter and summer sampling periods.

Concentrations of metals in water samples were higher in winter than in summer. Among the samples analysed, the seepage contains the highest metal concentrations, notably Pb, Zn and Cd. The adit discharge also has quite high concentrations of Zn (Tables 2, 3), but much lower Pb and Cu. If the adit discharge contributes to the seepage then clearly it has picked up metals as it passed through the solid waste. The river water sample immediately downstream of the point where the seepage enters the river has significantly raised concentrations of Pb and Zn and slightly raised Cd. Both Pb and Zn concentrations in the samples taken further downstream of the site (W013) are also raised but the concentrations are much reduced – the river water has almost recovered the composition it showed in the sample taken upstream of the mine (W010).

Table 2: Summary statistics for water samples, January 2007, Glendalough

| Sample (Fig. 3) | Flow l/s | pH | Acidity mg/l CaCO ₃ | Pb (tot) µg/l | Zn (tot) µg/l | Cu (tot) µg/l | Cd (tot) µg/l |
|--------------------|-------------|------|-----------------------------------|------------------|------------------|------------------|------------------|
| W014 | n.d. | 6.88 | 40 | 22 | 4691 | 23 | 28 |
| W012 | n.d. | 6.26 | 20 | 1270 | 7630 | 54 | 60 |
| W010 | n/a | 6.13 | 65 | 3 | 100 | 17 | <1 |
| W011 | n/a | 5.81 | 15 | 35 | 443 | 18 | 2 |
| W013 | n/a | 6.05 | 15 | 13 | 208 | 24 | <1 |

n.d.: not determined; n.a.: not applicable

Table 3: Summary statistics for water samples, July 2007, Glendalough

| Sample (Fig. 3) | Flow l/s | pH | Acidity mg/l CaCO ₃ | Pb (tot) µg/l | Zn (tot) µg/l | Cu (tot) µg/l | Cd (tot) µg/l |
|--------------------|-------------|------|-----------------------------------|------------------|------------------|------------------|------------------|
| W014 | 2.3 | 6.6 | 19 | 12 | 3247 | 16 | 20 |
| W012 | 2 | 5.72 | 12 | 812 | 4423 | 65 | 39 |
| W010 | n/a | 5.85 | 10 | 4 | 90 | 90 | <1 |
| W011 | n/a | 6.03 | 8 | 56 | 371 | 58 | 2 |
| W013 | n/a | 5.9 | 8 | 22 | 170 | 14 | <1 |

