Condition Report:
The First Lime Kiln on Otago Peninsula

By Carl Murray and Stuart Griffiths (March 2019)

Report for Hereweka/Harbour Cone Management Trust

Introduction

This report will assess the condition of the Sandymount Lime Kiln site complex (site I44/85) located along Sandymount road on the Otago Peninsula in the South Island of New Zealand, near Portobello (see Figure 1). The site can be accessed from Sandymount Road (Figure 2) by walking northward from the top lime kiln (I44/83), down through the valley past the second lime kiln (I44/84) and traversing west near the base of the hill. To enter the site complex continue walking west through a gate and over a small creek. The area around the base of the site (I44/85) is very swampy.

The report will be focused on investigating the condition of the lime kiln structure which was constructed in 1865 (Middleton, 2008) and is in a ruined state. The lime kiln is a masonry structure with local limestone, volcanic tuff and bricks being used in its construction. The condition of other features relating to the lime kiln structure and the production of lime will also be briefly discussed. Features relating to this site include: the lime kiln, work areas, lime waste area, and limestone outcrops which exhibit quarrying. These features have been mapped and are exhibited on the site plan (Figure 3). The site plan, elevation drawings and plan drawings of the kiln will need to be updated after vegetation is cleared, as details of the structure were obscured.

The objective of this report is to examine the condition of the lime kiln structure and record any observable damage. The processes which are responsible for the deterioration will be discussed to better understand the causes of damage and to ultimately aid in the development of a conservation plan. These processes include weathering, vegetation, and trampling damage caused by stock as well as people. Observations regarding the deterioration of historical features will be recorded by photograph and scale drawings where applicable and will serve as a periodic marker for future monitoring of the site complex. This comparable method will be useful in understanding the rate of deterioration over time and aid in developing a conservation plan for the site complex as well as the development of procedures that can halt or reduce the impacts of deterioration.

Consulting stone mason Stuart Griffiths gave advice on specific conditions of the masonry work in the kiln along with possible solutions to rectify any problems regarding stabilization and deterioration of the structure. The role of the archaeologist, Carl Murray, was to convey in text and graphics the very complex state of deterioration of the masonry in the lime kiln structure and to help interpret what the original state and function of each feature probably was.

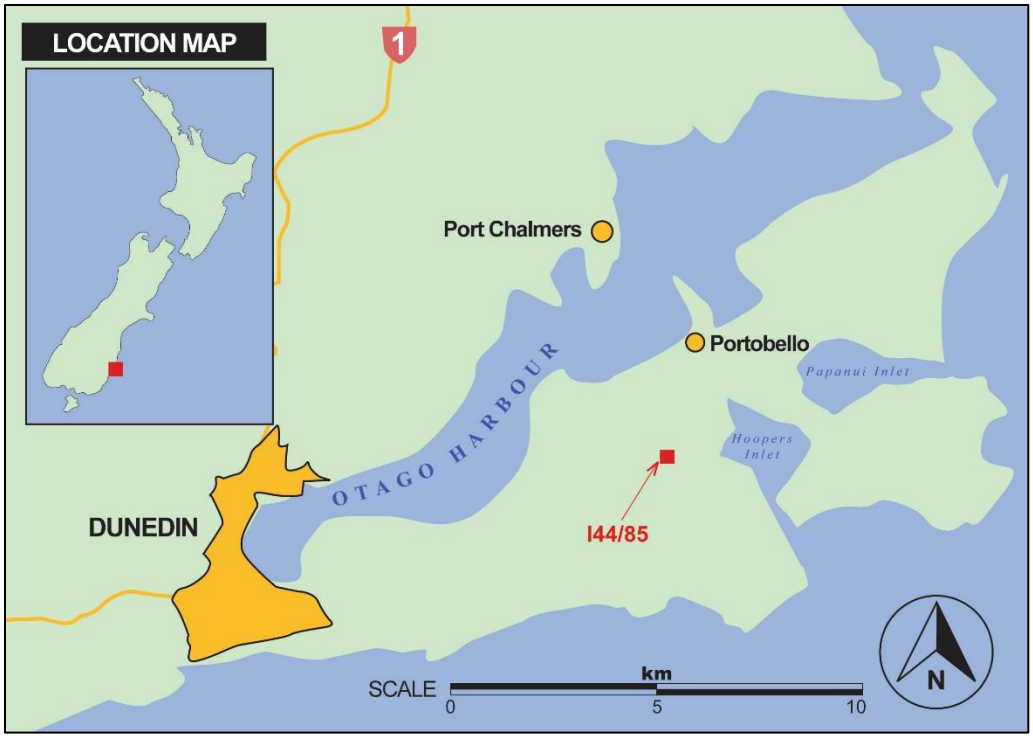

Figure 1. Location map for site I44/85.

