ABBEYTOWN MINE

Background information

Mine District: Abbeytown

Mine Name: Abbeytown

Alternative Names:

Elements of interest:
Pb, Zn, Ag, Cu, As, Ni, Hg

Project Prefix: ABB-

County:	**Townland:**	**Grid Reference:**
Sligo	Abbeytown	E165991, N329711

Introduction

Abbeytown mine is located immediately west of Ballysadare village on the south shore of Ballysadare Bay in Co. Sligo, 6 km south of Sligo town. The site as defined (Fig. 1) covers approximately 30 ha. The mine was last worked in 1961 and since then has been largely subsumed by a large limestone quarry that now extends beyond the original boundaries of the mine site. None of the original mine buildings remains. The major extant surface feature at Abbeytown is the tailings pond, its surface now covered by soil and hardcore and in use for various quarry-related works. During the last period of mining a major tailings spill created a large fan of contaminated material on the foreshore. Since this is an active quarry site and subject to monitoring by Sligo County Council, work under the HMS-IRC project was largely confined to the tailings pond and the contaminated material on the foreshore.

Geology and Mineralization

The mineralization is hosted by the Lower Carboniferous Abbeytown Limestone Formation, a transgressive carbonate sequence of calacarenites, shale and sandstones, and the overlying Ballyshannon Limestone Formation, comprising thick-bedded calcarenites. The Abbeytown Limestone Formation unconformably overlies the Precambrian to Cambrian metasedimentary basement of the Ox Mountains Inlier. Three main mineralizing events were recognized by Hitzman (1986). The first resulted in dolomitization of the host rocks along two NNE-SSW-trending fracture zones. Pyrrhotite (FeS) and pyrobitumen were deposited in this phase. The second and main mineralizing event produced dedolomitization and precipitation of marcasite (FeS_2), pyrite (FeS_2), chalcopyrite ($CuFeS_2$), sphalerite (ZnS) and galena (PbS) in the form of stratabound replacements, veins and internal sediments. They were best developed in highly permeable rocks such as calcareous sandstones and adjacent to impermeable shale beds. The third event saw the formation of calcite-pyrite breccias. The mineralization has been related to extensional movement on two faults that terminated in the Abbeytown area. The textures and timing of the mineralization relative to the host-rock suggests that Abbeytown can be classified as an MVT deposit.

