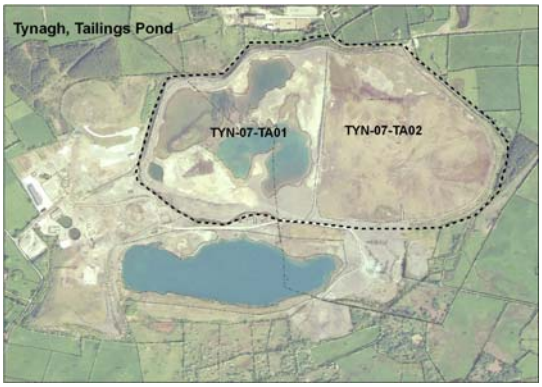
Tynagh – Tailings Pond

Background information



Mine Name: Tailings Pond

Mine District: Tynagh

Alternative Names: TMF

Elements of Interest:
Zn, Pb, Cu, As, Ni, Cd, Ba

Project Prefix: TYN-TA

County:	Townland:	Grid Reference:
Galway	Derryfrench, Garraunnameetagh	E175142, N213129

Site Description and Environmental Setting

The Tynagh Tailings Pond, or Tailings Management Facility (TMF), site covers just over 58 ha. It is bounded to the east and northeast by a public road and farmland. To the north is the former Milchem plant, now a private equestrian centre. To the west and south lie the remainder of the mine site (Fig. 1).

The walls of the TMF are impervious earthen dykes. No liner was used. The TMF comprises two cells separated by a semi-permeable dyke. Fine tailings, or slimes, were pumped to the centre of the pond while sandy tailings were spread around the periphery. The western cell (TA01) is unvegetated (photo, right) and partly flooded (right), with a permanent wetland occupying the northwest side (Fig. 1). In the latter part of the mine's life, tailings containing 30 – 50% barite, were being removed from this cell by Milchem for barite recovery and the eastern cell (TA02) was the main repository for tailings then being produced by the mine. As a consequence the eastern cell is higher than the western cell and water drains through the semi-permeable barrier that separates the two cells, flooding the western cell. At the southwestern end of the western cell is the clean water pond, a deep pond that was used to store water used in mine processing. The pond still contains the remains of a decant tower.

The eastern cell has undergone revegetation and is largely covered by grass. A thin layer of soil rests on the tailings (photo, left). Attempts at growing trees on the south side had only limited success. The cell is prone to seasonal flooding, especially in the northwest corner.

The TMF comprises the single largest accumulation of mine waste on the Tynagh site. The combined volume of waste in the two cells is estimated to be in excess of 2.2 million m^3 (Table 1). In addition, the TMF discharges leachate at three known points along its base, one on the northern side and two on the eastern side (Fig. 1). The volume of each of these discharges did not exceed 1 l/s when examined during the project.

Table 1 Area and volume of the TMF, Tynagh

Waste ID	Area (m^2)	Volume (m^3)
TYN-TA01	261915	8887713
TYN-TA02	253462	1396365

Geochemical assessment

1. Surface Water

Surface water analyses for streams around Tynagh are discussed in the overall site report ("Tynagh Mine"). Only one TMF discharge was sampled in February 2007 (W014, Fig. 2), discharging directly into the Barnacullia stream on the northern side of the TMF) but all three were sampled in June 2007. The other two discharges issue from the eastern side, one to a sinkhole (W027, Fig. 2) and the other (W028, Fig. 2) to a surface stream. The flow rate for each discharge was less than 1 l/s. In summer, the pH of the discharges ranged from 7.3 to 8.0 and EC from 0.98 to 1.68 mS/cm. The latter reflects the high concentration of Zn (550 – 4753 µg/l) and SO_4 (336 – 856 mg/l). Metals such as Ni (15 – 156 µg/l), Cu (40 – 41 µg/l) and Cd (<0.4 – 3 µg/l) were also detected in significant amounts. The highest values of Zn, Ni and SO_4 were measured in discharge W014. The concentration of Zn, Ni and Cd significantly exceed the Draft EC Environmental Objective (Surface Water) Regulations. Pb (2 – 3 µg/l) and As (<1 – 2 µg/l), both present in high concentrations in the solid waste at Tynagh, were present in relatively low concentrations in the discharges in summer.

Discharge W014 was also sampled in winter (February 2007) when the flow rate was significantly higher but still below 1 l/s. Concentrations of metals were broadly similar, e.g. Zn (5757 µg/l) and Ni (177 µg/l). A notable difference was higher As (9 µg/l).

