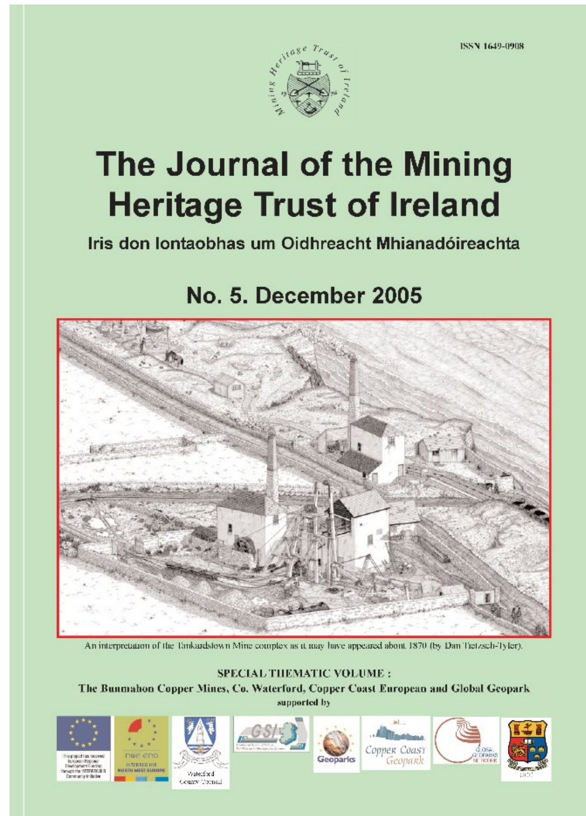


Morris, J. H., Tietzsch-Tyler, D., Scanlon, R., (2005) 'The Knockmahon-Tankardstown Mineral Tramway, Bunmahon, Co. Waterford' *Journal of the Mining Heritage Trust of Ireland,* **5**, pp. 53-74

# THE KNOCKMAHON - TANKARDSTOWN MINERAL TRAMWAY, BUNMAHON, CO. WATERFORD.

**by John H. Morris[1,2], Daniel Tietzsch-Tyler[2] and Ray Scanlon[1]**

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**Abstract: This paper presents a review, survey and interpretation of a mineral tramway built by the Mining Company of Ireland in 1854 to service its copper mining activities in the Bunmahon area, Co. Waterford. The c. 1.6 km length system linked the copper ore dressing floors at Knockmahon at the western end, with the Copper Yard storage and transhipment point at Stage Cove close to the mid-point of the system, and, at the eastern end, Tankardstown, the principal site of copper mining from c. 1855 to 1877. It is inferred that the system was built in two discrete sections: a dual track, gravity and horse powered western section and a single track eastern section. The latter section was probably powered by a steam winding engine located in a tramway Engine House adjacent to the Tankardstown mine site.** *Journal of the Mining Heritage Trust of Ireland*, **5,** 2005, 53-74.

## INTRODUCTION

The existence of a 19th Century mineral tramway in Bunmahon, Co. Waterford is still fairly widely known, both in the immediate district and further afield. It was constructed by the Mining Company of Ireland (MCI) to service their copper mining activities, and although it provided the surface transport "backbone" during the latter period of those operations, details of the history of this tramway, when it was constructed, and how it operated, have, at best, been treated only in a cursory manner in all mining history research on the Bunmahon copper mines published to date.

Those historic mines now lie at the heart of, and have given their name to the "**Copper Coast Global and European Geopark**", which, in 2004, was awarded very substantial grant aid by the INTERREG 3B programme, North West Europe Region, to advance development of the Geopark, including its mining heritage features. The purchase, conservation and presentation of the iconic Tankardstown Engine House complex are the most substantial mining heritage actions undertaken to date, though a number of others will be completed by the time the project finishes in December 2006. But it has become increasingly apparent that the impact and success of some of those actions necessitate a more thorough appraisal, interpretation and understanding of the construction and operation of the tramway and its associated features. Accordingly this paper seeks to present, after reviewing briefly the history of the copper mines, an overview of what is known about the history of this tramway, its construction and survey of current remains, and finally an interpretation of how it operated.

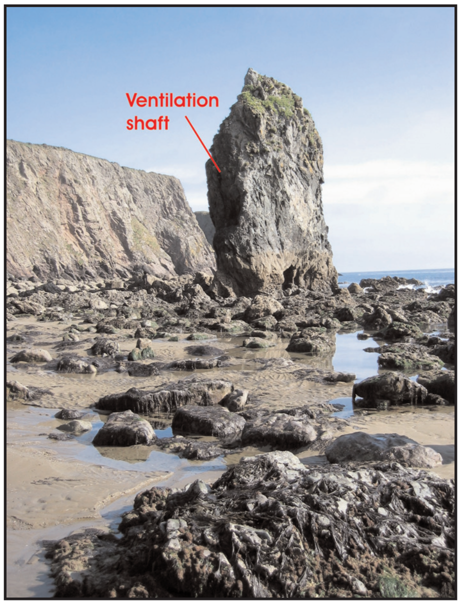
## A BRIEF HISTORY OF THE BUNMAHON COPPER MINES

Despite allusions to "Old Men's Workings" and "Dane's Mines", and even to conjecture that the copper mineralisation may have been first worked during the Bronze Age, the first substantive evidence of mining activities date to the period from about 1740 onward. This includes the development by Thomas "Bullocks" Wyse of a small lead-silver mine at Ballydwane, about 2 km west of Bunmahon, (Figs. 1, 3; Cowman, 1982).

In 1824, two mining companies were established by Act of Parliament, the Hibernian Mining Company (HMC) and the Mining Company of Ireland (MCI), both founded and funded initially with philanthropic aims, the former by English adventurers, the latter by Irish. Both companies acted very quickly to establish their interests over the seemingly most desirable mines and mineral prospects then known in Ireland, including those in the Bunmahon area, where their interests brought them into rivalry (Cowman 2002). Despite receiving somewhat dubious advice from its technical advisors, the HMC reasonably sensibly leased the area west of the River Mahon, the area in which most activity had been concentrated over the preceding 80 years, mainly in Templeyvrick townland.

The MCI leased the area east of the River Mahon from 1824. They established water powered dressing floors in a valley in the central part of this vein system, the ruinous remains of which remain visible to this day (Fig. 2). During the 1830s and 1840s, the focus of development and production gradually shifted east to Knockmahon - Kilduane. Various records document the erection of five steam powered pumping and winding engines by the mid-1840s, two in Knockmahon (Stage Cove), one in Kilduane, one in Ballynasissala and one on the dressing floors (Brown 1996, Cowman 2006; see Fig. 5 for location of these and other townlands mentioned in the subsequent text sections). Underground workings extended both inland from the cliff top location of the mine complex at Knockmahon (Stage Cove), as well as southeast out under the seabed. Some of the latter workings were developed close to the sea floor, and eventually the inevitable happened - sea water breached into the underground workings. This soon led to the progressive abandonment of at least the lowest working levels from about late 1852 onward. The final abandonment of the Knockmahon (Stage Cove) workings is not known with certainty, but was most likely by about 1855 (Cowman 2005, this Journal).

From then until final closure of the mines in 1877, Tankardstown became the primary focus of all ore production. But throughout that period 1855 - 1874, and the earlier period of operations at Knockmahon during the 1830s to the mid-1850s, all ore dressing was still undertaken at the original 1824/5 dressing floor complex (Fig. 2). From there dressed ore was transported c. 0.8km back uphill to a "Copper Yard" at





*Figures 1 (left), 2 (right); ventilation shaft in sea stack developed as part of "Bullocks" Wyse mid-18th Century mining venture, Ballydwane Cove (Fig.1); the main MCI "dressing floor" complex at Knockmahon, mostly destroyed (Fig. 2).*

Stage Cove, close to the Knockmahon mines, and, from there, shipped out on schooners to Swansea, Wales, for smelting. While the 1820s to late 1840s surface transport operations and requirements were fairly constrained, the development of Tankardstown a further c.0.8km to the east of Stage Cove added significant surface haulage logistical problems and requirements: undressed ore to be taken from Tankardstown c. 1.6km downhill to the dressing floors; dressed ore concentrates then to be hauled c. 0.8km back uphill to the Copper Yard for transhipment, while coal and other materials had to be hauled up to Tankardstown - from either the dressing floors, or direct from the Copper Yard.

It may be surmised reasonably that these more complex surface haulage requirements probably provided the primary stimulus for undertaking the construction of the Tankardstown-Knockmahon mineral tramway.

## THE TRAMWAY: PREVIOUS STUDIES AND RECORDS

Nearly 50 years ago, Walter McGrath (1959), wrote a brief, two page article summarising all the then known information concerning the history and operation of the tramway. Sadly, virtually nothing was known about it even then, as most of his article provides only general location and contextual information. He does, however, record the oral memory of then elderly residents who stated "emphatically" that the railway was operated by horses, but never by a steam locomotive (in that connection, he discounts speculation which arose in the 1950s that a steam locomotive built by Stephen Lewin at Poole, UK may have been used on the tramway). He further notes that the Copper Yard at Stage Cove (Fig.3) was the focal point of the tramway, with two branches converging upon it, from the dressing floors in Knockmahon to the west, and from Tankardstown to the east.

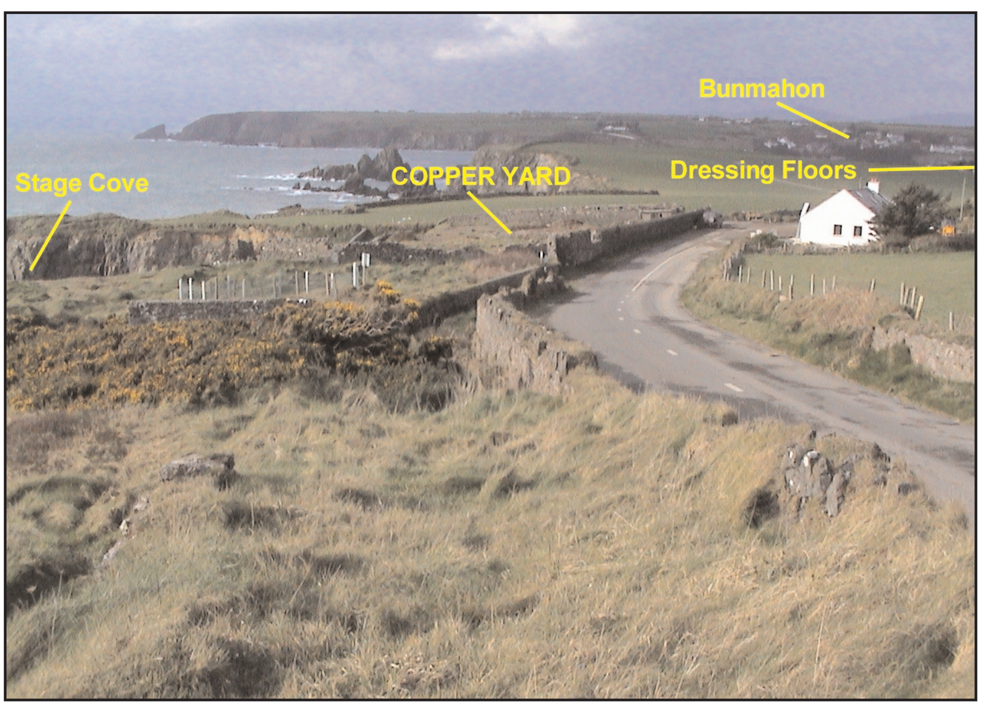



***Figure 3. A panoramic view looking west from the crest of the "Main Ramp" towards the "Copper Yard". Part of the village of Bunmahon is visible towards the top right, while the dressing floors shown in Figure 2 are located in a valley out of view to the right. Stage Cove, from where coal and copper ore were imported into and exported out of the copper mining district, is located below and immediately to the left of the Copper Yard. Ballydwane, the site of 18th Century lead-silver mining (cf. Fig.1), is located just beyond the cliffs visible in the background.***

McGrath (1959) also makes reference to map information, noting that the tramway is marked as an "old tramway" on both the 1903 and 1922 editions of the 25 inch and subsequent 6 inch scale Ordnance Survey maps of the district. He makes no reference to any other documentary or map based information.