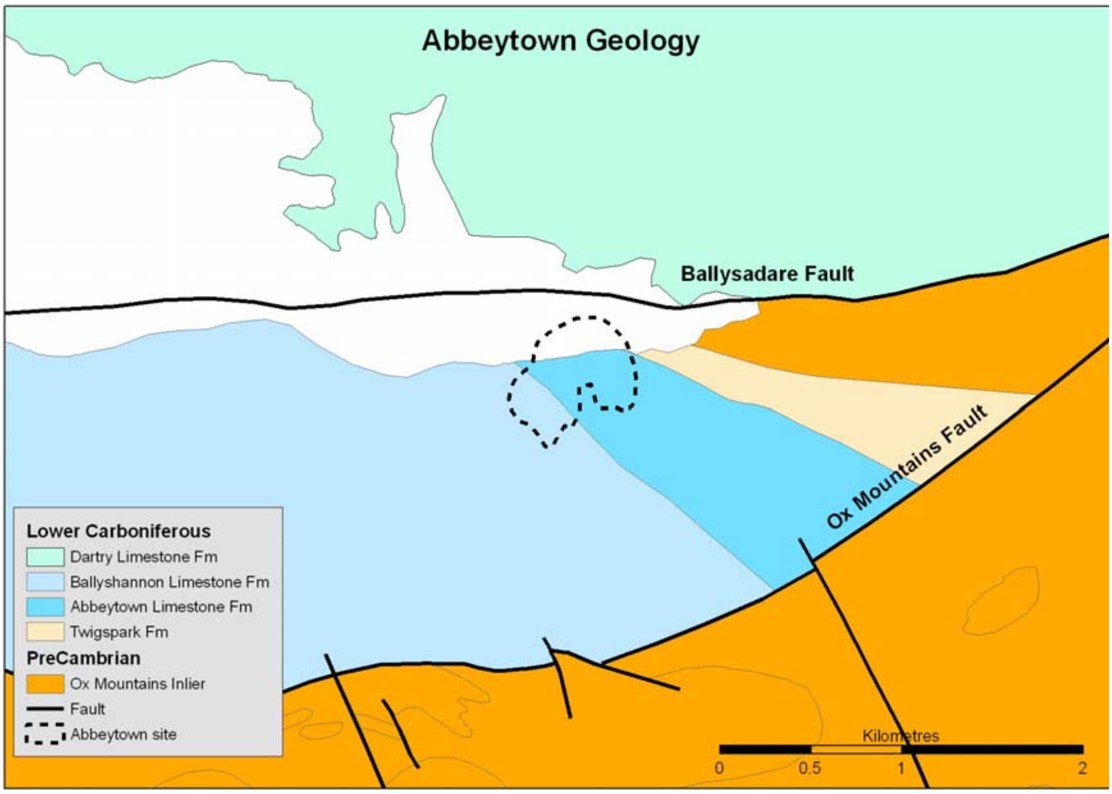

Fig. 1 Geology of area around Abbeytown Mine

Mining History and Production

Abbeytown was originally mined for silver as well as lead and zinc. The earliest documented workings were in the 18th century, though it is likely that the monks from the adjacent abbey mined the deposit at an earlier date. Production in the 18th century was intermittent – for example, in 1790 20 tons of ore at a grade of 40 oz of silver per ton were produced. The ore was crushed by a horse-driven millstone and smelting carried out on the spot. However, the mine closed the following year and there is no record of production until the 1870s when a group of local merchants reopened the mines. Hundreds of tons of ore were produced in this period and again between 1917 and 1921, partly using grants from the state. In the aftermath of the Second World War, metal prices were controlled and, as a consequence of demand, very high. JCI, a mine finance house, purchased the deposits and began producing ore from surface dumps in 1950. But lead and zinc metal prices were decontrolled in 1952-53 and subsequently fell. JCI mined underground in search of richer ore but its operation was always marginal as ore grades rarely matched expectations created by test drills. At its peak, it produced 280-300 tons of ore per day. Abbeytown was a small mine by comparison with Ireland's modern zinc-lead mines, such as Tara and Lisheen. It closed in 1961 after exhaustion of the main ore zone. Total production was around 1.1 Mt of c. 1.5% Pb, 3.8% Zn and 40-45 g/t Ag.

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Site Description and Environmental Setting

The site today has three main components remaining from the 1950s mining period (Fig. 2): (1) the TMF, now partly revegetated and partly used as a host for quarry settling ponds; (2) the tailings spill on the foreshore and (3) the extant underground mine workings, accessible through the modern quarry. The 1950s open pit has now been subsumed by the modern quarry.