Two samples of water were taken from the surface of the TMF in the southwestern corner of the site in both winter and summer (Fig. 2). The westernmost sample (W016, Fig. 2) was from a narrow neck of water connecting the ponded water on the northwestern side of the TMF with the mine's clean water reservoir south of it (photo, right). The other sample (W008, Fig. 2) was from a small pond that appears to collect run-off and seepage from the TMF along its southern boundary. Levels of metals in these samples were generally lower in summer than in the TMF discharges (W014, 27, 28, Fig. 2) though one sample (W016) had 13 µg/l Cd and 40 µg/l Pb. Zn exceeded 1000 µg/l in both. In winter, metal concentrations

were significantly higher in both samples: W016 had 29 µg/l Cd and 3522 µg/l Zn, W008 had 3176 µg/l Zn.

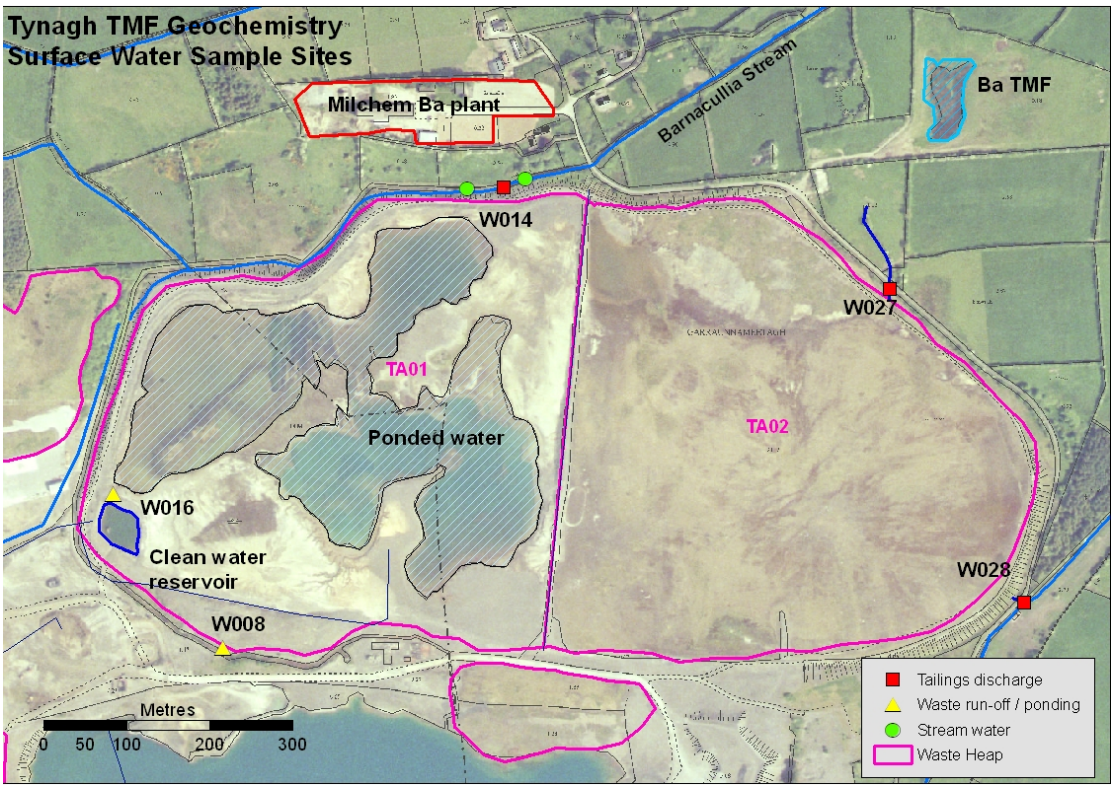


Fig. 1 Surface water sample sites, Tynagh TMF

2. Groundwater

Groundwater chemistry is discussed in the overall site report. As a proxy for groundwater in the risk-ranking exercise, four leachate samples were prepared from composite tailings samples, three from the western cell and one from the eastern cell. The leachate sample from the revegetated tailings in the eastern cell contained elevated values of Ba (169 µg/l) and somewhat elevated Pb (31 µg/l) and Zn (40 µg/l). Of the three samples from the western cell, two from the northern part had low Ba (28 – 36 µg/l) but higher concentrations of Pb (80 – 109 µg/l) and Zn (223 – 1810 µg/l) as well as elevated Cd (23 – 27 µg/l). The sample from the southern part of the cell had low Pb and Zn (10 and 14 µg/l, respectively) but high Ba (365 µg/l). These leachate tests demonstrate that there is potential for groundwater contamination by Pb, Zn, Cd and Hg below the tailings pond.