However, other map and documentary sources do exist and provide additional information, especially as they constrain the time period when the tramway was most likely constructed. The tramway is not shown on either the 1st edition Ordnance Survey 6 inch map of the district, which was surveyed in 1840-1841, and published in 1842; or, more importantly, on a very detailed Mining Company of Ireland map of the Knockmahon - Stage Cove complex which is dated 1845 (by Warrington Smyth, GSI Mine Records Archives). The latter map provides a surprising level of detail, including the courses of water leats supplying water to the water wheels on the dressing floor, shaft and engine house locations, roads, and even information about the use of specific buildings on the dressing floor. Given that the tramway would have been a very substantive and obvious component of the mining infrastructure, it is reasonable to conclude that its omission indicates that it had not been constructed prior to the date of this map - 1845.

In contrast, the course of the "old tramway" is shown on a map of the Knockmahon - Tankardstown mine complex, which forms part of a prospectus issued in 1898 by the "Knockmahon and Tankardstown United Copper Mines Ltd" (Fig. 4: Geological Survey of Ireland, mine records archive). It is also shown, as noted also by McGrath (1959), on the 2nd edition Ordnance Survey 6 inch scale map of the district, published in 1905 (revised 1922), marked, yet again, as an "Old Tramway".

The dates of these various map publications constrain the time of construction and operation of the tramway to post 1845. A much tighter constraint may, however, be gleaned directly and indirectly from information provided in various bi-annual MCI reports issued to shareholders over the period 1826 to 1864.

These reports provide quite comprehensive details of developments being undertaken at various times, especially prior to 1851, after which date they become quite cursory in nature. Between 1845 and 1850, the reports note progressive deepening of the Knockmahon shaft to its ultimate depth of 200 fathoms [1,200 feet, about 366 metres]. This clearly indicates that mining operations continued at that location at least up to 1850. Reports for the latter part of that year, and the first half year report of 1851, note that a new shaft was needed at the "North" mine. The 1851 report further notes that a winding engine, previously erected at a shaft in Kilduane in 1842, was in the process of being erected at the new location. It is surmised that this is a reference to the North Tankardstown mine site, as, by that time, all other possible sites which could be construed to lie "north" of Kilduane, such as those in Ballynasissala, had ceased operations.

Further developments are recorded in the December 1853 report, which notes that a total of £2145-12-11 had been expended on sinking the Engine Shaft at Tankardstown, while Cowman (2005) notes, from other sources, that an engine "was

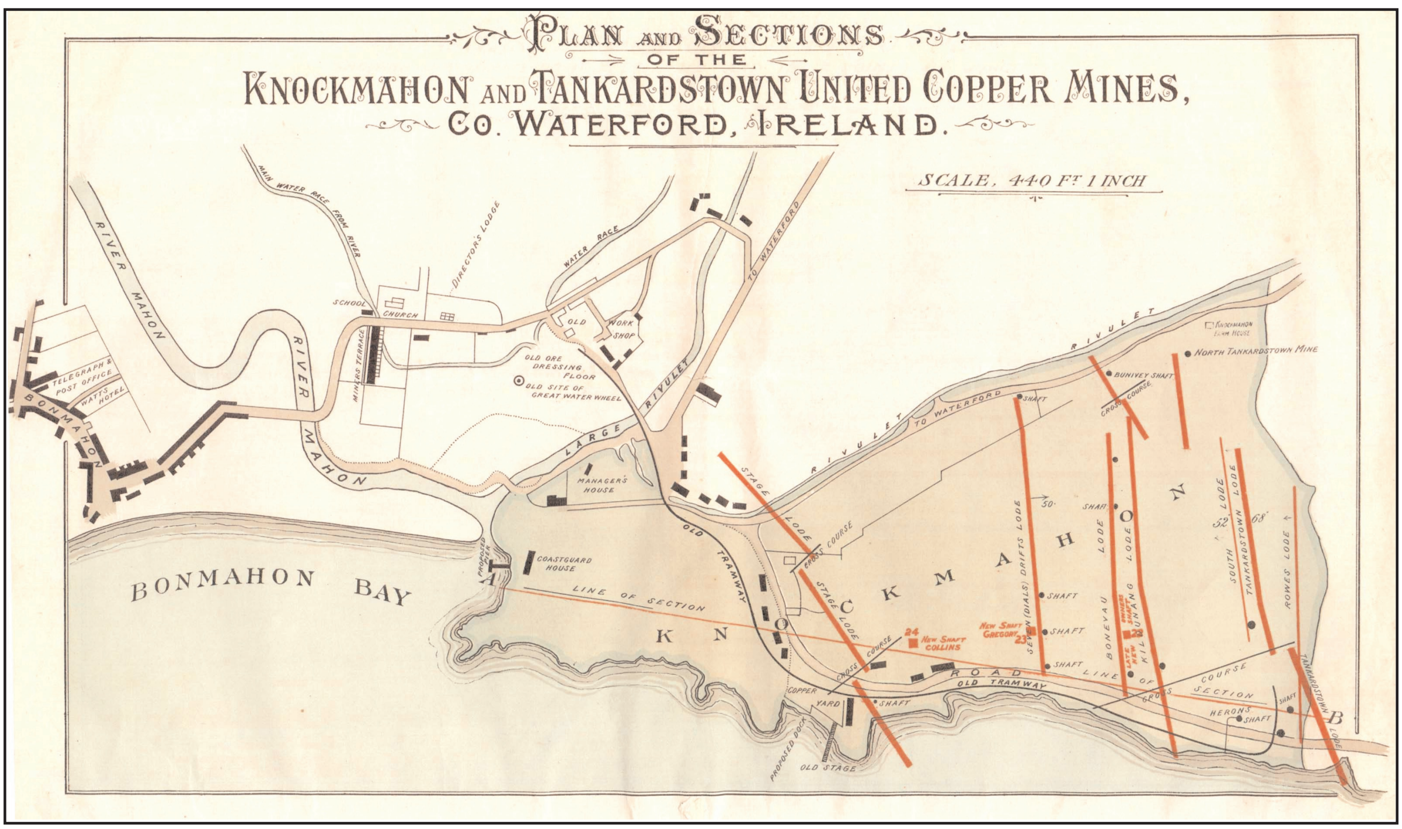



*Figure 4. A plan of the Knockmahon - Tankardstown mine infrastructure presented in the prospectus of the "Knockmahon and Tankardstown United Copper Mine", dated 1898. In particular, note the course of the "Old Tramway" ["Descriptive particulars with Mining Experts' and other reports on the Knockmahon United Copper Mines. Co. Waterford, Ireland", GSI Mine Records archive].*

started" in Tankardstown on Dec. 24, 1852. This latter reference most likely refers to the engine moved to North Tankardstown from Kilduane, as the time interval between the references is only about 6 months or so. However, the shaft and other developments at North Tankardstown were relatively limited in extent, suggesting that the reference to expenditures incurred on sinking an "engine shaft" most likely refer, not to this location, but to developments atop the cliffs at (South) Tankardstown.

A number of extant shafts are still visible at this location, including an "Old Engine Shaft" as well as the one at which both extant engine houses were sited, "Heron's Shaft" (Figs. 4, 5). It appears that during the initial development phase, the "Old Engine Shaft" was sunk too close to the surface outcrop of the lode at this location, was consequently abandoned, and a new shaft, "Heron's Shaft" sunk about 100m or so to the west. Three other shafts, "Pope's Shaft", "Boundary Shaft" and a "Whim" shaft located about 30m from the cliff edge (Figs. 4, 48), were all sunk in the footwall of the lode. It is not known if engines were ever erected on any of these shafts or were ever intended to be. Overall though, the sinking of five shafts, all in relatively close proximity to each other, including two "engine shafts", would have been quite costly and easily account for at least a substantial part of the expenditure noted.

Of much more immediacy, however, is the mention of "railways" in no less than three separate reports, those dated December 1, 1838; May 31, 1847 and December 1, 1854.

The first record alludes to a railway "laid down" on a portion of the mine lands leased from a Miss Osborne. Her estate lands lay broadly between the dressing floor area in Knockmahon and the then active mines in Ballynasissala townland to the northwest, well to the west of the mineral tramway under consideration here, and consequently an unrelated development (D.Cowman, *pers. comm.*, 2006). The subsequent record in 1847 also appears unrelated, as it alludes to the erection of another waterwheel, machinery and an incline plane for a railway to remove "halvens" (coarse ore) to the "stamps". This description almost certainly relates to developments undertaken solely within the area of the Dressing Floor complex (D.Cowman, *pers. comm.*, 2006).

In distinct contrast, the final reference to a "railway" in the 1854 report almost certainly refers to the Knockmahon-Tankardstown tramway, as, by that date, exploration and mining activities and developments had shifted east to that area. The report notes a total expenditure of £2,918-4-6 ".. in extension of the mines, and in making a railway and an incline plane to lessen the expense of dressing and shipping the ores". The phraseology of this reference is quite interesting. It not only clearly indicates that the railway [the mineral tramway] had been completed by the end of December 1854, as the cost is referred to in the past tense, but it also implies that while the railway was constructed to facilitate ore dressing, an incline plane was constructed to facilitate ore shipments ["..railway and … *incline plane*.." cf. "..dressing and *shipping*.."]. Tenuous as this grammatical interpretation may be, it is the sole evidence currently available to suggest the date of construction of certain features in and around the Copper Yard.

## THE TRAMWAY: SURVEY AND DESCRIPTION OF EXTANT REMAINS

McGrath (1959) notes that the tramway remains at Bunmahon were amongst the most extensive of any 19th Century mineral tramway then still in existence in Ireland. He describes, in particular, the then best preserved remnants: a lengthy, 5 feet deep cutting running east along the top of the cliffs between the Copper Yard and Tankardstown, and west, in the opposite direction, an embankment along the edge of a field between the yard and the dressing floors. Only a very short section of embankment may be identified now, although several sections of the cutting are still visible, though again much of it has now disappeared: one section due to erosion and collapse of the edge of the cliff through which the cutting passed; and other sections through field levelling and back filling of the cutting.

The entire, historically recorded length of the tramway, including the sections described above by McGrath (1959), has been surveyed during the present study. Figure 5 (a) presents a plan view superimposed upon a recent aerial photograph background map; Figure 5(b) a profile survey, with all positions and elevations determined by Differential GPS survey tied into Ordnance Survey of Ireland control points, kindly supplied by INTERREG Project partner, Waterford County Council. Figures 6 to 50 present a photographic record, as well as plans of various extant remains.

The Copper Yard is located at approximately the mid-point of the tramway system, and thereby provides a convenient reference point from which to describe the visible remains of the system: the western section, from the Copper Yard down slope to the site of the dressing floor complex at Knockmahon (Section 1); in and adjacent to the Copper Yard (Section 2); and an eastern section up slope from the Copper Yard to Tankardstown (Section 3).

### Section 1: Copper Yard to Knockmahon

Passing through what are presumably the remnants of masonry gate pillars for a road crossing (Fig. 6), the course of the tramway is readily defined by a well constructed stone wall along its northern margin as it descends down slope towards Knockmahon from the gateway (Fig. 7). It is also very easily discernible as a faint crop mark on the 2000 edition of the Ordnance Survey of Ireland 1:40,000 scale colour aerial photograph of the field through which it passes (see Fig. 5a). This corresponds, on the ground, to a very shallow, almost completely levelled depression about 3.66m (144 inches) wide running parallel to the stone boundary wall, as far as it extends, and then across the rest of the field to its western, boundary wall. It should, however, be noted that this course differs from that shown on the 1898 "prospectus map" reproduced in Figure 4. This shows the course of the tramway swinging more northward to parallel the course of the main road between the Copper Yard and the Coast Guard laneway (Fig. 9). The reason for this discrepancy is uncertain but it may reflect a cartographic error in the map, as the physical remains seem to be fairly clear, particularly the crop mark.