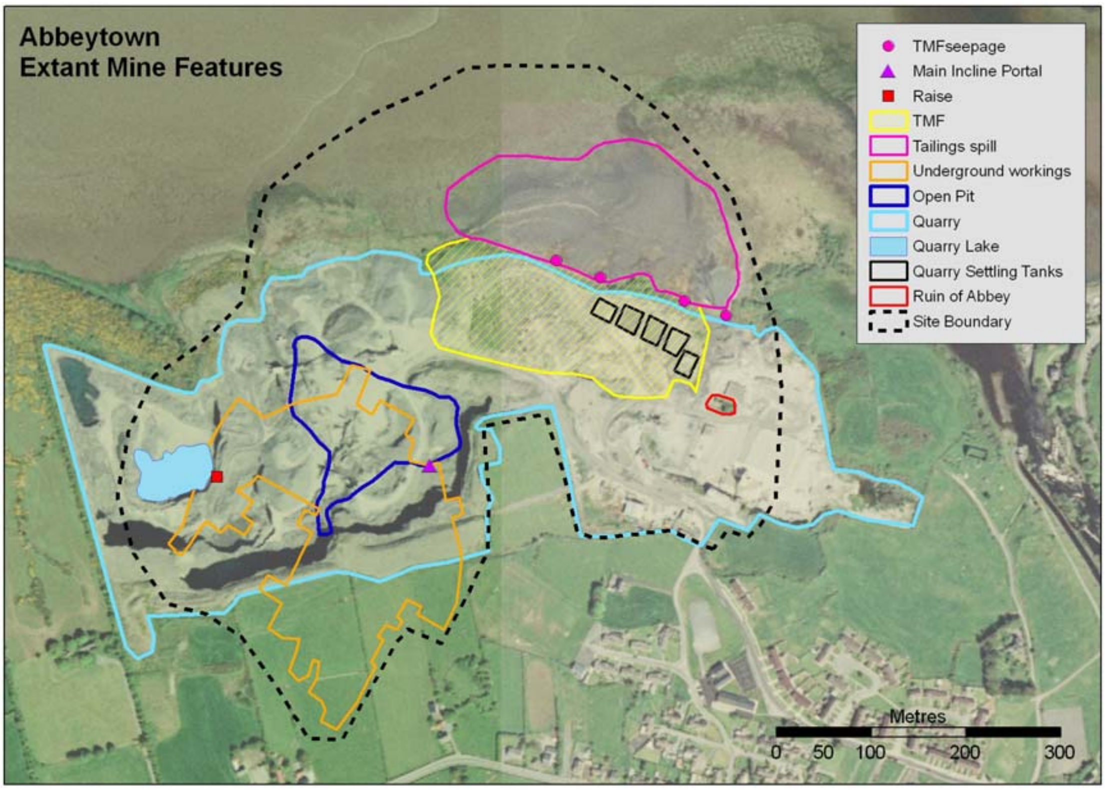

Fig. 2 Abbeytown: extant mine features

Solid mine waste on the site consists mainly of the tailings pond itself and the tailings spilled onto the foreshore during operation of the mine. Small amounts of spoil in the form of large boulders of mineralized or altered rock can be found in the inactive parts of the modern quarry site but these have not been assessed. Table 1 gives the estimated volumes of the tailings. The tailings spill on the foreshore immediately north of the tailings pond (right) is at least 2m thick near the mine. A vertical section sampled 100m north of the tailings pond contained a minimum 1.5m thickness of tailings-rich material and the volume in Table 1 has been modelled on this basis. Apart from solid waste, several orange-red discharges from the base of the tailings pond flow across the foreshore and into the Ballysadare Bay. One of them emerges from a cracked pipe and appears to have been installed as a drain in the tailings pond. The others are seepages that have escaped the pond via beaks in the seal.

Table 1 Area and Volume of tailings, Abbeytown mine

Waste ID	Volume (m^3)	Area (m^2)
ABB-07-FS	68,958	34,479
ABB-07-TA	136,141	19,611

Geochemical Assessment

1. Surface Water

Surface water sampling was carried out in both winter (February 2007) and summer (August 2007) seasons at a total of 3 sites (Fig. 3). Two tailings pond discharges were sampled (right) on both occasions. In winter, an additional site, where the tailings discharge entered the water of the bay, was sampled. Low tidal conditions precluded sampling of this site in summer.

The pH of the discharge samples ranges from 7.1 to 7.7 and EC is relatively high (1.3 – 1.9 mS/cm). The EC reflects the levels of metals in the discharge (Table 2): As, Pb, Ni and Zn are all present in high concentrations while Cd, Cr, Cu, Mo and U were consistently detected, albeit at concentrations typically below 10 µg/l. Sulphate concentration in the discharges ranged from 418,000 to 870,000 µg/l, suggesting a significant sulphur content in the tailings.

The sample taken from the point where the discharge enters the bay was a mixture of tailings discharge and estuarine water. Despite the dilution involved, the sample still contained significant concentrations of metals (Table 2). However, the amount of water discharged is low, with the combined volume probably not exceeding 1 – 2 l/s (visual estimate).

The tailings spill on the foreshore is also a significant volume of mine waste. This material is a potential contributor of metals to the waters of the bay owing to the action of the tidal waters. However, a leachate test on a composite sample of the tailings spill yielded only 8 µg/l Pb and 12 µg/l Zn. While these values are low relative to the concentrations of these metals in the in the parent material they nevertheless suggest the possibility that interaction between the tailings spill and tidal waters could increase the content of metals in the waters of the bay.