3. Stream Sediments

Stream sediments assessments are discussed in the overall site report for Tynagh.

4. Solid Waste

Sixty *in situ* XRF analyses of solid waste were taken on the tailings pond at Tynagh (Fig. 2 – 4). These were mainly taken on surface points but included a number of vertical profiles. Tailings at Tynagh are either sandy or silty (slimes). Though most have a grey-brown colour there is significant horizontal and vertical colour variation that corresponds, in places, to chemical variation. Thus along the northern

embankment in the western TMF cell three samples of yellow-green tailings had measured Pb of 3 – 5% but relatively low Zn and Ba (Fig. X2, X3, X4). In general, however, colour variation does not necessarily imply compositional variation in the tailings.

Table 2 summarizes the data for all *in situ* tailings analyses. The median values for Pb, As and Ba are particularly high, while both Cd and Sb were detected in over half the sites. As with all XRF analyses, caution is required when interpreting very high measured element concentrations. Where measured Pb exceeds 1%, As concentrations tend to be exaggerated in XRF analyses. Samples from 13 tailings sites were returned to the lab for grinding and lab analysis by XRF in GSI and by MA-ES in an external laboratory. In general, the MA-ES analyses confirmed the high Pb and As levels measured by GSI XRF in the lab and field. However, they also suggested much lower Ba concentrations (78 – 4290 mg/kg) than measured by the GSI XRF (14352 – 98483 mg/kg). This large disparity is specific to Tynagh samples – Ba measured in other check samples generally showed reasonable agreement between XRF and MA-ES analyses. For standards analysed, in which the Ba concentration was less than 1000 mg/kg, the XRF analyses were in reasonable agreement with accepted standard concentrations. Moreover, the XRF spectra for samples with measured high Ba show strong Ba peaks, clearly indicating that these samples do have high Ba contents, as would be expected for tailings that originally contained up to 50% barite. The upper calibration limit for Ba in MA-ES analyses is 5000 mg/kg and it may be that the disparities observed at Tynagh are a consequence of unusually high Ba concentrations and inadequate calibration.

Table 2 Summary statistics for tailings analyses, Tynagh

mg/kg	Pb	Zn	Cu	As	Ni	Cd	Sb	Ba
n	60	60	60	60	60	60	60	60
Minimum	402	347	58	0.0	0.0	0.0	0.0	3621
Maximum	53070	43112	4241	5175	388	269	2446	71306
Median	13100	4468	950	1054	0.0	40	471	23381
Mean	14165	10381	1258	1307	8.6	59	519	29909

The most striking compositional variation in the TMF is between the east and west cell. Concentrations measured in the east cell are almost uniformly low for all elements, with most values in the lower 20% quantile (Fig. 2 – 4). Revegetation of the east cell may have influenced the measured concentrations, either through chemical changes during amelioration prior to planting or subsequently during the growth phase. However, the difference may reflect the original composition of the tailings. Chemical variation within the west cell demonstrates that compositional variation of this kind is to be expected across the TMF. High Pb concentrations in the tailings of the west cell reflect the difficulty of extracting metals fully from the supergene, oxidized ore that formed the upper part of the ore body.