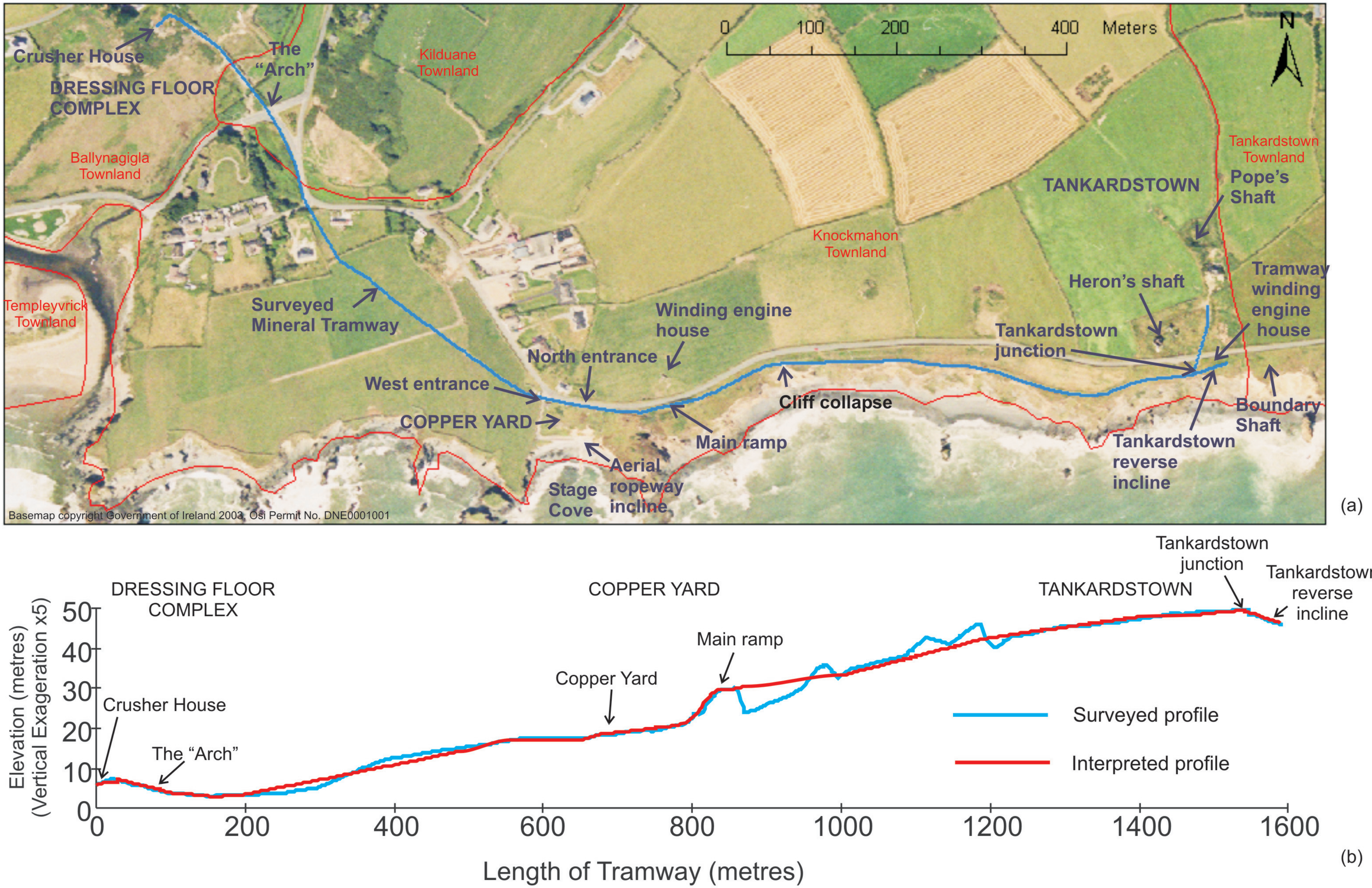



*Figure 5. (a) An aerial photographic plan view of the Knockmahon-Tankardstown section of the Bunmahon mining district, showing the course of the mineral tramway, annotated with key sites and townland names and boundaries. (b) an elevation diagram of the surveyed and interpreted profiles of the mineral tramway: vertical axis = height in metres above sea level; horizontal axis = length of tramway measured east from the site of the Crushing Engine House in the Dressing Floor complex.*

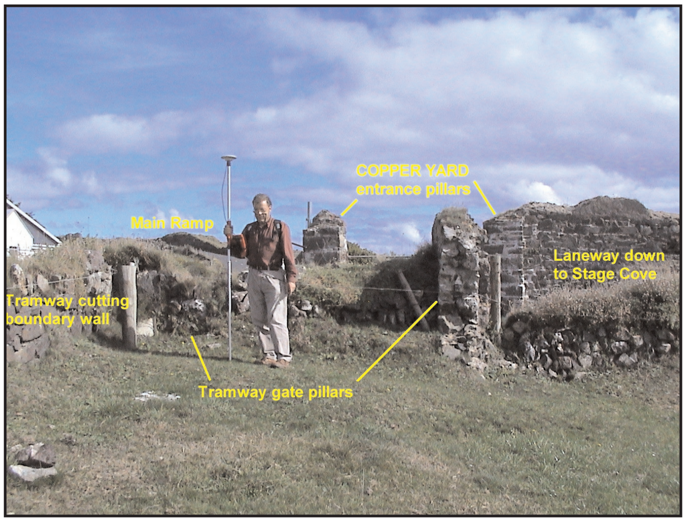



*Figure 6. JHM standing at entrance of tramway route into field. Note the pillars in the background which define the west entrance into the "Copper Yard".*


*Figure 7. Shallow depression marking the course of the tramway cutting across the field to the west of the Copper Yard, with remnant of one bounding wall on the right.*


*Figure 8. Looking up the nearly completely backfilled course of a short incline beside the laneway to the old Coast Guard station: remnant of one bounding wall running up hill away from camera.*


*Figure 9. View looking northwest across the Coast Guard laneway in the foreground, and along the modern coast road towards the approximate site of "The Arch" on the far side of the triangular road junction.*

It is presumed that the extant tramway wall is one of two which may once have existed on either side of it. There is, however, some disagreement about the configuration of the tramway through this section, if McGrath's (1959) description of it descending along an embankment applies to this section, as local resident Mr. Phil Dunne (*pers. comm.*, 2005) states, from personal observation made over 30 years ago, that it lay in a cutting along this section. We concur with the latter suggestion, as it is consistent with the depression noted above, which presumably results from back filling into the cutting.

The course of the tramway through the modern day western field boundary is marked by a section of crudely built stone wall, adjacent, on the west side, to a section of much finer construction stone wall immediately adjoining a low, roughly triangular shaped stone walled platform, the purpose of which is unknown. From here, the tramway course descends at a notably steeper inclination for about 30 metres. Most of this section has been backfilled, although an original boundary wall survives along the west edge (Fig. 8). From the base of this short incline section, the tramway must have passed across the laneway leading up to the Old Coast Guard station, and then along the edge of the road as far as what is known locally as "The Arch" (Fig. 5a; Fig. 9). This entire section has been heavily reconstructed in modern times, however, such that features visible now, and perhaps even road levels, correspond only very approximately to the course of the tramway.

"The Arch" refers to what at one stage was the arch of a bridge which carried the tramway over a foot/cart track, located very approximately along the modern section of roadway, from Bunmahon to Kill, which forms one side of the triangular road junction (Fig. 9; P. Dunne, *pers. comm.*, 2006). A compilation map of the Knockmahon area, dated 1956 (by W.H.Wilson, Mining Engineer; GSI Mine Records Archive) depicts the course of the tramway along this section on what appears to be an embankment, a configuration corresponding with Mr. Dunne's (*pers. comm.*, 2006) recollection of its appearance, and perhaps reflecting the location of the embankment noted by McGrath (1959). Indeed, the course of the tramway from the


*Figure 10. View looking northwest towards the dressing floor complex, with remnant of tramway embankment on left.*

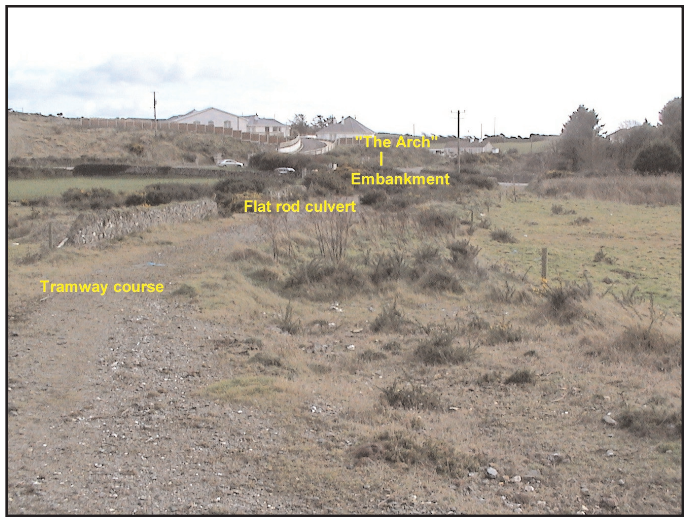



*Figure 11. View looking southeast along the course of the tramway from the Dressing Floor area towards "The Arch" and adjoining remnant of the tramway embankment.*

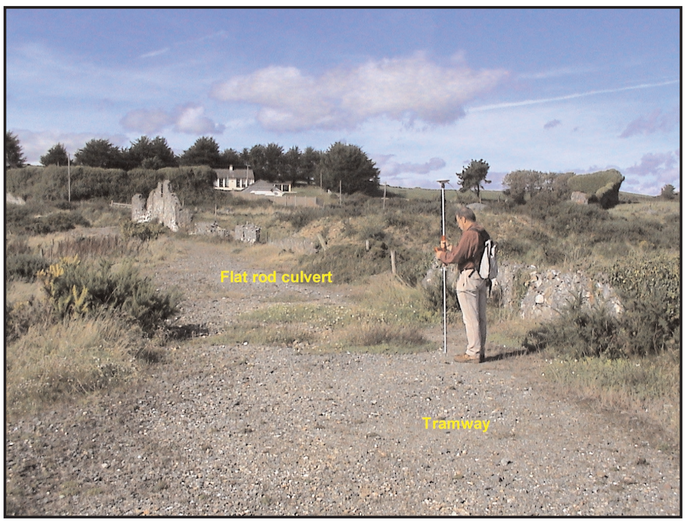



*Figure 12. View looking north along the course of the tramway into the Dressing Floor area. Note the location of a flat rod culvert which passes under the tramway.*


*Figure 13. View looking down a shallow incline towards the site of the Crusher House.*

modern road wall boundary to a stream about 20m to the west, is marked by an embankment (Figs. 10, 11), the top of which is about 1m above present day road level. It is reasonable to surmise that this is now the sole surviving remnant of the original tramway embankment.

The tops of two bridge pillars on either side of the stream now lie at a lower level than the embankment, perhaps reflecting removal of masonry some time after abandonment of the mine site. This somewhat lower level merges into a prominent strip of mine spoil just to the west, which probably defines the course, and approximate level of the "permanent way" of the tramway at this point (Fig. 12). This rises gently northwest across another low arch bridge, believed to have accommodated flat rods connected between a 40 feet diameter water wheel installation just to the west, and the operational shaft just to the east (Fig. 12). From here it continues to run gently uphill to the vicinity of the gable wall ruins of several mine buildings (Fig. 13). Where it went from there is entirely conjectural, though it is reasonable to assume that at least one spur ran gently down hill, on a reverse gradient into the vicinity of where a Cornish crushing engine house was once located (Fig. 5a, b).