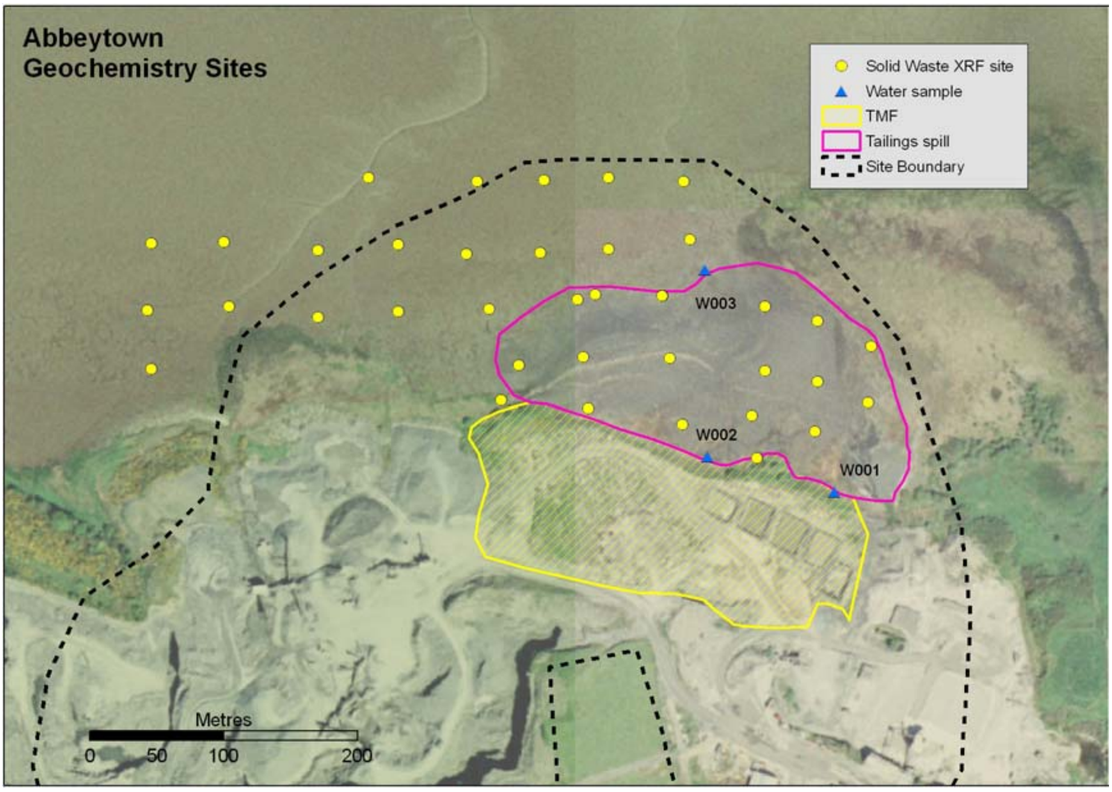

Fig. 3 Geochemistry sample sites, Abbeytown

Table 2 Summary of water geochemistry, Abbeytown

µg/l	As	Cd	Pb	Ni	U	Zn
TMF Discharge						
Winter	0 - 38	0 - 10	7 – 14	157 - 263	7 – 10	5463 - 9121
Summer	3 - 106	2 - 5	24180 - 24210	110 - 208	4 – 5	3511 - 4580
Bay						
Winter	5	0	8	192	8	3772

Note: "0" = <DL

2. Groundwater

No groundwater was sampled at Abbeytown for the HMS-IRC project. The chemical composition of the tailings pond discharges indicates the potential for groundwater contamination by tailings leachate if it were to seep into an aquifer.

3. Stream Sediments

There are no streams in the vicinity so no stream sediment samples were collected.

3. Solid Waste

The tailings spill on the foreshore was analysed *in situ* by XRF in August 2007 to assess the extent of contamination in the bay. The aerial photograph (Fig. 1) provides an indication of the extent: a distinctive grey-brown colour forms a 300m-wide fan-shaped area north of the tailings pond. This, as well as field observation, forms the basis for the definition of the boundaries of the tailings spill on Fig. 1. However, action by tides can be expected to have dispersed at least some of this material further into the bay to a degree not apparent from aerial photographs. Moreover, it became clear during sampling that a thin layer of brown estuarine mud now covers dark grey material in some of the sites to the west of the spill area outlined in Fig. 1 (right). In appearance, this dark grey material resembled the tailings material to the east. All analyses were carried out on the grey material below the layer of mud.