n.a.: not applicable

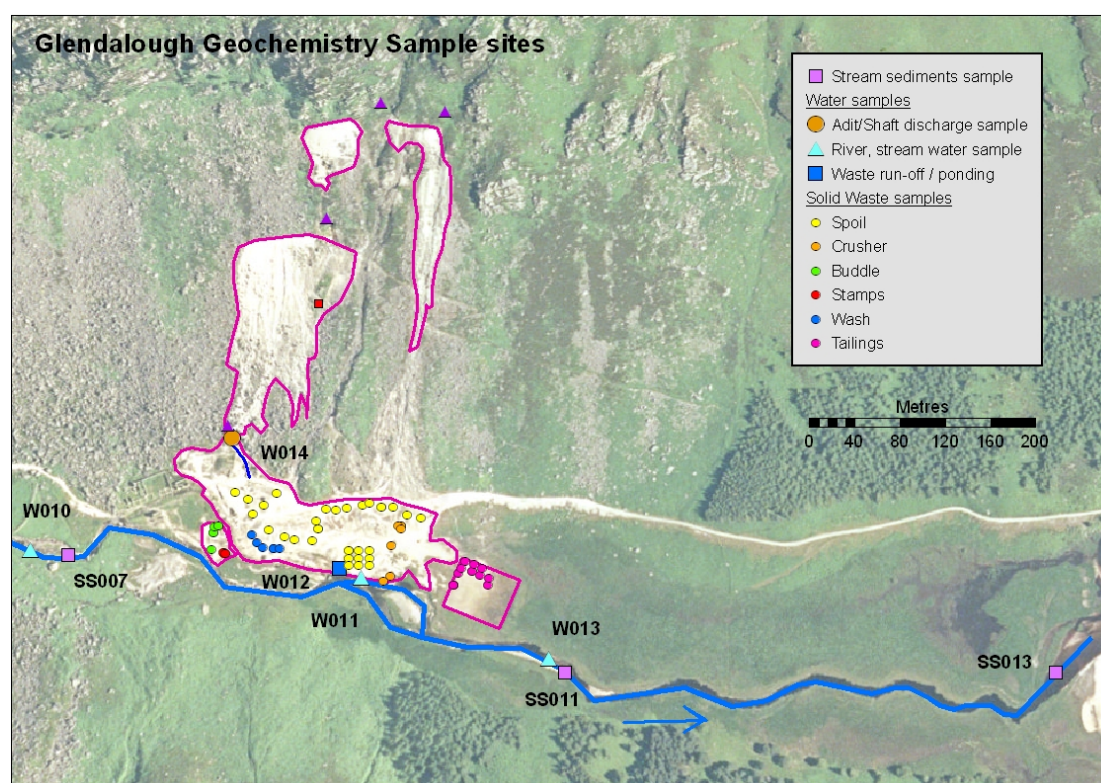


Fig. 3 Geochemical sample sites, Glendalough

Surface water geochemistry is discussed further in the Glendalough District report. At the Glendalough site there is clear evidence that the river suffers some contamination as a result of mine water discharge but recovers relatively quickly, either as a consequence of dilution or precipitation of metals in the sediment. While mine water serves to raise the concentration of metals in the receiving water, it also increases the pH and the concentration of other elements such as Ca and Mg, thereby reducing slightly the sterile nature of the acidic Wicklow mountain water.

2. Groundwater

No groundwater sources were sampled for the HMS-IRC project. Two samples from SP15 were subjected to a leachate test to determine a potential contaminated groundwater composition. One sample was of typical solid waste (GLD-LCH008), the other fine wash material (GLD-LCH007) (Fig. 3). The former had 1563 µg/l Pb, 679 µg/l Zn and 4.5 µg/l Cd. The latter had 270 µg/l Pb, 587 µg/l Zn and 4.1 µg/l Cd. Concentrations of Zn and Cd were notably higher in the seepage from the same waste heap (Table 2, 3). The leachate test releases metals held in secondary phases in the waste, i.e. in phases that are readily leachable in the short, five-minute period of the test. Interaction between water and minerals in the waste heaps is a much longer-lived process and these results suggest that under those conditions sphalerite, the main source of Zn and Cd, is leached to a greater extent.

3. Stream sediments

Stream sediment sampling is discussed in the Glendalough District report and samples from the Glendalough site are compared to those elsewhere in the district. Three stream sediment samples were collected at Glendalough (Fig. 3) and the two downstream samples show significant contamination by metals. The highest concentrations were measured in the sample furthest downstream at the entrance to the lake: maximum 6273 mg/kg Pb, 3328 mg/kg Zn and 278 mg/kg Cu. The elevated Cu is consistent with stream sediments elsewhere in the district but somewhat surprising at Glendalough since Cu does not occur in any significant concentration in mine water (Table 2, 3). The concentration of Pb at the entrance to the lake is very high and suggests the possibility that there is widespread contamination of sediment at the western end of the Upper Lake. This is potentially a threat to wildlife, particularly birds such as swans, geese and ducks..

4. Solid Waste

Field XRF analyses were carried out at 61 surface points on solid waste at the Glendalough site. Around half the analyses were of quartz- and granite-rich spoil, typical of the Glendalough District. The remainder were divided up between the tailings lagoon and the various waste types found in the processing area: stamp waste, crusher waste (20th-century operations), bubbles and fine material washed down onto the river bank (wash). The spatial distribution of the samples is shown on Fig. 3. Tables 4 and 5 and Fig. 4 summarize the data. The major elements detected were Pb and Zn, with lesser amounts of Cu and Cd. Sulphur is present in significant concentrations in some of the processing waste samples.

Fig. 4 shows the Pb distribution on the Glendalough site. The values shown relate only to the samples from Glendalough, i.e. samples from elsewhere in the district were not included when estimating quantiles. The highest Pb concentrations were measured in process waste, notably buddle, wash, stamps and crusher waste. The latter had the highest measured Pb concentration of all samples (19%) and the highest median Pb. This waste appears to have been generated in the period 1913-1925 when material was being reworked to extract Pb. The reworking of the waste, possibly involving some pre-selection of Pb-rich material, may have helped increase the relative Pb concentration of this material. Metal concentrations in spoil are typical of the concentrations measured elsewhere in the district (Table 5). The

median concentration of Pb in the tailings is above 1%. In common with tailings elsewhere in the district, the Glendalough tailings have a layer of grey, Pb-rich material at the base of the tailings column. The tailings in the lagoon have a thickness of the order of 1m or less.