## Section 2: Copper Yard

The Copper Yard is, apart from Tankardstown, the most substantial complex of built mine heritage features still extant in the district (Figs. 14, 15). It consists primarily of a prominent and well built stone curtain wall enclosing the yard, within which there are quite extensive remains of cobbled floor surfaces at two distinct levels (Fig.15, pre-1840 and elevated cobble floor levels). The wall is punctured, on the southeastern, seaward side by a very distinct, steep ramp (Fig. 26; "aerial ropeway" in Fig. 15) down to the cove, and by three entrances in the other walls: one at the western corner opposite the crossing gate pillars described above (Figs.15, 19), another in the north wall which runs parallel to the Bunmahon - Annestown main road (Figs. 15 -18), and a third entrance in the southwest corner.

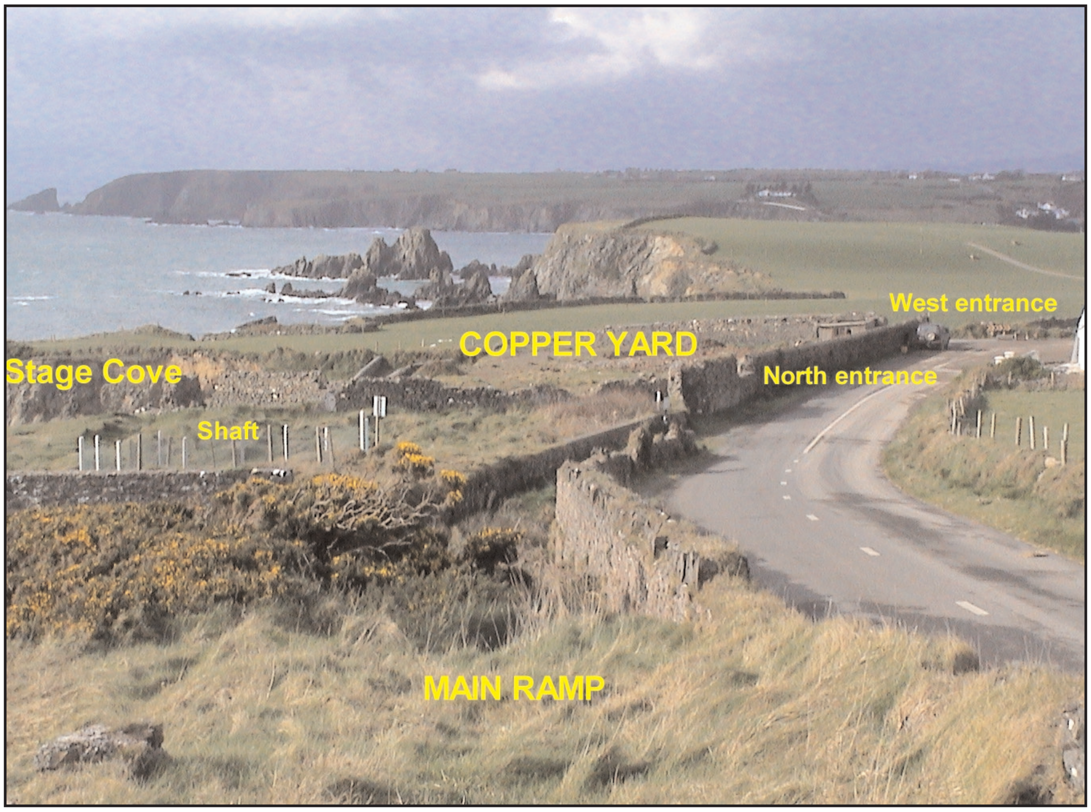
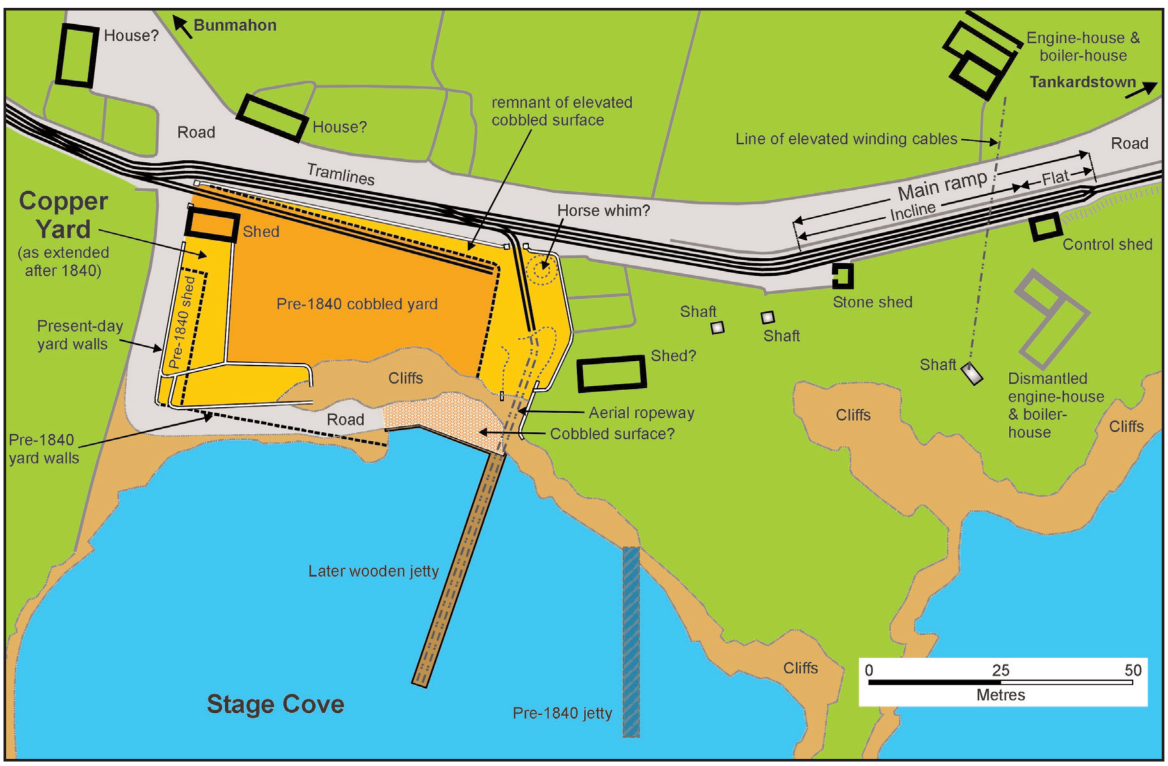



*Figure 14. A view looking west across the remains of the Copper Yard.*

*Below. Figure 15. A composite plan of extant and historical surface features shown on 1842 and 1905 (revised 1922) edition Ordnance Survey six inch scale maps in and around the Copper Yard.*




The curtain walls, and gateways, appear to have been built in several stages. About 70% of the western length of the roadside curtain wall is built entirely of dark green coloured basaltic andesite, with a medium dark grey lime mortar. This is in marked contrast to a much lighter, off-white coloured mortar used in the north and west entrance pillars (Figs. 16, 18, 19) and in the remaining eastern section of wall, which is constructed of a wide variety of building stone, including quartz and quartz veined blocks, Devonian sandstone, and even bricks, in addition to basalt (Fig. 17). The north gateway is itself blocked with masonry, most likely during the 19th century as it is bonded with lime, rather than Portland cement mortar (Fig.18). The significance of these differences is considered further in a later section.

The inside of the yard is characterised by remnants of cobble stone floors at two levels (Figs. 20, 21). One level defines the area of the pre-1840 cobble yard (Fig. 15), while the other defines a narrow wedge shaped level just inside the north wall of the enlarged post-1840 yard (Fig.20). This lies at the same level as an irregular shaped, unpaved floor level which extends from the north entrance into the central eastern part of the yard, adjacent to two very prominent depressions. Finally, a steep decline extends from the southeastern corner down to the Stage Cove foreshore below (Fig. 26).

The lower and upper cobble stone floors are set at an elevation difference of about 1m, the lower floor area being much more extensive (including sections damaged during installation of a

*Figure 16. View looking east along the edge of the Copper Yard, with Des Cowman standing on the course of the tramway. Note the very distinct outward curve of the curtain wall at the North entrance (beside the horse whim in Fig. 15), the distinct off-white coloured lime mortar therein contrasting with the darker grey mortar in the near part of the wall, which is constructed entirely of basaltic andesite.*

*Figure 17. View of wall section east of the North entrance constructed of a very mixed assortment of masonry (andesite, quartz, "Old Red Sandstone" conglomerate) and bricks.*

*Figure 18. Close up view of the North entrance.*

*Figure 19. Close up view of the West entrance (at the north-west end of the Copper Yard in Fig. 15).*

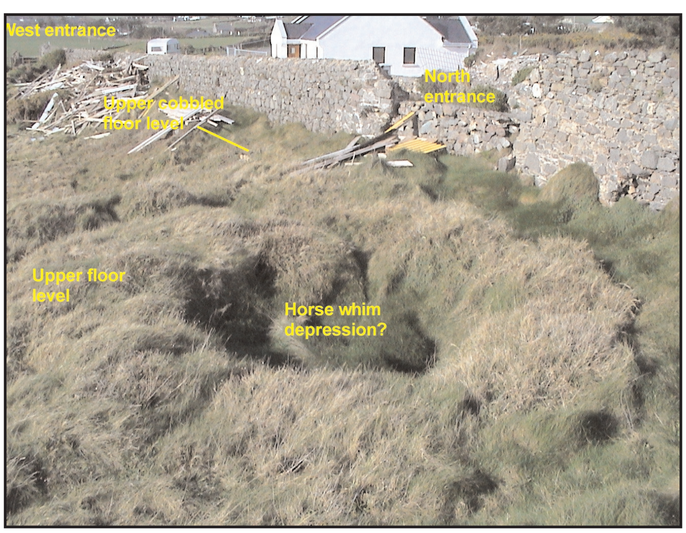
*Figures 20 (left), 21 (right). Views of the cobbled floor surfaces within the Copper Yard: the edge of the upper floor area beneath the pile of timber (Fig. 20), and the most extensive remnant of the lower, main yard cobbled floor surface (Fig. 21)*

*Figures 22 (left), 23 (right). Two views of the wedge shaped upper level: Fig. 22, view looking west along the level towards the west entrance (beneath piles of timber - cf. Fig. 20); and a temporary cross section through the level, showing the very distinct colour contrast between its foundation material (pale yellow-brown) and adjoining dark brown coloured back fill (Fig. 23)*

septic tank in February 2006) and perhaps covering as much as 60 - 70% of the original yard area (Fig. 21). In distinct contrast, the upper floor is restricted to a very small area close to the north entrance and forms part of a narrow level along the inside edge of the roadside (northern) wall, between the northern and western entrances (Figs. 20, 22). It averages about 2.2 m (84") wide over much of this length, although it gradually tapers, in width and height, to merge with the lower floor level about 10m short of the western entrance. The septic tank works provided a convenient, albeit transitory trench section across this level, which is composed of a distinct, light yellowish brown pebbly clay material abutting directly against a dark brown, humus rich pebbly soil along its southern edge (Fig. 23). The contact between the two materials is near vertical.

The origin and purpose of this narrow level and small section of cobbled floor is entirely conjectural. While it might have served as a loading ramp within the yard, it is more likely to reflect the re-alignment of the northern wall of the yard. The position and alignment of this wall shown on the 1842 and 1905 (revised 1922) versions of the OS six inch scale differ subtly but distinctly (Fig. 15), the currently visible wall corresponding well with the position shown on the latter map. In contrast the earlier wall lies inside this alignment, and its orientation defines a narrow wedge shaped area between the two wall positions (Fig. 15). It is here suggested that the vertical inside edge of the upper level (Fig. 25) defines what was the outer edge of the original wall, while the upper cobbled floor level marks what was originally a floor level outside the earlier wall. The original wall was presumably demolished some time after 1842, and rebuilt further north, thereby enclosing these features into the new extended yard area.

The entrance into the eastern part of the yard through the north wall passes a very prominent circular depression on its eastern edge (Fig. 24). This extends up to and around the eastern edge of another, very irregular shaped depression (Fig. 25), which aligns with the very steep decline from the Yard down to Stage Cove noted earlier.