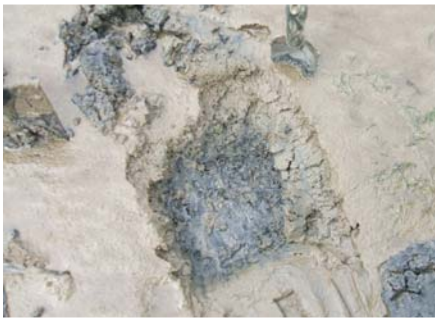

Fig. 4 shows the distribution of Pb in the samples analysed, indicating that the extent of contamination extends at least 100m further west than the boundaries drawn from aerial photographs and initial visual inspection. Some caution is needed in respect of these analyses since the *in situ* samples were often quite wet, particularly those to the north and west. The area immediately north of the tailings pond is drier because it is raised above the level of the original foreshore as a consequence of the tailings spill, so it is normally not covered by the tide. One possible effect of this is to dilute the concentrations of elements in the samples taken from wetter areas to north and west. A comparison of one sample analysed *in situ* by XRF (50 mg/kg) and after drying by MA-ES (98 mg/kg) does indeed suggest some dilution but not sufficient to revise the conclusion that Pb concentrations decline sharply in the west. A similar distribution is apparent for Zn (Fig. 5).

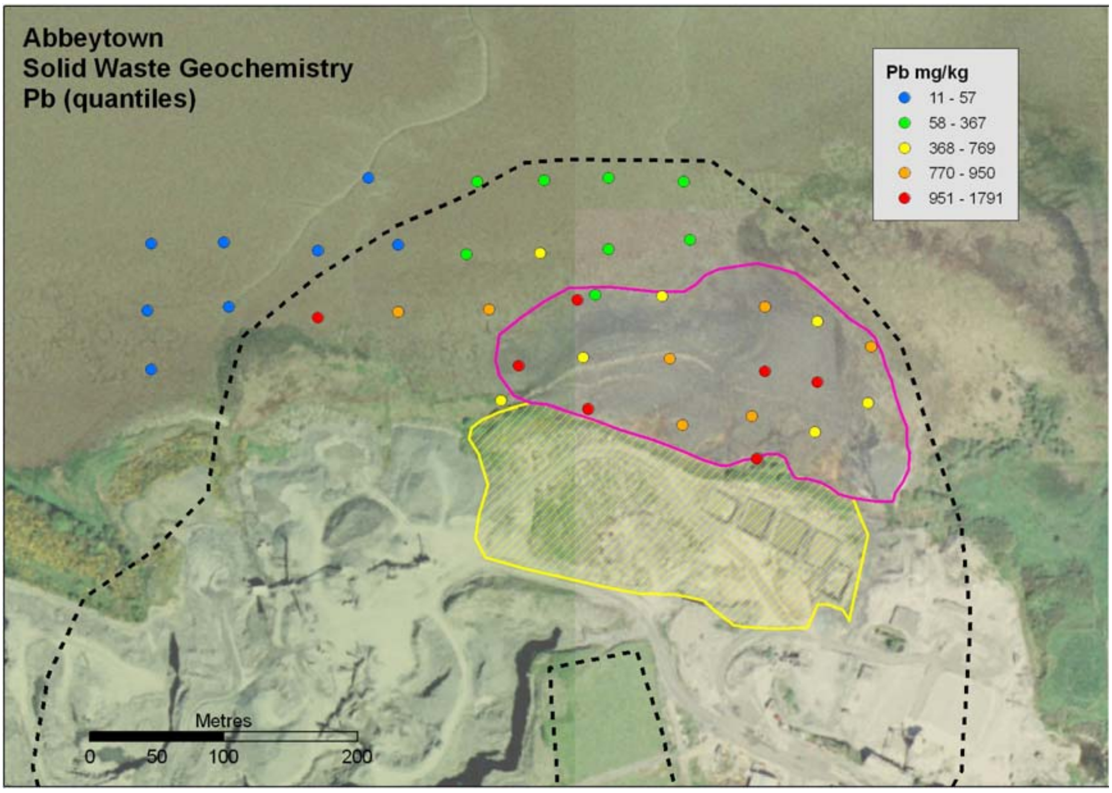

Fig. 4 Solid Waste Pb XRF analyses, Abbeytown

Table 3 summarizes the data for the *in situ* analyses. Apart from Pb and Zn, only Cu among metals was consistently detected in the field analyses. Analyses of five dried and ground samples by MA-ES indicated Cd concentrations up to 18 mg/kg and up to 1.5% S. Other elements detected at relatively high concentrations in the tailings discharge, such as Ni and Cr, were measured at less than 40 mg/kg by MA-ES.