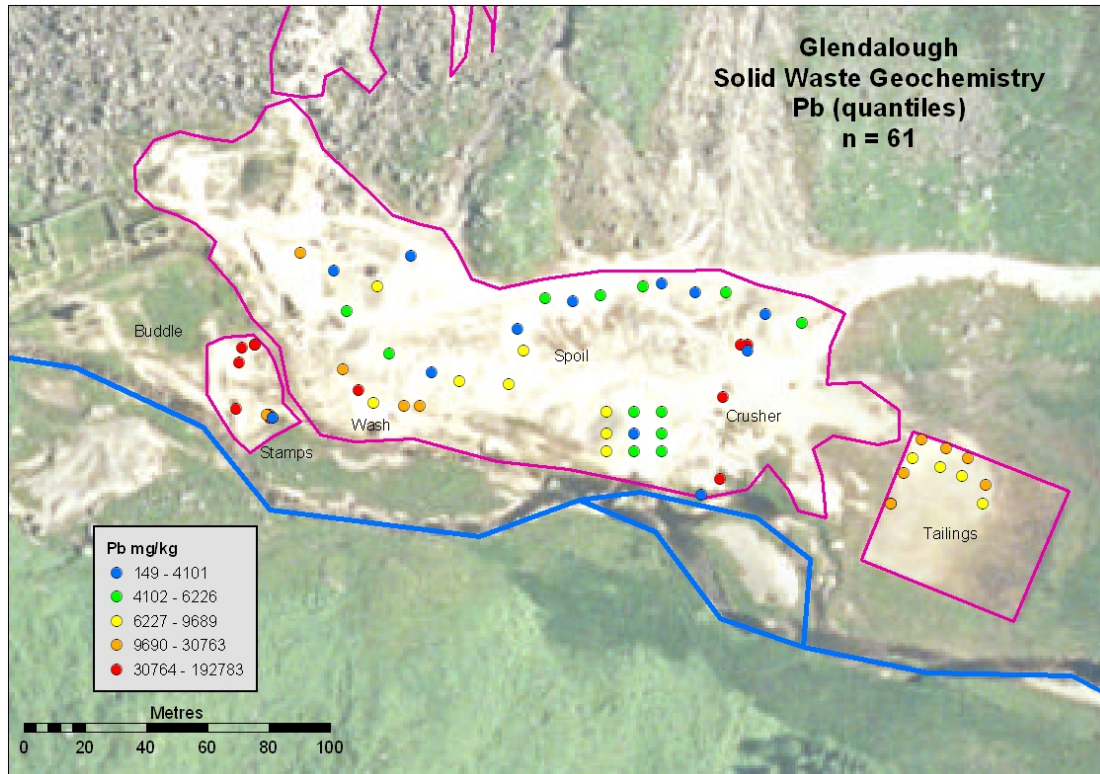


Fig. 4 Glendalough Solid Waste Geochemistry: Pb

Table 4: Summary statistics, field XRF analyses of solid waste, Glendalough

| mg/kg | Pb | Zn | Cu | Cd | S |
|---------|--------|--------|------|-----|-------|
| n | 61 | 61 | 61 | 61 | 61 |
| Minimum | 149 | 1601 | 0.0 | 0.0 | 0.0 |
| Maximum | 192783 | 110333 | 3174 | 446 | 30856 |
| Median | 8347 | 8794 | 343 | 60 | 0.0 |
| Mean | 26222 | 11069 | 553 | 76 | 3913 |

Note: 0.0 indicates < limit of detection

Table 5: Median values for different solid waste types, Glendalough

| mg/kg (median) | Pb | Zn | Cu | Cd | S |
|-----------------------|-----------|-----------|-----------|-----------|----------|
| Spoil (n = 29) | 4903 | 9653 | 213 | 56 | 0.0 |
| Crusher (6) | 101039 | 5296 | 1462 | 116 | 13024 |
| Buddles (5) | 59604 | 10194 | 734 | 96 | 8844 |
| Wash (5) | 29036 | 9026 | 831 | 64 | 8664 |
| Stamps (5) | 24776 | 6619 | 574 | 94 | 9214 |
| Tailings (11) | 11153 | 10635 | 367 | 47 | 0.0 |