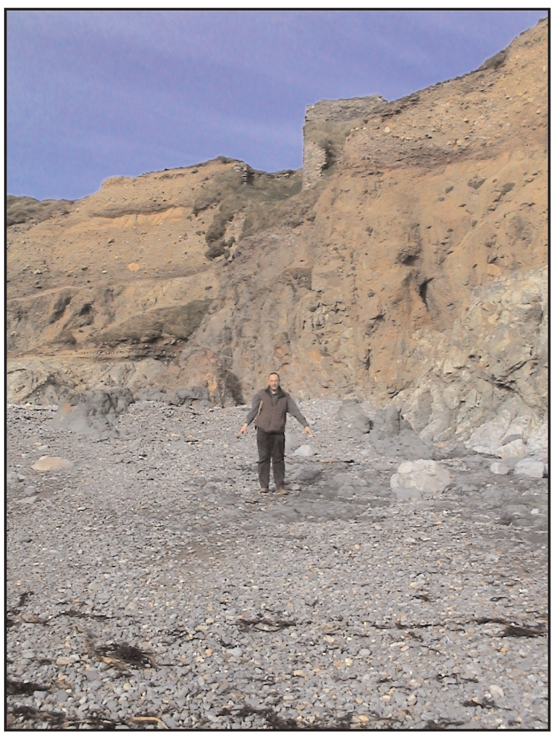
*Figures 24 (left), 25 (right). Two views of the upper floor level showing location of features relative to the North entrance.*

The decline is very precipitous (Figs. 26 - 28): the upper section, at an angle of about 30$^0$, ends at the top of a near vertical cliff. At the base of the cliff, the last vestiges of a cobbled floor surface are still visible, just below and to the west of the decline (Figs. 29 - 30). This cobbled surface extends back under the overlying grass covered subsoil, believed to be a block of unconsolidated sediments which has slumped down from higher up the cliff section. The floor is presumed to have formed part of a quay side construction (Fig. 15), most of which has now been destroyed by erosion.

The centre line of the decline aligns almost perfectly with the centre point between successive pairs of bolts set, about 2m apart, at regular intervals into rock along a straight line between high and low tide levels (Figs. 27, 31). The bolts most likely mark the anchor points for presumably upright timbers supporting a wooden jetty along this alignment (Fig.15). One set of bolts at the immediate landward end is offset 3m west of the incline-jetty alignment. This is interpreted as an orthogonal section of jetty set around a prominent rock crag, constructed both to connect with the cobbled floor level and perhaps also to delimit the landward end of the mooring space alongside the jetty.

directly towards a very well preserved and prominent lean-to style, windowless and now roofless shed, with a narrow single doorway (Figs. 33, 34), while the rest of the section swings gently northeast towards the base of a very prominent, stone walled ramp (the "main ramp" hereafter, Figs. 15, 33, 35). The ramp rises at a constant inclination of about 10$^0$ for 47m up to its crest, from which it runs roughly level for about 10m before merging indistinctly into the presumed, but overgrown course of the tramway further east.

The ramp and top platform stone retaining walls are well exposed, particularly along the roadside, where two inclined grooves form a very prominent feature (Fig. 36). These face, across the coast road, towards the remains of a winding engine house complex which was installed in 1838 (MCI reports; Figs. 35, 52). The opposite stone wall margin is less extensively exposed, apart from a section along part of the western length of the level platform (Figs. 37, 38). There, a section of badly undermined masonry extends along part of the ramp at ground level, terminating abruptly at the western end in the vestiges of a masonry and brick construction wall keyed into, and built at right angles to the ramp (Fig. 38). This wall is aligned directly with the crest of the incline, and it extends through the entire



***Figures 26 (left), 27 (right). Two views of the steep incline down from the Copper Yard into Stage Cove; view looking downslope from the yard (Fig. 26); and, Fig. 27, looking back up the cliff and upslope from the mid-line of pairs of bolts marking the anchor point for a wooden jetty. Co-author DT-T standing at the mid-point between, and pointing towards two pairs of bolts.***

The location and alignment of this jetty is very well defined, but curiously, it does not correspond in any way to the location of a similar structure shown on the 1842 edition OS six inch scale map (Fig.15). There is now no visible expression of this earlier structure or of how it may have connected to the Copper Yard or quayside cobbled floor, although it is conceivable that it may have been connected by an eastward extension of the cobbled floor level, all of which has now been lost to erosion.

East from the Copper Yard, the course of the tramway passes between two stone walls, one, a relatively low wall, which separates it from the adjoining coast road, the other separating it from an area around an open top shaft (Fig. 32). This section broadens and divides just to the east: part of it aligns almost

visible thickness of the ramp, suggesting that it may well have extended further up above the ramp level. These remains are here interpreted to represent the remnants of a small, two storey building built into the ramp.

## Section 3: Copper Yard to Tankardstown

The course of the tramway east for several hundred metres from the ill-defined eastern end of the ramp is very speculative as the entire area has been crudely levelled, cleared, and is now overgrown by scrub (Fig. 39). Further east, the assumed course is truncated by a prominent cliff collapse, which occurred in the 1970s, beyond which the tramway appears as a prominent cutting in the edge of the cliff scarp (Fig. 40).


*Figure 28. A view looking east along the modern slip way lane into Stage Cove, showing a profile view of the inclination of the aerial ropeway decline from the Copper Yard into Stage Cove.*

*Figure 29. Co-author JHM standing beside a remnant of the quay side cobble floor level.*

*Figure 30. A close up view of the quay side cobble floor level constructed on sub-soil just above rock level, and overlain by Pleistocene sediments believed to have slumped down onto the quay level as a result of cliff top erosion - compare with in situ sediments capping the cliff top in the background.*

*Figure 31. Close up view of a pair of wooden jetty hold-down bolts.*


*Figure 32. View looking east along the tramway route towards the base of the main ramp, and its crest, on the horizon, top left.*

*Figure 33. Close up view of roofless shed at base of, and looking directly up the main ramp incline.*

***Figure 34. View looking down lower part of the main ramp across the small yard area in front of the shed shown in Fig. 33.***

***Figure 35. Panorama view looking directly up the main ramp incline, showing the roofless shed on the right hand side, and, on the left, across the coast road, the extant ruins of the Winding Engine House and ancillary features erected in 1838.***

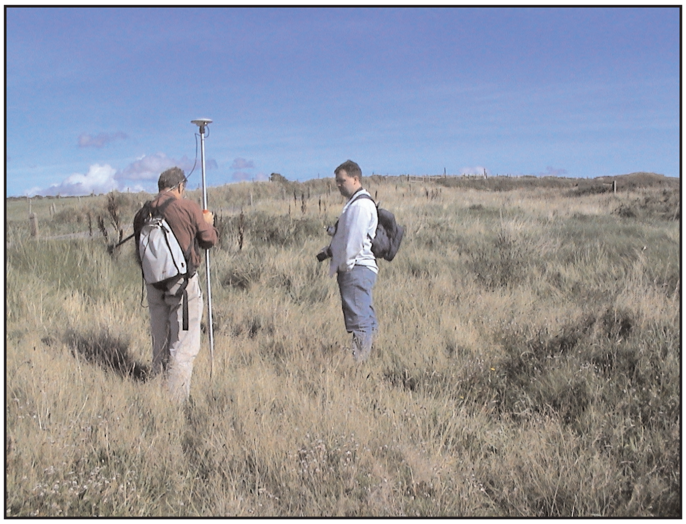

***Figure 36. A close up view of the road side edge of the main ramp, the wall top contour clearly reflecting the incline and level sections of the structure. Note the two very prominent near vertical grooves built into the ramp masonry.***

***Figure 37. A general view showing length of damaged masonry along the seaward side of the main ramp. The sharp vertical left hand edge of this damaged section aligns exactly with the crest of the main ramp incline.***

***Figure 38. A close up oblique view of the damaged section shown in Fig. 37, showing the remnants of a wall tied in at right angles to the ramp.***

The cutting continues east for about 20m from the cliff scarp (Fig. 40) before it passes into a long section in which all trace of its course has been obliterated by back filling during field reclamation works. Nonetheless, the short section does provide a good approximation not only to the original level of the tramway at this point, but also to the width of the tramway. Here it is about 2.16m (84") wide, although it is difficult to give a precise figure as the edges of the banks, cut through unconsolidated Quaternary sediments, have partially collapsed into the cutting (Fig. 40). The cutting re-emerges from back fill into a very prominent and deep rock cutting (Figs 41 - 42). This provides yet another good approximation to the level of the original trackway, but also an even more definitive constraint on the maximum width of the system - here an average of about 1.85m (c. 72") wide, but ranging up to about 2m (78").

Further east, the course of the tramway is relatively well preserved and discernible as a shallow cutting, rising gradually along a gentle gradient of about $2^0$ to $3^0$ which at many points



*Figures 39 - 42 all showing views of the course of the tramway east from the main ramp towards Tankardstown. Figure 39. View of the levelled and overgrown area immediately east of the main ramp.*

*Figure 40. View of the tramway cutting truncated by cliff erosion. Co-author JHM and Ewan Duffy standing at the base of the cutting which appears to be close to its original level. Part of the Tankardstown engine house complex visible on the horizon in the background.*

*Figure 41. Close up view of course of tramway through a rock cutting. Note the completely backfilled section of cutting in the immediate foreground.*

*Figure 42. A general view of the same cutting depicted in Fig. 41, showing the course of the tramway extending up slope towards the east on the flat or in a shallow cutting. This entire section appears to be at or close to the original tramway level.*

*Figures 43 (below left), 44 (right) showing views of the tramway route close to Tankardstown (Fig.43) and the shallow rock cutting abreast of Tankardstown (Fig. 44).*

appears to be at or close to the level of the original trackway (Figs. 41 - 43). Towards the top of the incline, opposite Tankardstown (Fig. 44), the tramway passes through a shallow cutting, partly in rock, before it splits into two branches, at what is here

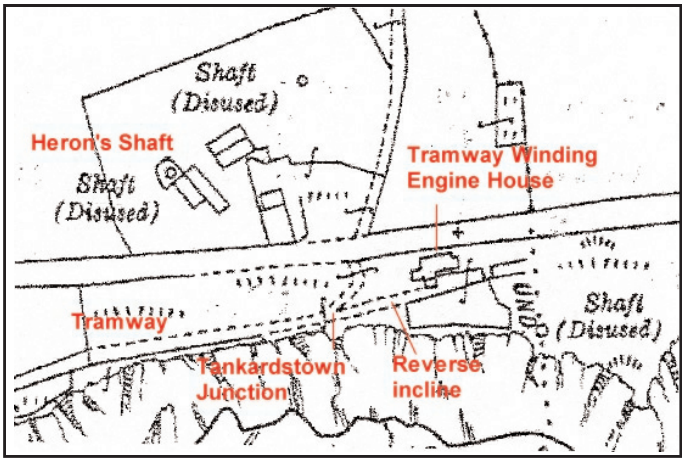



*Figure 45. A plan view of the Tramway route, Winding Engine House and other features shown on a 1905 (revised 1922) OS six inch scale map.*

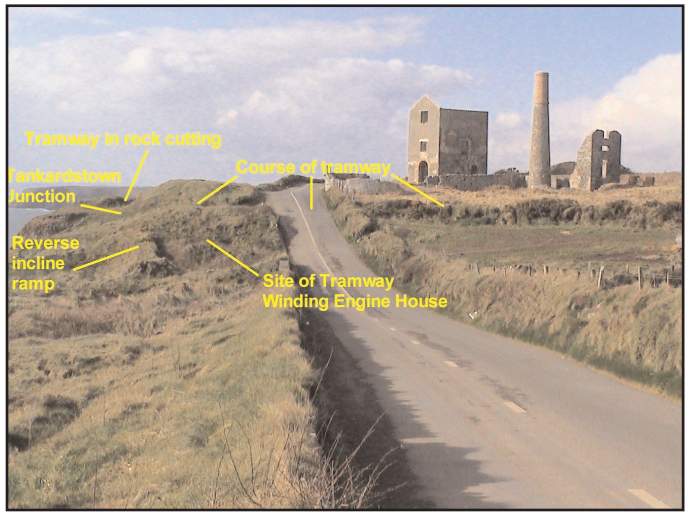



*Figure 46. A general view, looking west, showing the extant tramway features, all labelled, and mine site buildings on the right, as they appeared in 2006, after completion of conservation works: in the centre a single chimney which served the boilers of the Pumping Engine House, on the left, and the Winding Engine House on the right.*