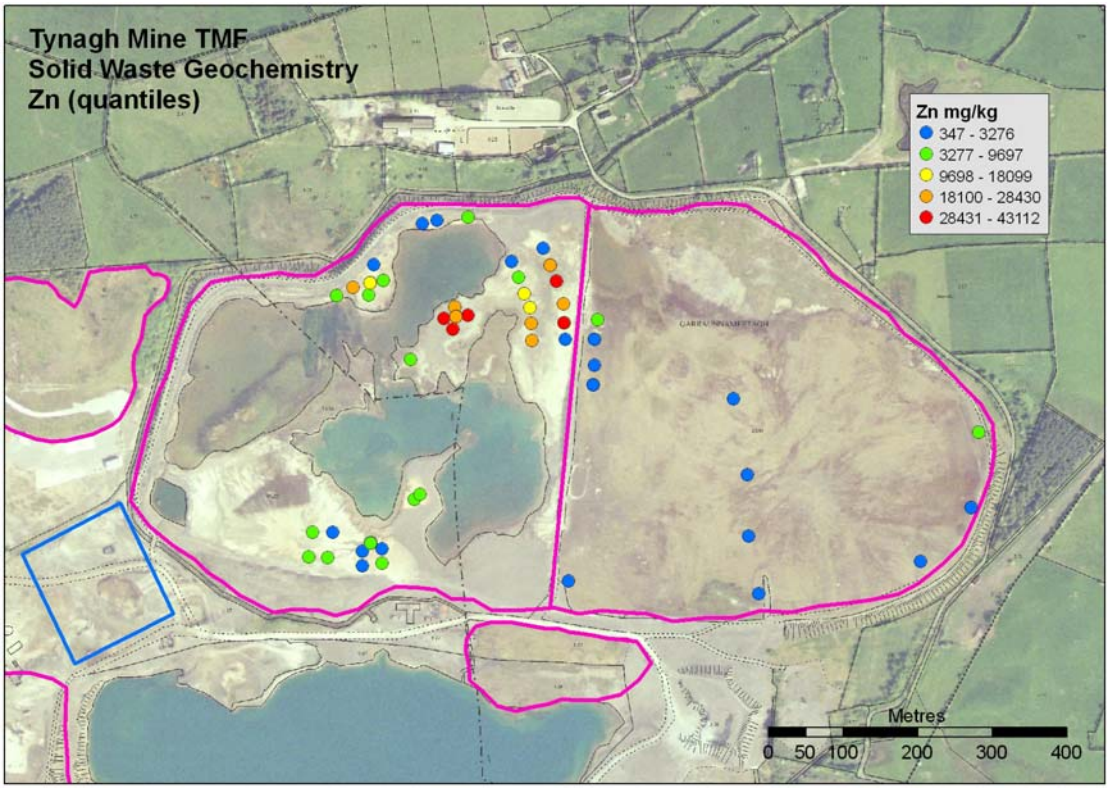


Fig. 2 Pb distribution in tailings samples, Tynagh

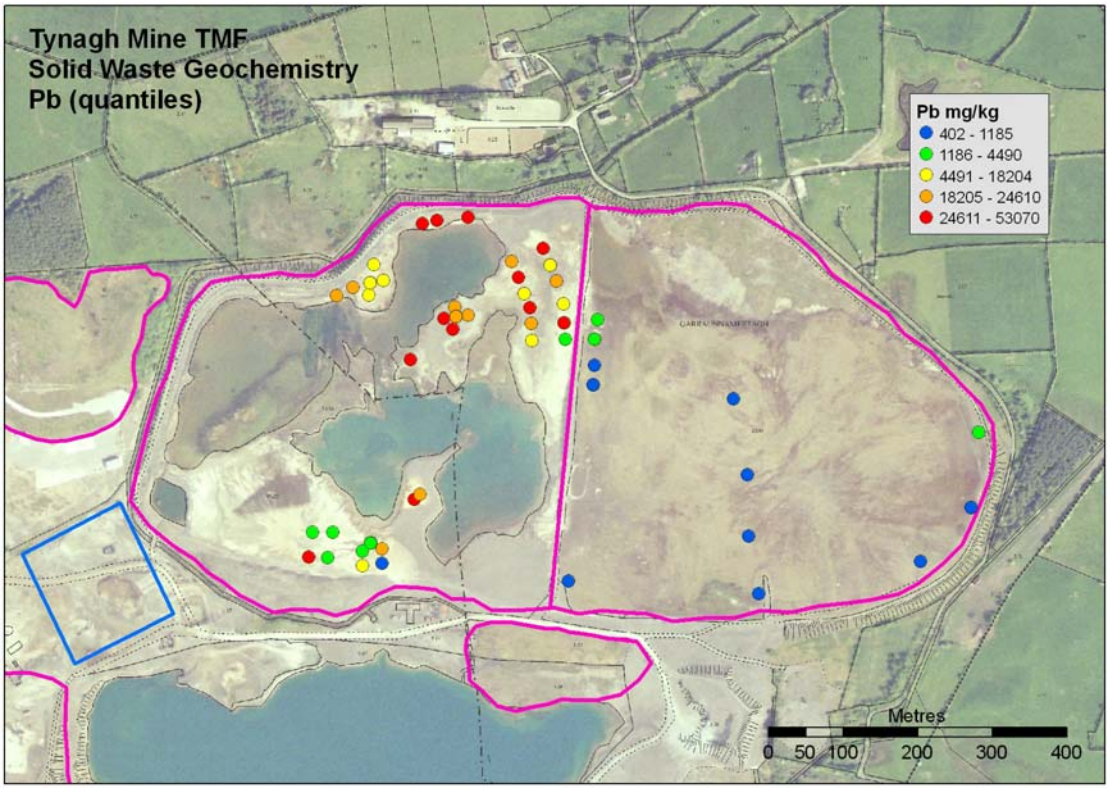


Fig. 3 Zn distribution in tailings samples, Tynagh

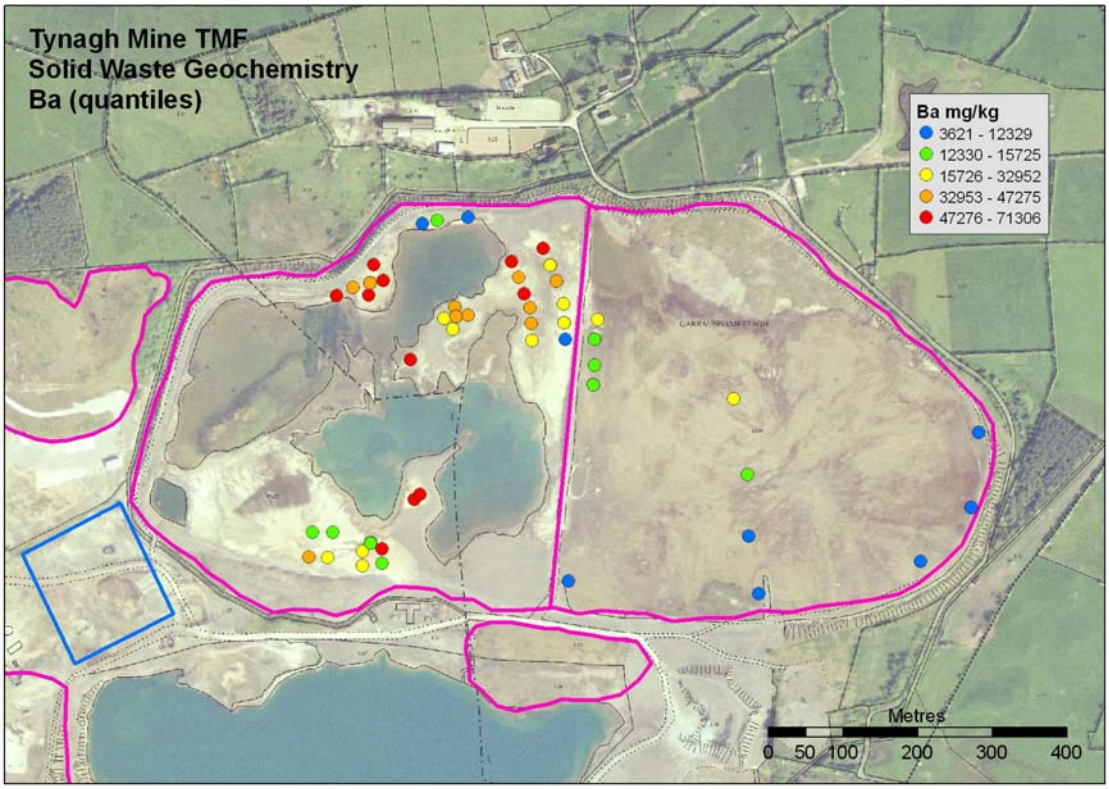


Fig. 4 Ba distribution in tailings samples, Tynagh

5. HMS-IRC Site Scores

Table 3 HMS-IRC Site Scores, Tynagh TMF

Waste	TA01	TA02	W014	W027	W028	Totals
1. Hazard Score	**4911**	**269**	**30**	**15**	**12**	**5237**
2. Pathway Score						
Groundwater	674.89	32.66	3.10	0.59	0.28	711.24
Surface Water	374.67	20.93	7.85	4.38	3.74	407.28
Air	57.64	0.04				57.68
Direct Contact	63.41	2.53				65.94
3. Site Score	**1,171**	**56**	**11**	**5**	**4**	**1246**

The total site score for the TMF site at Tynagh is 1246 (Table 3). Almost 94% of this score is contributed by the western cell of the tailings pond and 98.5% by both cells together. The very high score for the western cell reflects the very high metal concentrations, chiefly Pb, measured, the large volume and surface area and the lack of any rehabilitation of the waste, e.g. vegetation. The eastern cell contributes a much lower score because of the much lower concentration of metals measured. It is possible that the surface chemistry of the eastern cell is lowered as a consequence of revegetation and other efforts at amelioration and that metal concentrations are much higher at depth. If so, the total score for the eastern cell of the tailings pond is an underestimation. The three discharges/seepages from the tailings pond contribute modest scores to the total. These reflect both the low volumes of the discharges and their chemistry, specifically the fact that, of the elements considered to have the highest relative toxicity in the scoring system (As, Cd, Cr, Pb, Hg, Ni, Sb, U) only Ni is present in significantly elevated concentrations.