5. HMS-IRC Site Score

Table 6 HMS-IRC Site Score, Glendalough Valley

| Waste | SP15a | SP15b | SP16 | SP17 | SP18 |
|-------------------------|--------------|--------------|-------------|-------------|-------------|
| 1. Hazard Score | 73 | 110 | 25 | 44 | 26 |
| 2. Pathway Score | | | | | |
| <i>Groundwater</i> | 3.28 | 4.62 | 1.02 | 1.35 | 1.08 |
| <i>Surface Water</i> | 21.65 | 38.68 | 4.57 | 6.14 | 4.86 |
| <i>Air</i> | 0.98 | 0.07 | 0.10 | 0.98 | 0.10 |
| <i>Direct Contact</i> | 3.55 | 0.26 | 0.35 | 3.55 | 0.35 |
| 3. Site Score | 29 | 44 | 6 | 12 | 6 |

| Waste | Van Diemen's | TA04 | W012 | Stream Sediments | Total |
|-----------------------------------|---------------------|-------------|-------------|-------------------------|--------------|
| 1. Hazard Score | 222 | 45 | 235 | 390 | 1170 |
| 2. Pathway Score | | | | | |
| <i>Groundwater</i> | 9.38 | 1.59 | 11.21 | | 33.52 |
| <i>Surface Water</i> | 2.80 | 11.30 | 40.11 | | 130.11 |
| <i>Air</i> | 0.05 | 0.19 | | | 2.46 |
| <i>Direct Contact</i> | 0.15 | 0.68 | | | 8.89 |
| <i>Direct Contact (livestock)</i> | | | | 156.02 | 156.02 |
| 3. Site Score | 12 | 14 | 51 | 156 | 331 |

The total HMS-IRC score for the Glendalough Valley site, including the Van Diemen's site, is 331 (Table 6). The largest single score for Glendalough Valley is that for stream sediments (156, or 47.3% of the total), reflecting contamination of over 700 m of stream bed by Pb and Zn at concentrations up to 6273 and 3328 mg/kg, respectively. The next highest contributor is the mine water discharge (51, 15.5%). The seepage from the waste heap (W012, Fig. 3) that flows into the river was used instead of the adit discharge for scoring purposes since this is the mine water that is observed discharging to the river. High concentrations of Pb (812 µg/l) and Zn (5037 µg/l) are responsible for the large relative score contributed by the discharge. It is likely that the adit discharge contributes to it, at least indirectly. The scores for the solid waste heaps on the Van Diemen's site have been merged for convenience. The nine small heaps have uniformly low scores, ranging from 1.1 to 1.3, giving an aggregate score of 9. The waste heaps SP16, SP17 and SP18 were not analysed – data from SP15a were used as a proxy to allow scoring of this waste. The main area of solid waste, subdivided into waste heaps SP15a and SP15b (Fig. 1), has a score of 73, making up 66% of the total score (111) contributed by solid waste. The relatively small SP15b (600 m³) has the largest individual solid waste score. This is a processing area with a median Pb concentration of 4.1%. The much larger SP15a

(27,187 m³) comprises quartz- and granite-rich waste of the kind common throughout the Glendalough District. Its median Pb concentration is 5,392 mg/kg (0.53%) and this difference in Pb concentration is the main reason why a waste heap as small as SP15b can have such a relatively large score. The tailings lagoon at the head of the Upper Lake contributes a score of 14, a relatively large score given its size – its median Pb concentration exceeds 1%. Fig. 5 illustrates the relative contributions of the different waste sources.