*Figure 47. Looking up the top end of the reverse incline, across the junction towards the main tramway incline passing through the shallow rock cutting also visible in Figs. 44, 46.*

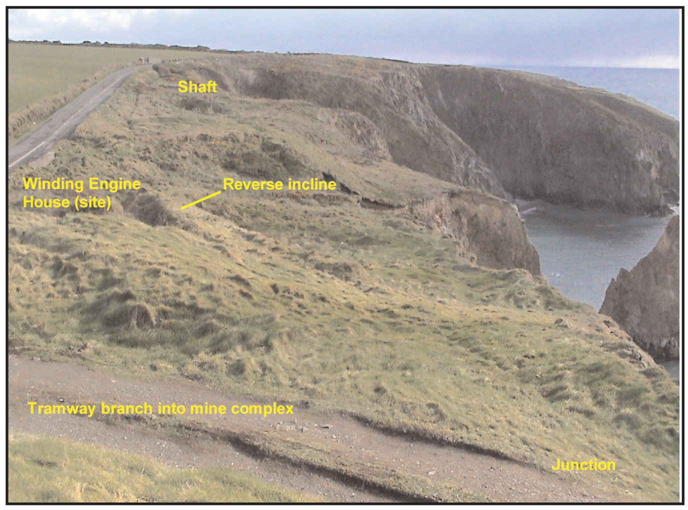



*Figure 48. View looking down on the junction, showing the reverse incline extending down slope, and the mine branch passing along the trackway in the foreground.*

*Figure 49. Close up view of the masonry edge of the reverse incline ramp, beside the irregular mounds immediately to the left which mark all that now remains of the Tramway Winding Engine House.*

*Figure 50. Tramway branch passing north across the coast road into the Tankardstown mine complex beyond*

termed the "Tankardstown Junction" (Figs. 45 - 48) one branch of which continues eastward down a short reverse incline (the "Tankardstown reverse incline" hereafter, Figs. 45, 46, 48, 49), the other branch curving gently northward towards and into the entrance of the Tankardstown complex (Figs. 45, 46, 50).

The reverse incline is a very conspicuous, straight embankment, about 43m long, and varying between 1.8m (72") and 2.1m (84") in width. A well constructed masonry wall defines part of its northern edge (Figs. 48, 49). This lies immediately adjacent to an irregular mound located at the site of what is shown as an Engine House on the 1905 (revised 1922) edition of the OS 6 inch scale map of the area (Figs. 45, 48, 49). There is no masonry wall along the southern edge of the embankment, which instead consists entirely of collapsed soil, as does the rather abrupt down slope termination of the ramp (Fig. 49). There is no visible remnant of the short ramp section further to the east, nor the presumed field enclosure immediately to the south (Fig. 45 cf. Fig. 48).

The other branch, now expanded to a laneway width of about 2.5m, continues up to and across the Bunmahon - Annestown coast road and through a gated entrance opposite into the mine site (Fig. 50). From there, the 1905 (revised 1922, Fig. 45) plan of the mine site shows the tramway running almost due north towards a shaft (Pope's shaft) where it ends. This section has now been widened into, and is used as a farm trackway. Geophysical evidence (Barton 2005, this Journal) strongly suggests the presence of yet another branch of the tramway curving westward from the vicinity of the farm trackway towards and almost up to the principal production shaft (Heron's Shaft, Fig. 45) and extant buildings on the site. However, neither the 1905 mine site plan show such a branch, and nor is there any physical evidence of its course visible on the ground. Nonetheless, such a configuration is very reasonable as a tramway to this point would have served to draw ore from the shaft top, as well as deliver coal and other supplies to the mine buildings.

## INTERPRETATION

In the absence of any definitive or detailed descriptions of the tramway at the time it was built in 1854 up to abandonment in c.1877, any interpretation of its configuration or mode of operation is necessarily hypothetical as it has to be based entirely upon deductions derived from observations of extant remains, comparison with other systems, and conjecture.

Some extant features are critical to consequential interpretations: for instance, the contrast in width of the tramway on the main ramp, in the rock cutting to the east, and in the backfilled cutting across the field to the west (Figs 7, 33 and 41); the configuration of the main ramp itself (Fig. 53); and the configuration of the Tankardstown incline (Fig. 57).

## Trackway configuration and gauge

East of the main ramp, the tramway route is much narrower than it is on the ramp and to the west. On the ramp itself it is 3.79m (149") wide and about 3.66 m (144") wide in the back-filled cutting across the field to the west of the Copper Yard (Fig. 7), an average width of 3.73m (147"). This is in distinct contrast with the width in the cutting on the cliff edge to the east of the ramp (Fig. 40), where it is only about 2.16m (84") wide, although this reflects a fair degree of collapse inward from both banks. Further east, it is 1.85m (72") wide in the rock cutting (Fig. 41), approximately 3m (120") wide just short of the Tankardstown junction (Fig. 44), and 1.8 - 2.1m (72" - 84") wide on the Tankardstown incline, as noted above (Fig. 49). Of these figures, that in the rock cutting, 1.85m (72"), is undoubtedly the best constrained and is here taken to be representative of the operative trackbed width of the entire eastern section.

The width of the main ramp and western section of the tramway is remarkably similar to that of the still extant mineral tramway incline at Ballygahan, Avoca, Co. Wicklow (Fig. 51). There, the maximum directly measurable width is 4.52m (178"), but, allowing for two parapet walls, each about 0.48m (19") wide (the measured width of the parapet walls at Tankardstown), the maximum trackbed width is reduced to about 3.56m (140") -

***Figure 51. A c. 1945 image of the Avoca Mineral tramway incline, Co. Wicklow. Note the cable support rollers between each pair of 24" gauge tracks, which replace the original 42" gauge tracks installed in the 1870s (Geological Survey of Ireland, mine records archive).***

the width of the trackbed visible between the retaining walls on either side of the double tracks in the c. 1945 historic photograph reproduced in Figure 51. Waldron *et al.* (2004) note a gauge of 0.61m (24") for the tracks then in situ, in contrast to a 1.06m (42") gauge for double tracks which were in place in 1870, and remnants of which were still visible in 2003 (Duffy, 2003).

The latter gauge would be far more consistent with the available, 3.56m (140") width of the trackbed, than occupation by a pair of 0.61m (24") gauge tracks which, by comparison, appear distinctly undersize within the available trackbed width (Fig. 51). At an original, 1.06m (42") gauge, the pair of tracks would have occupied 2.13m (84") of the available trackbed, leaving 1.42m (56") for clearance between the tracks and between each pair of tracks and the sidewalls/parapets - exactly 0.47m (18.6") in each instance if all gaps were equal. Approximate scaling of gaps visible in Figure 51, suggest a gap of about 0.5m (20") between the track and sidewalls and about 1.22m (48") between the tracks. The latter is undoubtedly excessive, though the marginal gap appears reasonable, and consistent with that calculated above for the 1.06m (42") gauge. Whether or not clearance gaps were all equal is, however, unknown, but if they were, or even approximately so, then it would suggest that ore wagons had near vertical sides, rather than over-hanging outward, as with some designs of that era, in order to avoid wagons colliding with each other at passing points.

need to manually transfer loads from one gauge to the other at the main ramp. The available evidence therefore suggests that the eastern section accommodated a single, 1.06m (42") gauge track only.

The inferred single and double track sections meet, as best as can be determined from visible remains, at, or just east of the eastern end of the main ramp. It is tempting to speculate that these two sections may have been built at different times, to service gradually evolving operational needs as the epicentre of production moved east to Tankardstown in the early 1850s: the western section, including the main ramp, to service operations between Knockmahon and the Copper Yard up to the early 1850s; and the single track section from about 1854 onward. While the available evidence is permissive of such an interpretation, it is, however, unlikely.

Neither of the maps published or compiled in the 1840s, the first edition OS map, published in 1842, nor the MCI map compiled in 1845, depicts any part of the tramway, while the MCI reports indicate that the tramway was built in 1854. The most logical inference is that the latter reports refer to the entire system, as there is nothing in any of the MCI reports to suggest that this "railway" was built at different times. We may surmise from MCI reports that the Knockmahon mines at Stage Cove were finally abandoned about 1855, after "robbing" remaining ore sections above sea level, and removal of the primary steam

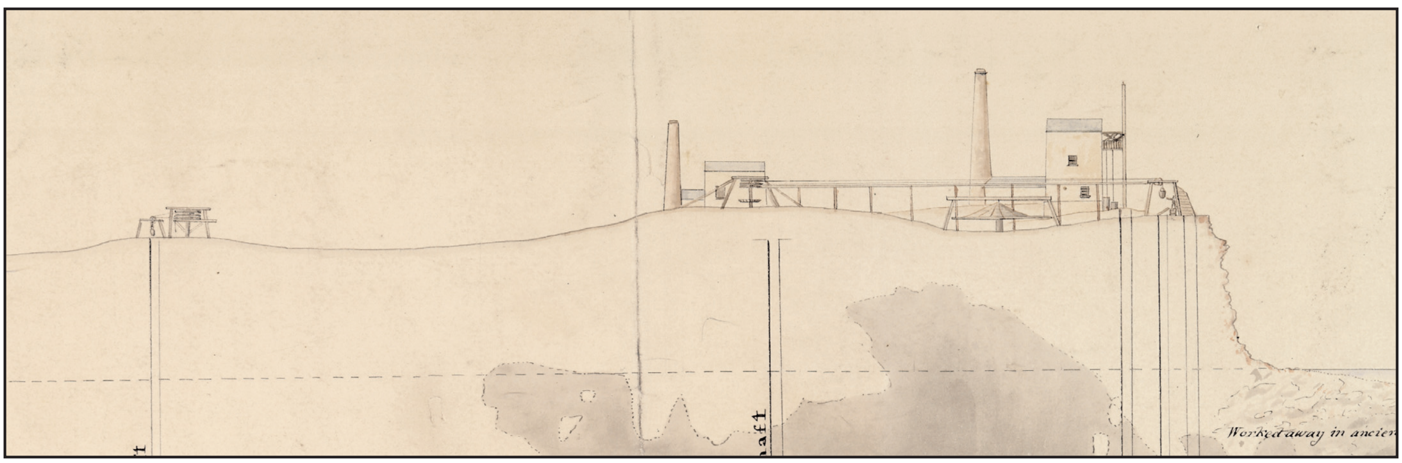


***Figure 52. A vignette of the cliff top mine buildings at Knockmahon (Stage Cove), enlarged from a mine plan dated 1845 (Warrington Smyth, September 1845; Geological Survey of Ireland mine records archive), from which it may be surmised that all infrastructure depicted was still fully functional at that time. Note the large Pumping Engine House near the cliff edge, of which the engine, boiler and perhaps other components were later removed to and re-erected at Tankardstown. Note also the elevated gantry supporting winding cables extending from the inland Winding Engine House (cf. its extant ruins shown in Fig. 35) to winding gear mounted over a cliff top shaft.***

It is evident, that, at a trackbed width of 3.79m (149"), 0.23m (9") greater than the c. 3.56m (140") width at Avoca, the western section of the Bunmahon tramway could easily have accommodated a pair of tracks, each of 1.06m (42") gauge. In contrast, the best constrained width of the eastern section, in the rock cutting (Fig. 41), is only 1.85m (72"). This is far too narrow to have accommodated two tracks each of 1.06m (42") gauge, and even a narrower gauge, of say 0.61m (24"), when due allowance is made for reasonable clearance distances between the tracks and between them and the side walls. Furthermore, adoption of a dual gauge system would have introduced a further complication, and cost, resulting from the

pumping engine (Fig. 52) to the new production centre at Tankardstown.