Fig. 5 shows the contribution of the different pathways to the total site score for the Tynagh TMF site. Pathways are the routes by which receptors are exposed to the hazard. The groundwater pathway dominates the scoring, accounting for almost 60% of the total score. The relatively large number of wells in the vicinity, as estimated from CSO statistics, and the high volume/area ratio of the tailings pond waste are the main reasons why the groundwater pathway predominates. Although the proportional contribution of both the direct contact and air pathways are modest relative to the other pathways, both contribute a significant absolute score (Table 3). For example, the direct contact pathway score (65.9) is almost identical to the total score (64.5) contributed by all pathways in for the tailings pond at Avoca (Shelton Abbey report). The unusually high relative air pathway score reflects the large exposed surface area on the western cell of the tailings pond.

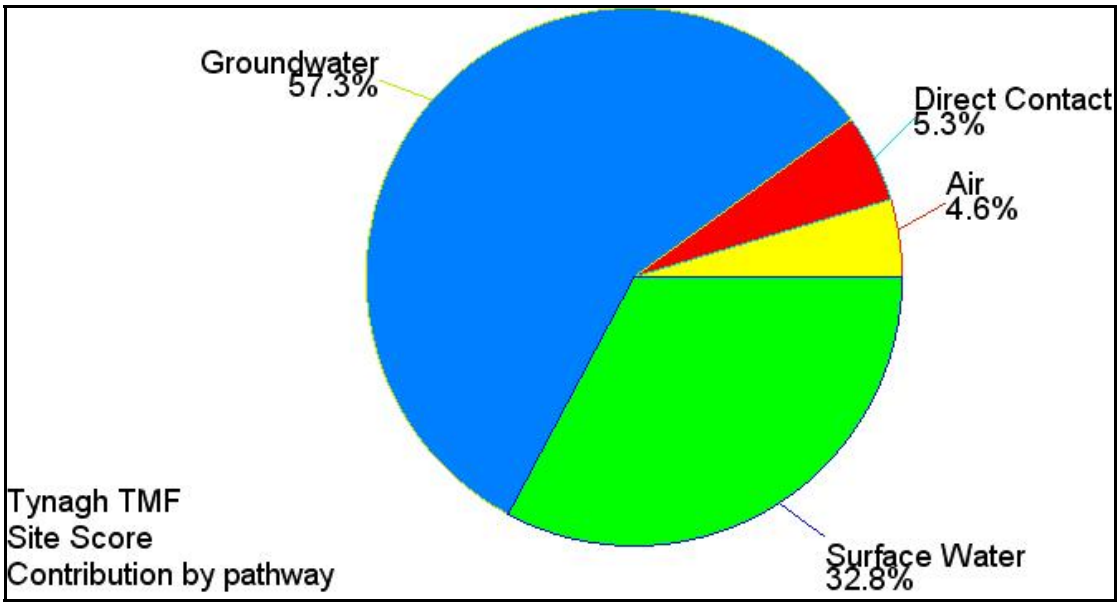


Fig. 5 Site Scores, Tynagh TMF: contributions by pathway

6. Geochemical overview and conclusions

The TMF at Tynagh has an estimated volume of more than 2.2 million m^3. High metal concentrations in the unvegetated western TMF cell give rise to a very high site score for this site.

Three discharges from the TMF enter local streams and, in one case, the groundwater system via a sinkhole. The discharges have high concentrations of Zn, Ni and SO_4 and elevated Cd and As. As expected for a limestone-hosted ore deposit, the pH of the discharges is high and there is no risk of acid mine drainage at Tynagh. Leachate analyses of tailings samples confirm the potential for groundwater contamination below the unlined tailings pond.

The tailings in the western cell have very high concentrations of Zn, Pb, Cu, As, Ni, Cd, Sb and Ba. Those in the revegetated eastern cell have much lower measured metal concentrations. The high site score reflects these high metal concentrations and the very large volume of the TMF.