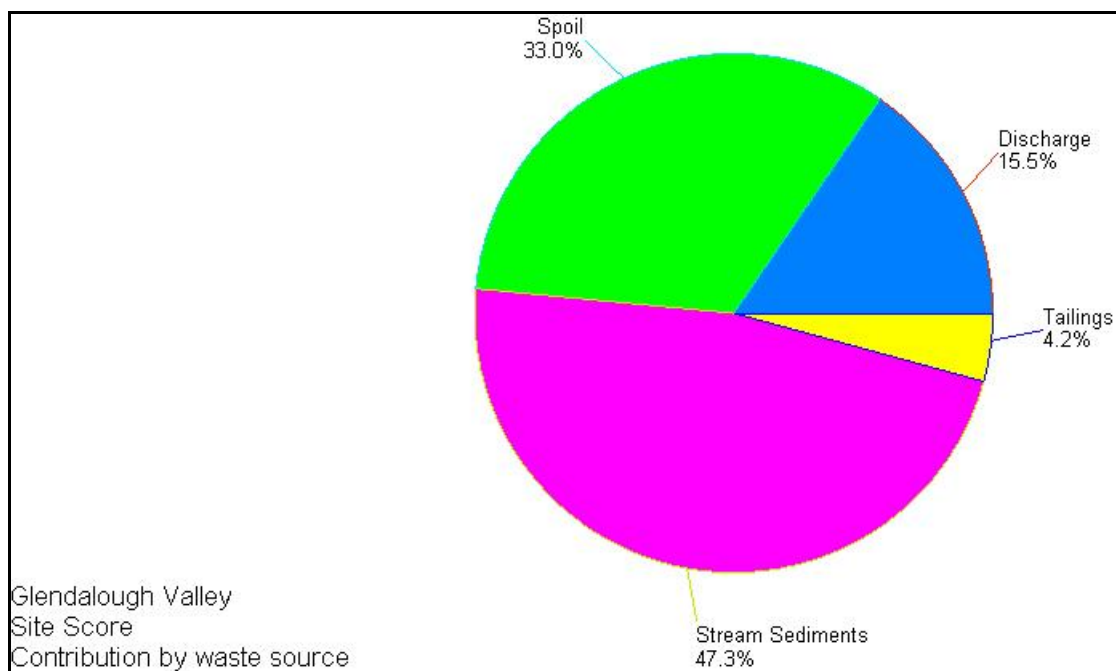


Fig. 5 HMS-IRC Site Score, Glendalough Valley: contribution by waste source

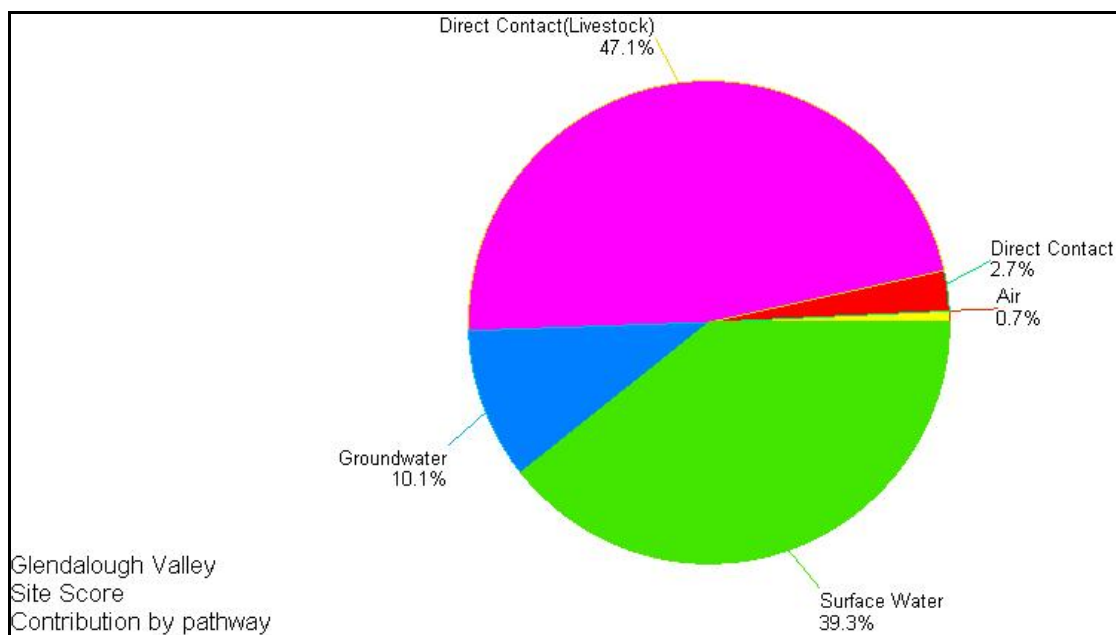


Fig. 6 HMS-IRC Site Score, Glendalough Valley: contribution by pathway

Fig. 6 shows the contribution of the different pathways to the total site score at Glendalough Valley. Pathways are the routes by which receptors are exposed to the

hazard. The location of the site on the banks of a river combined with poor aquifer quality and a low population density, and hence low number of wells, means that the surface water pathway (39.3%) dominates the groundwater pathway (10.1%). Stream sediments (Direct Contact, livestock) account for almost half of the pathway score.

6. Geochemical overview and conclusions

The Glendalough Valley site contains a large volume of solid waste, some of which is processing waste containing very high concentrations of Pb, Zn and other metals. Most of the solid waste chemistry is typical of quartz-rich mine waste found in the district, with Pb concentrations typically of the order of 5000 mg/kg. However, Pb concentrations in processing waste can exceed 4%. Water seeping from the solid waste heap has high Pb (812 µg/l) and Zn (5037 µg/l). Discharge of this water to the Glenealo River contributes directly to contamination of the river water, although it recovers quickly downstream. Stream sediments in the river are seriously contaminated, however, with concentrations of Pb in excess of 6,000 mg/kg at the point of discharge to the Upper Lake. The HMS-IRC Site Score for the Glendalough Valley is 331.