The two prominent grooves in the main ramp masonry (Fig. 36) are critical to these chronological interpretations, as it reasonable to presume that they served a function which must have been contemporary with at least this part of the tramway. We suggest that they most probably served to accommodate timber legs for a gantry system passing over the top of the ramp, an inference drawn from the size, shape and orientation of each of the slots.

The purpose or function of such a gantry is complete conjecture, but one possibility is that it acted as part of a support for winding cables connected between the 1838 Winding Engine House just to the north of the road (Fig. 35), passing over the top of the tramway to one or more shafts between the main ramp and the cliff edge just to the south. A vignette on an MCI plan dated 1845 shows exactly this configuration at this location, but without any representation of a tramway passing under the gantry (Fig. 52; by Warrington Smyth, September 1845; Geological Survey of Ireland mine records archive). Assuming that the vignette representation is accurate, then it clearly indicates that the tramway/main ramp was constructed after this date, but, critically, before operations had ceased at Stage Cove not earlier than 1855, as it would have been illogical, and an unnecessary expense to provide a gantry system to facilitate an operation which was either on the verge of closure, or had indeed closed.

The inferred double track configuration of the western section most logically suggests that it was intended to function either as an entirely gravity operated system (a "self acting incline", Le Neve Foster, 1905, p. 388), or at least partly gravity driven. Waldron *et al.* (2004) and Le Neve Foster (1905) provide detailed descriptions of how such systems operated, although the principle is very simple: the weight of a string of ore wagons descending on one line drawing a string of wagons up slope on the other line. Apart from the obvious requirement that the weights of the two strings of wagons had to be finely balanced to ensure that they ascended and descended under control, layout details could vary quite considerably.

been attached, at one end, to a winding drum or drums at the upper end of the system, while the other, "free" ends, were attached directly to strings of wagons.

The system was set in motion by allowing the string at the top of the incline to descend on one track and, in so doing, haul the other string of wagons up the opposite track. All of this would have been controlled through a clutch and brakes on the drum or drums operated by an "engineman" positioned at a location to see most, if not all of the incline. Each rope was supported by flanged, wooden or metal rollers set at intervals on horizontal axles between each pair of rails, in order to reduce wear and tear on the rope (cf. Fig. 51).

Such rollers were all that was required for absolutely straight inclines, but for non-linear inclines, as at Bunmahon, the configuration is more complicated, as it would have been necessary to keep the rope in place as it curved around bends in the trackway. Le Neve Foster (1905, p. 389) mentions the use of small vertical rollers to provide such control, these normally positioned beside the trackway, rather than between the rails (presumably because there would be insufficient clearance between the tops of vertical rollers and the base/axles of the ore wagons). This configuration is assumed here to have been applied along the entire double and single track length of the Bunmahon tramway, with arrays of vertical rollers positioned along the inner arc of each bend.

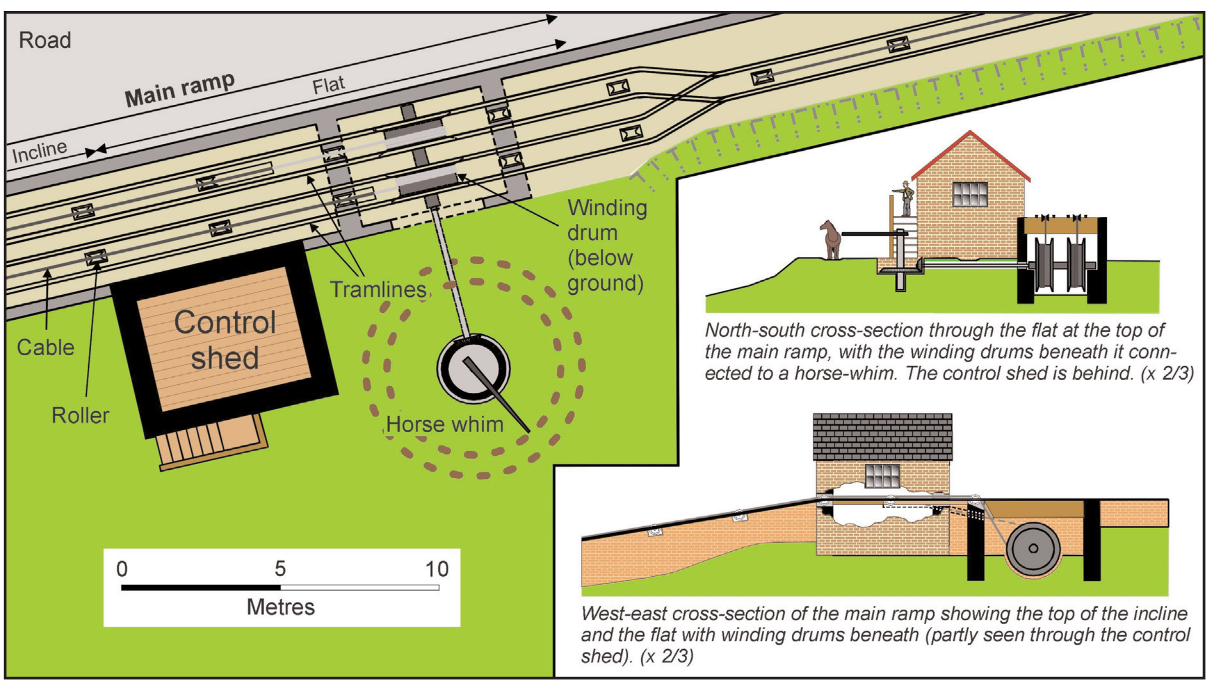



***Figure 53. An interpretation of the operational configuration of the "main ramp" structure near Stage Cove. See text for description.***

Le Neve Foster (1905) describes and illustrates a number of possible tramway configurations, admittedly all for underground installations, although it is reasonable to presume that the general principles applied equally to surface installations. Of these, the most likely configuration used on the Bunmahon tramway was a double line system with single ropes for each trackway (as used at Avoca, see Fig. 51). Each rope would have

## Main Ramp

The main ramp undoubtedly provided the control point for the entire western section of the tramway, and as such may be presumed to have been the site of the winding drum or drums, as well as the "engineman's" vantage point. This is believed to have been located in the small, inferred two storey building located beside the crest of the main ramp incline, on its seaward, southern edge, as described earlier (Fig. 38, and Fig. 53, "control shed"). The first floor level of a building at this location would have provided an excellent vantage point for the "engineman" to observe virtually unimpeded all sections of the western and eastern tramway routes, as well as control operations from that point.

The inferred configuration of the "control shed" is derived from that shown in a 1907 photograph of an "engineman's" control hut built beside, and at the top of the West Somerset Mineral Railway (WSMR), in England (Fig. 54; Madge, 1984). This photograph also provides a vital clue about the possible location and configuration of the winding drum or drums - housed under the tracks, rather than above ground at the eastern end of the ramp. There are two significant advantages to this configuration: weather protection at a very exposed, cliff top location; and, not least, a clear and un-obstructed course for extending the tramway further to the east, which would not have been the case if the drum or drums had been set above ground. Figure 53 presents a surface plan and longitudinal interpretation of the main ramp configuration based upon these premises.

***Figure 54. A photograph dated July 21, 1907, showing the configuration of surface infrastructure at the crest of the standard gauge West Somerset Mineral Railway incline, England. Note the Engineman's control hut located at the crest of the incline, and winding ropes passing through slots between each pair of rails on to winding drums mounted below surface. For discussion, see text. Image reproduced by permission of the Dovecote Press.***

The drum configuration, and whether or not it was powered, and, if so, how, are entirely conjectural. Figure 54 clearly shows the two haulage ropes of the WSMR system passing under the level of the trackway through slots set between each pair of tracks. It is notable that these slots are offset significantly relative to each other, one being set very close to the crest of the incline, the other much further back (Fig. 54). While this might suggest the presence of two separate drums, it is far more likely to reflect over- and under-winding of haulage ropes onto adjoining sections of a winding drum mounted on a single axle beneath the track level. This configuration would have allowed one rope to wind onto one section of the drum, and the other off its section as the axle rotated in one direction only, thereby providing a single control point for governing speeds of descent and ascent on the incline.

Madge (1984) notes that the WSMR system was powered by a steam winding engine, also set beneath the level of the tracks, and though such a system could be invoked for the main ramp, there is no evidence to indicate that such an installation ever existed at Stage Cove. On the contrary, McGrath (1959) notes the oral recollection that the system was horse powered, not steam powered. But where and how might horsepower be applied in a system which otherwise appears clearly designed to make use of gravity as a motive force?

It is reasonable to surmise that horses were used to haul individual wagons around marshalling points in the Copper Yard, on the dressing floors at Knockmahon, and around mine facilities at Tankardstown. They may indeed have been used also to haul single wagons on the main incline, but it is unlikely they were used to haul strings of wagons given both the gradients over certain sections, as well as the difficulty of integrating direct horse haulage with the inferred gravity powered system. Instead it seems more likely that horses were used to provide power indirectly to the gravity system, conceivably through a horse whim attached through a gear and clutch system to the winding drum, as shown in the interpretation presented in Figure 53. This configuration is based upon analogy with a horse whim observed and recorded at the Tassan lead mine in Co. Monaghan (Morris, 2002; Fig. 55 here). There, the wrought iron horse whim consists of a vertical drive shaft connected via a narrow ground level flange underground through bevel gears to a horizontal drive shaft which powered carpentry shop machinery in the adjoining mine office building. This configuration is favoured as, similar to housing the winding drum under the ramp, it provides a degree of protection in the exposed cliff top location, as well as placing the underground main drive shaft on the same level as the winding drum axle.

The main ramp is a very obvious and substantial feature, and while Figure 53 provides an interpretation of its configuration, one question still remains: why was it needed at all, as not only could the winding drum and horse whim have been accommodated in a far less elaborate structure, but the incline itself introduces a seemingly unnecessary steep slope. The most logical explanation is that the steep incline on the west flank was considered necessary to set in motion haulage at the other end of the dual track system - out of the Knockmahon dressing floors.

The 1898 prospectus mine plan shows that end of the tramway starting to curve towards the location of a crusher house (Figs. 2, 4). This part of the dressing floor, however, is topographically lower than the adjoining course of the tramway as it runs southeast out of the yard towards "The Arch" (Figs. 4, 13). If the tramway originally extended into the vicinity of the crusher house, then some considerable impetus would have been required at the opposite end of the system to set loaded ore wag-

*Figure 55. Wrought iron horse whim, Tassan Lead Mine, Co. Monaghan. The angled draw bar (main section about 3.9m in length; short, angled horse hitching bar about 70cm) is connected via an inverted conical shaped hub to a circular shaped flange at ground level, and below ground level to a bevel gear and horizontal drive shaft.*

ons in motion up this gradient, even though it is relatively gentle (Fig. 13). It is conjectured here that the steep western slope of the main ramp was constructed specifically to provide the requisite impetus.

## Copper Yard

Figure 15 shows a plan view of key features visible within and immediately adjacent to the Copper Yard, all described above. It is reasonable to infer that a single line branch of the tramway ran straight into the yard through the west entrance, presumably along the inside edge of the north curtain wall, as the tramway course just to the west aligns directly with the entrance.

The north entrance is also presumed to have served as a separate tramway entrance leading straight onto the upper floor level, set at the same level as the "aerial ropeway" (Fig. 15). This ran out into the east central part of the yard, directly in line with the very steep decline from the yard down to the original slipway in Stage Cove immediately below (Fig. 15). We presume that this marks the location of the aerial ropeway noted by McGrath (1959), which served to convey bagged ore from the yard down to the slipway below. The map evidence, combined with the very distinct contrast in building materials used in the walls either side of the north entrance, suggests that this eastern part of the presently visible yard area represents an extension built sometime between 1840 and 1905.