Table 3 Summary statistics of *in situ* solid waste XRF analyses, Abbeytown

mg/kg	Pb	Zn	Cu	As
n	37	37	37	37
Minimum	12	24	0.0	0.0
Maximum	1791	3597	321	101
Median	604	782	53	0.0
Mean	598	906	60	7

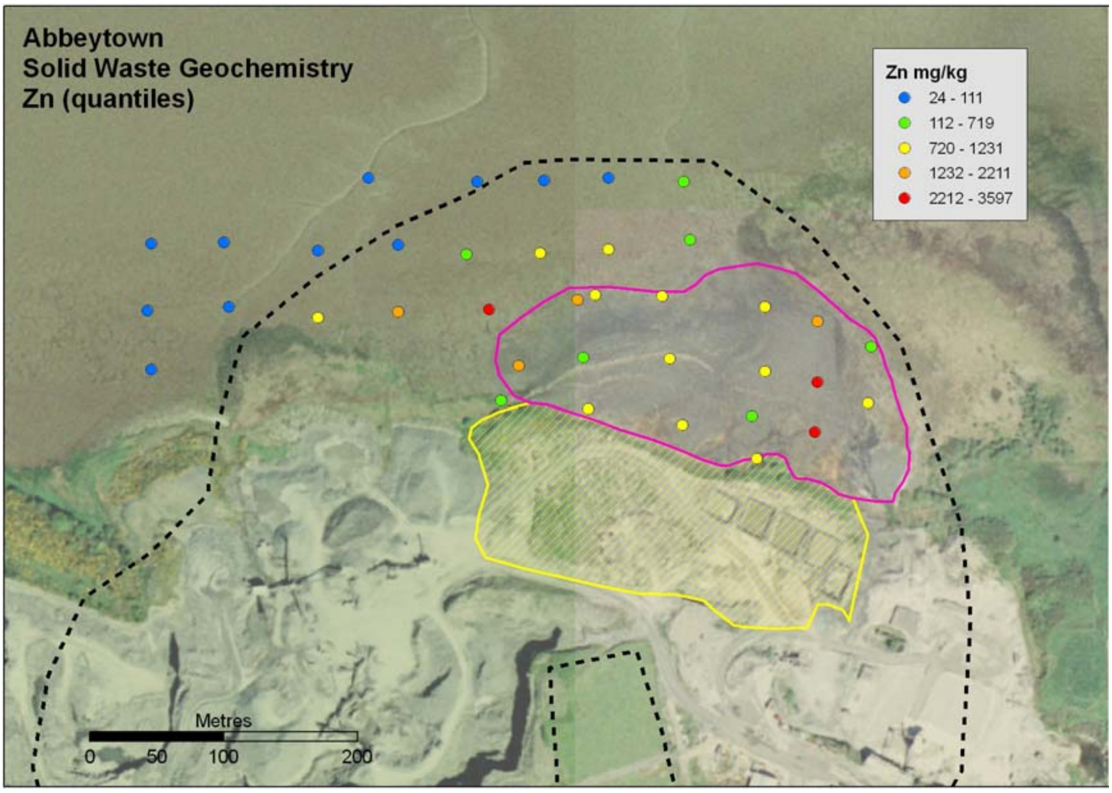

Fig. 5 Solid Waste Zn XRF analyses, Abbeytown

Some additional sampling was carried out on the tailings spill area in October 2006. High levels of As and Ni were measured where the tailings pond discharges flow across the tailings spill material. Here the tailings spill material is discoloured orange-red by the discharges. One dried sample of discoloured tailings spill material yielded 252 mg/kg Hg and 1314 mg/kg Ni. A dried sample of orange-red precipitate, taken from the main tailings discharge (the western location on Fig. 3), yielded very high concentrations of As (4968 mg/kg), Ni (678 mg/kg), Sb (496 mg/kg) and Hg (117 mg/kg).