The date of construction may however be even more tightly constrained - most likely to 1854, when the MCI report for December that year notes that an incline plane was constructed to facilitate ore shipments (see discussion on p. 56). It is here postulated that the "incline" refers to the aerial ropeway decline, and, by association, the extension of the yard to enclose that facility securely, as the north entrance is most reasonably interpreted to have been built to provide a direct connection between the aerial ropeway and the tramway. It is also reasonable to presume, in the absence of any other information to the contrary, that the wooden jetty and quayside cobble floor below and in line with the aerial ropeway decline were constructed as part of the same works programme.

The remains of the steep decline from the yard down to Stage Cove, as well as the last remnants of a quay side cobble floor level, are still readily visible (Fig. 26, 29, 30), the latter presumed to have formed part of the landward end of the wooden jetty described earlier. The mid point of successive pairs of jetty bolts aligns with the mid-line of the decline, suggesting that the ropeway may well have extended out onto the wooden jetty, rather than just terminating on the pier side cobbled floor. This would have reduced man-handling and made it easier to off load bagged copper ore straight on to lighters moored against the jetty, as well as to transfer bagged coal off such boats straight onto the ropeway for haulage back up into the yard.

Apart from noting that the ropeway involved an endless chain, McGrath (1959) makes no mention of how the system operated, or how it was powered. It is assumed here that it was a relatively standard configuration overhead system, with the chain looping, at one end, around a powered, horizontal capstan mounted overhead on a vertical drive in the yard, and a similar, freely rotating capstan at the other end, on the jetty. A horse whim, conceivably of the same type as that inferred on the main ramp, and possibly located in the shallow depression on the east flank of the ropeway ramp (Figs. 15, 24) was the most likely power source, as there is no physical evidence of, or mention of a steam powered system within the yard.

The configuration of the tramway outside the yard is totally conjectural, as there are no physical remains of it whatsoever. Nonetheless, double sets of points may be inferred to have been located proximal to each yard entrance in order to facilitate marshalling wagons from either track onto, or off, the lines running into the yard. The inferred configuration at the west entrance is relatively straightforward, although track curvatures are somewhat sharp in order to provide clearance around the projecting NW gate pillar (Fig. 15). The curvature of the wall on the west side of the north entrance constrains the presumed single line yard track to curve towards the west, with an inferred cross over configuration pointing in that direction (Fig. 15). Horses probably provided the motive power for marshalling single or limited numbers of full or empty wagons into and out of the yard on to the running tracks. The small roofless building at the foot of the main ramp (Fig. 33) possibly served as a tramway equipment store, as the lack of windows, combined with the narrowness of the doorway suggests that it was unlikely to have been used as a stable.

## Tankardstown

The eastern tramway section differs significantly from the western section of the system, including the main ramp, described above. It is a single line system, but, most importantly, there is reasonable evidence to suggest that it was powered by a steam winding engine, notwithstanding the emphasis placed on horse power by McGrath (1959). It is postulated here that the engine house located immediately beside the Tankardstown incline (Figs. 45, 48, 49) served as a tramway winding engine house, rather than providing motive power to in-shaft applications, as there are no shafts anywhere near this location, apart from the "Boundary" and "Whim" shafts, the latter about 100m upslope to the east (Fig. 48). If it had been intended that the engine house should service either of these shafts, then it would have made far more sense to locate it on the open space beside them rather than position it at a distance, and on a constricted site on the opposite slope of a shallow valley (Fig. 48).

Sadly, there is absolutely no known surviving information about this engine house, its design, purpose or operational configuration. The footprint space on the site where it was located is very small, constrained by the incline on one side, and the coast road on the other (Figs. 45 - 49). This suggests that the installation was quite small, probably about the same size as the winding engine house across the road in the Tankardstown mine yard site. This housed a 20" engine in a totally enclosed engine house, of a design almost identical to that at Levant in Cornwall. It is here speculated that the tramway winding engine was of similar design and size, as such a design would afford protection for both flywheel and bob at this very exposed cliff top site. How this may have connected to, and powered the tramway is dependent upon how best to interpret the operational design of the adjoining reverse incline (Fig. 48).

Most stationary, steam powered winding and pumping engine applications involved counterbalancing in one form or another in order to minimise energy consumption and running costs. Similar considerations also applied to steam powered tramways, as at Avoca (Fig. 51), and it is entirely reasonable to assume that the MCI would have endeavoured to provide some form of counterbalance for the postulated Tankardstown tramway engine. For a double track system, this could have been achieved very easily, with one string of wagons on one line counterbalancing another string on the other line moving in the opposite direction (cf. WSMR, Fig. 54, and discussion). But for a single line system, as at Tankardstown, the situation is a bit more complicated, as ascending and descending wagons could not use the one line simultaneously without colliding. This problem could, however, be readily resolved by the provision of a passing loop at the mid point of the single line, controlled by manually operated entry and exit points at each end of the dual track section (of which there could be several different configurations - for examples, see Le Neve Foster, 1905, Figs. 417-419, p.392; Fig. 56 here).

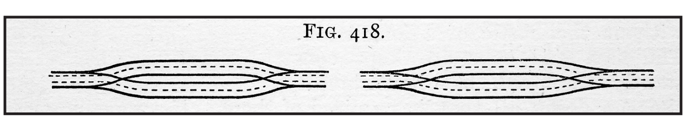
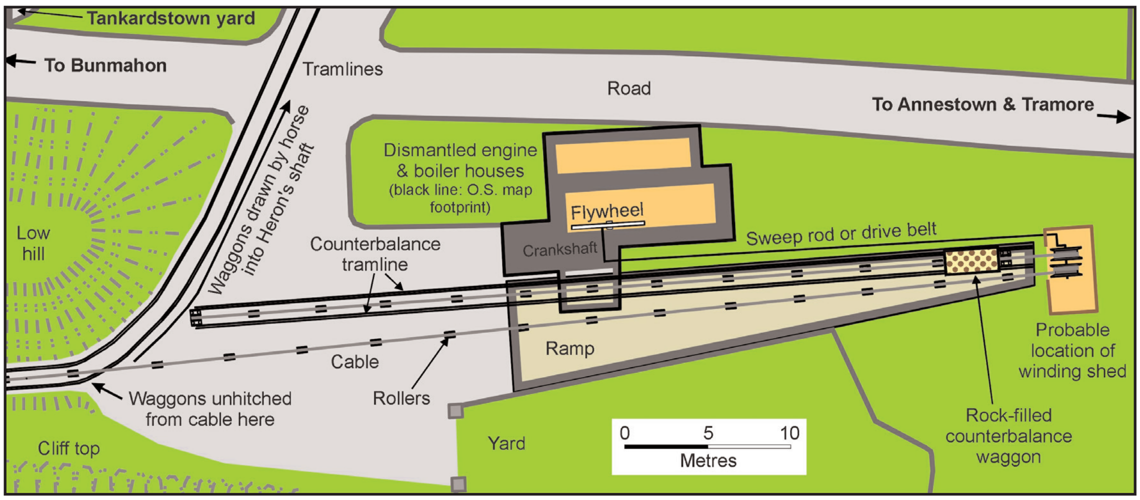



*Figure 56. Single line passing loop configurations (reproduced from Le Neve Foster, 1905).*

*Figure 57. An interpretation of the operational configuration of the Tramway winding engine house and reverse incline at Tankardstown.*




There is, however, no visible evidence of an expanded width trackbed at the mid-point of the eastern section, which would have been essential to accommodate a short section of dual trackway for a passing loop. It is therefore suggested that the counterbalancing was provided by the Tankardstown reverse incline (c. $4.5^0$), which, at least in orientation, provides a gradient in the reverse direction to that of the single haulage track. The reverse incline (Figs. 45, 48) is, however, considerably shorter, so any counterbalance operating along the length of the reverse incline would have to have operated through a geared system in order to render the reverse incline length (total observable about 46m) equal to that of the main haulage line. This could, at least in theory, be achieved relatively easily by two arrays of multiple pulley systems, one at each end of the reverse incline, such that the total length of the multiple rope loops was equivalent to that of the tramway haulage rope. One end of the incline rope could then be attached to one or maybe two counterbalance wagons which operated along the length of the short incline only, and the other end attached to the winding drum, the interpretation favoured in Figure 57.

It is assumed that the winding drum was located at the bottom end of the incline, most likely in a partly or totally enclosed shed to provide at least some form of weather protection, with ropes entering and leaving through slots in the wall facing up the incline. It is further assumed that the drive connection between the engine house located about 40m or so upslope from the presumed location of the drum, was effected by a sweep rod, or conceivably even a cable drive system, located in the

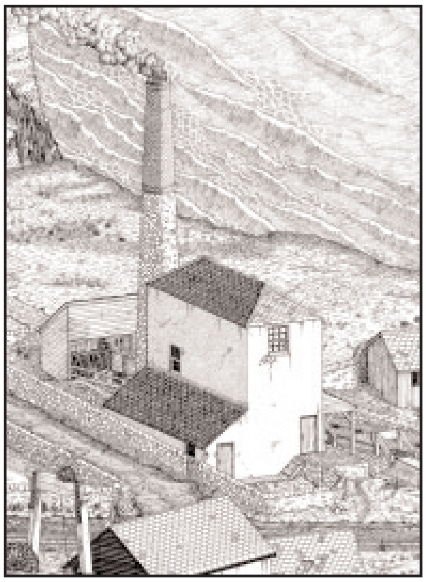


***Figure 58. An artist's reconstruction of the possible appearance of the Tramway Winding Engine House complex, c. 1870. This illustration is enlarged from a pen and ink drawing of the entire Tankardstown Mine site complex by co-author Dr. D. Tietzsch-Tyler. See Tietzsch-Tyler, 2005, this Journal.***

gully running along the leeward side of the reverse incline ramp. Figure 58 presents an artist's reconstruction of how the tramway engine house installation may have appeared in c. 1870.

Again, under and over winding of the ropes on opposite halves of a single, partitioned drum would impart opposing haulage directions to each rope. The one attached to wagons on the main haulage route are presumed to have been mounted on rollers to one side of the incline, most likely on the southern side as this would give a clear run up to and over the Tankardstown junction (Figs. 57, 58). This was probably the limit of steam powered haulage on the eastern section. From there it is postulated that wagons were hauled by horses into the mine site, and, as in the Copper Yard, it is reasonable to assume that horses were used for all marshalling operations within the mine site area.

As noted earlier, the MCI report for the second half of 1854 notes an aggregate expenditure of nearly £3,000 on the construction of the railway and extension of the mine during that reporting period. The report does not, unfortunately, state how much of this expenditure relates to the railway, although it is reasonable to assume that it represents a significant part of the total amount if the entire system was constructed entirely during the reporting period - the last 6 months of 1854. Whatever the actual cost, it is reasonable to presume that it included the cost of constructing the inferred tramway winding engine house at Tankardstown, as it was an integral part of the system.

While it could be conjectured that the MCI bought in an engine for this purpose, this is thought somewhat unlikely as the Company had three winding/drawing engines available at the time of cessation of operations at Kilduane/Knockmahon by the mid-1850s: one 30" engine, one 18" and one 20" (?) (MCI reports 1842 - 1853; Brown, 1996; Cowman, 2006). One of these, the winding engine originally erected at Kilduane in 1842, was almost certainly moved to the enclosed engine house at North Tankardstown in 1851/2. Of the two remaining engines, a drawing engine first erected at Knockmahon (Stage Cove: Fig. 52) in 1838, and a winding (?) engine first erected at Ballynasissala in 1842, it is reasonable to assume that the latter was moved to, and re-erected in the enclosed Winding Engine House (Fig. 46) at Tankardstown at some time in the mid-1850s, along with the 50 inch Pumping Engine from Knockmahon (Fig. 52). The fate of the third engine, the 1838 drawing engine, has always been something of an enigma, but it is here suggested that it was moved to Tankardstown to serve as the tramway winding engine.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