5. HMS-IRC Site Score

The total HMS-IRC Site Score for Abbeytown is 70 (Table 4), placing it in the lowest Class V. For a 20th-century mine site where Pb was the major product, this may appear as a somewhat anomalous finding. In part the low score reflects the fact that the tailings pond was not drilled so the chemical composition of the material on the foreshore, a mixture of tailings and estuarine sands and silts, was used as a proxy for the composition of the tailings. This may significantly understate the concentration of Pb and other metals. However, the low ranking for Abbeytown cannot be explained simply as a consequence of this. The volume of tailings in the tailings pond (136,141 m^3) is small relative to that of other sites, e.g. Tynagh (>2,000,000 m^3). Moreover, there are no major accumulations of other types of solid waste elsewhere on the site. Whether this reflects the original state of the mine at the time of closure or subsequent clearance during the course of quarrying operations is not known. The seepages from the tailings pond, while significantly enriched in metals, are of low volume.

Table 4 HMS-IRC Site Scores, Abbeytown

Waste	FS01	TA01	W001	W002	Total
1. Hazard Score	33	43	36	44	156
2. Pathway Score					
Groundwater	8.13	7.91	7.15	8.99	32.18
Surface Water	7.98	10.68	5.86	6.68	31.19
Air	0.60	0.02			0.62
Direct Contact	2.63	3.08			5.71
Direct Contact (livestock)					
3. Site Score	**19**	**22**	**13**	**16**	**70**

Of the total Site Score of 70, the tailings pond seepages account for 29 or 41.4% (Fig. 6). The remainder is split between the tailings pond itself and the tailings on the foreshore. The greater volume of the former gives it a significantly higher hazard score that accounts for its higher site score.

The groundwater and surface water pathways are the major contributors to the score for all waste sources (Fig. 7). Their respective contributions to individual waste scores and the total site score are broadly similar. Only the tailings pond and foreshore deposits have any input from the direct contact pathway, with the contribution from each being similar. The much greater surface area of the foreshore deposits give these a higher air pathway score than the tailings pond, though the absolute score (0.62) is negligible in the context of the site as a whole.

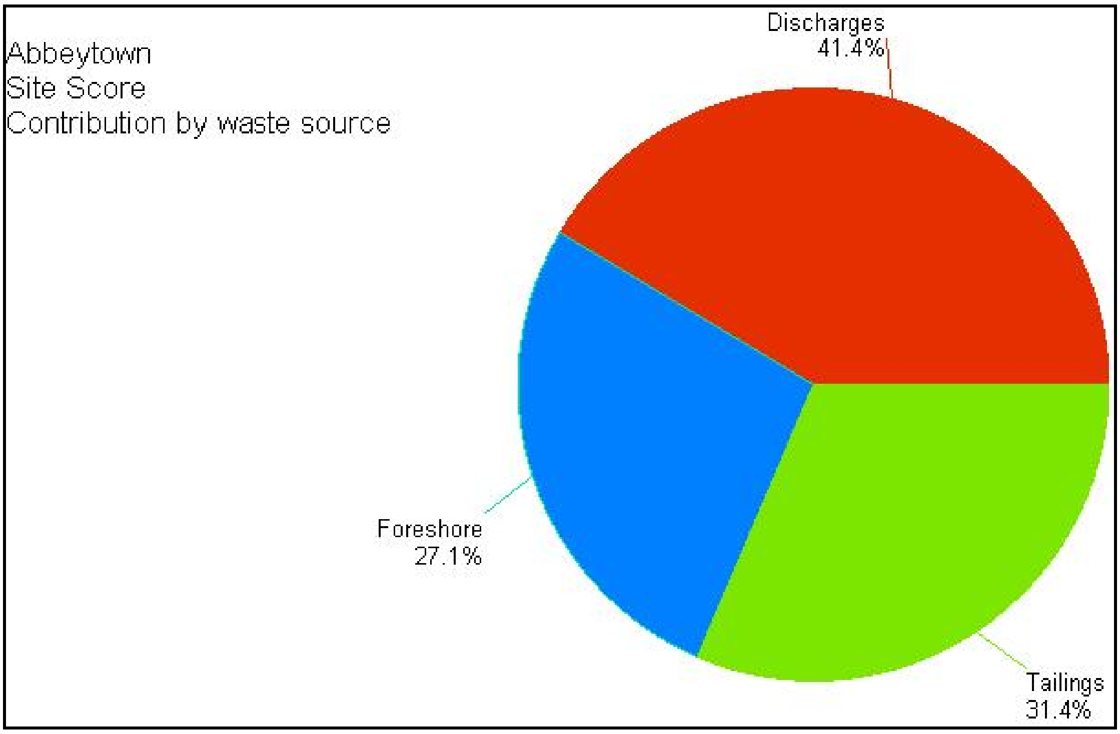

Fig. 6 Abbeytown HMS-IRC Site Score: contribution by waste source

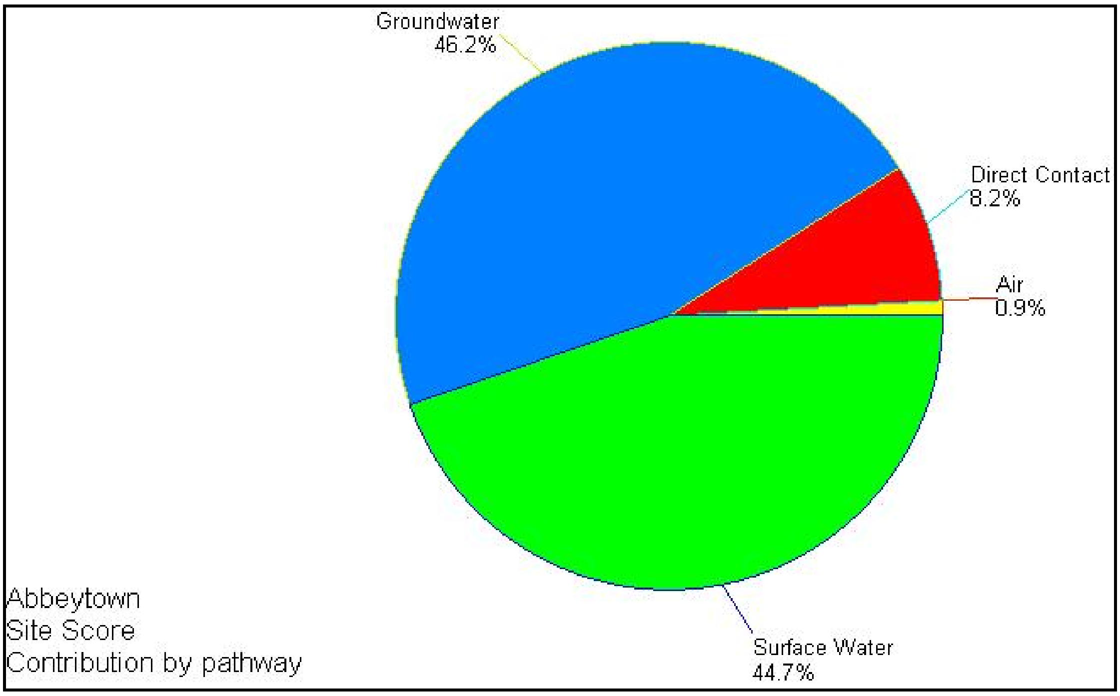

Fig. 7 Abbeytown HMS-IRC Site Score: contribution by pathway

6. Geochemical overview and conclusions

Abbeytown mine is now an active quarry and most mine features have been subsumed by surface excavations in the years since closure. However, the tailings pond remains intact although lined concrete settling ponds have now been built in shallow excavations on its surface. A previous tailings spill, apparently during the period of 1950's mining, has caused significant contamination of the foreshore by Pb, Zn and Cu in an area 300m wide. The action of tides has increased the dispersion of the contamination further west along the shore. Discharge from several seepages at the base of the tailings pond contains high levels of Pb, Zn, Ni and As. These seepages drain directly into the waters of the bay.

Abbeytown has a Class V Site Score of 70. By comparison with Pb mines elsewhere in Ireland, this relatively low score partly reflects the absence of solid waste heaps on the site and the low volume of tailings in the tailings pond. It probably also reflects the absence of direct analysis of tailings in the tailings pond. Even if analyses of tailings were available and Pb concentrations were higher than those assumed for this study, the low volume of tailings would still limit the total site score. The tailings spill on the foreshore and the discharge of seepage from the tailings pond into Ballysadare Bay represent specific environmental threats to the estuary. However, the relatively low Pb concentration of the tailings spill and the low volume of the discharges mean that none has a high score.

References

Hitzman, M.W. (1986). Geology of the Abbeytown Mine, Co. Sligo, Ireland. In: Andrews, C.J., Crowe, R.W.A., Pennell, W.M. and Pyne, J.F. (Eds.) *Geology and Genesis of mineral deposits in Ireland*. Irish association of Economic Geology, Dublin, 341 – 353.