The site complex I44/85

This historic industrial complex is the earliest of three lime kiln sites in the Sandymount area and is recorded as an archaeological site with New Zealand's site recording scheme through the New Zealand Archaeological Association (NZAA) as site number I44/85. The features which make up the site complex are associated with the process of procuring and burning limestone to produce quicklime. The lime kiln, which is central to this site, is a stone masonry structure with intricate brickwork arches observable in the interior of the drawing eye and firebox compartments, and a large drum called a charging bowl where layers of broken-down limestone (charge) and possibly coal (or coke) were loaded for burning (Rolando, 2007: 207). The large limestone outcrop approximately 15m south of the kiln displays signs of quarrying apparent from tool marks and large cuttings forming flat faces as well as a vertical rockface. A smaller limestone outcrop is above the charging bowl to the south-west approximately 10m and is more likely the main source of the limestone charge used for producing lime due to its accessibility to the kiln. Approximately 2m directly north of the lime kiln beneath several trees, is an area which exhibits scattered cut limestone cobbles along with material which looks to have been dressed for use as structural elements. These rejected materials were likely discarded from the flat working bench above which is directly to the west of the charging bowl. Approximately 15m to 20m north-east of the lime kiln is a tailing dump which flows down the western bank of a small creek cutting northward

through the valley. This dump likely consists of waste from the lime kiln including charcoal, ash and limestone charge which was under or over cooked. Analysis of the material in this feature would need to be undertaken for a more conclusive understanding of the discarded materials.

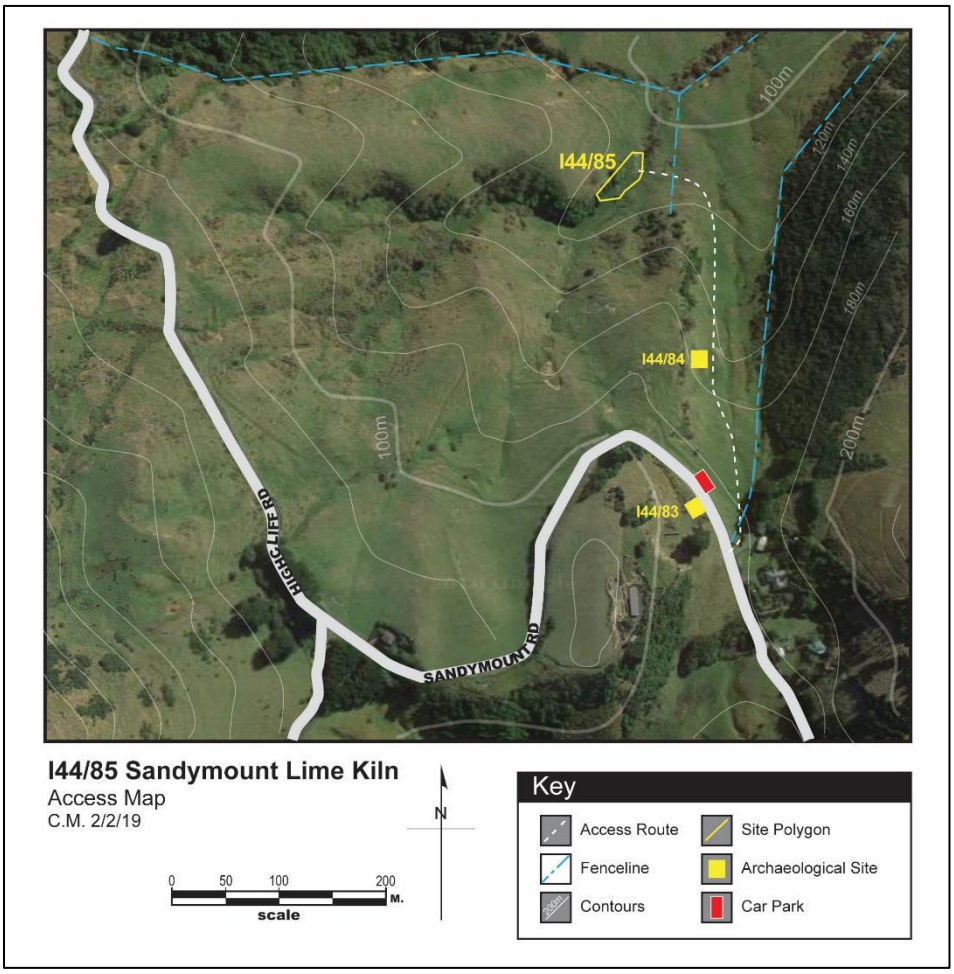

Figure 2. Site access map

This historic industrial site exhibits physical evidence of relations to several industries that were active during New Zealand's historic period. The purpose of the site being a lime production plant places the facility mainly within the construction and agricultural industries (Rolando, 2007: 205) which were dependent on the use of quicklime. Specialised tradesman would have been involved with the construction of the lime kiln, which displays intricately dressed stonework as well as brick work still observable in the structure. The procurement of the stone for burning as well as for the construction of the

lime kiln, required quarrying which was also a specialized industry during the mid-19th century.

The identification of archaeological features relating to these industries, allowed for a site polygon to be drawn around the complex demarcating the boundary of physical evidence which is remnant of this phase of activity and is offered in the site plan (Figure 3). The area within this boundary contains the features which are the basis of this report, with the condition of each of these being recorded. The site polygon may be updated after vegetation is cleared, as this is obscuring some details of the site complex.

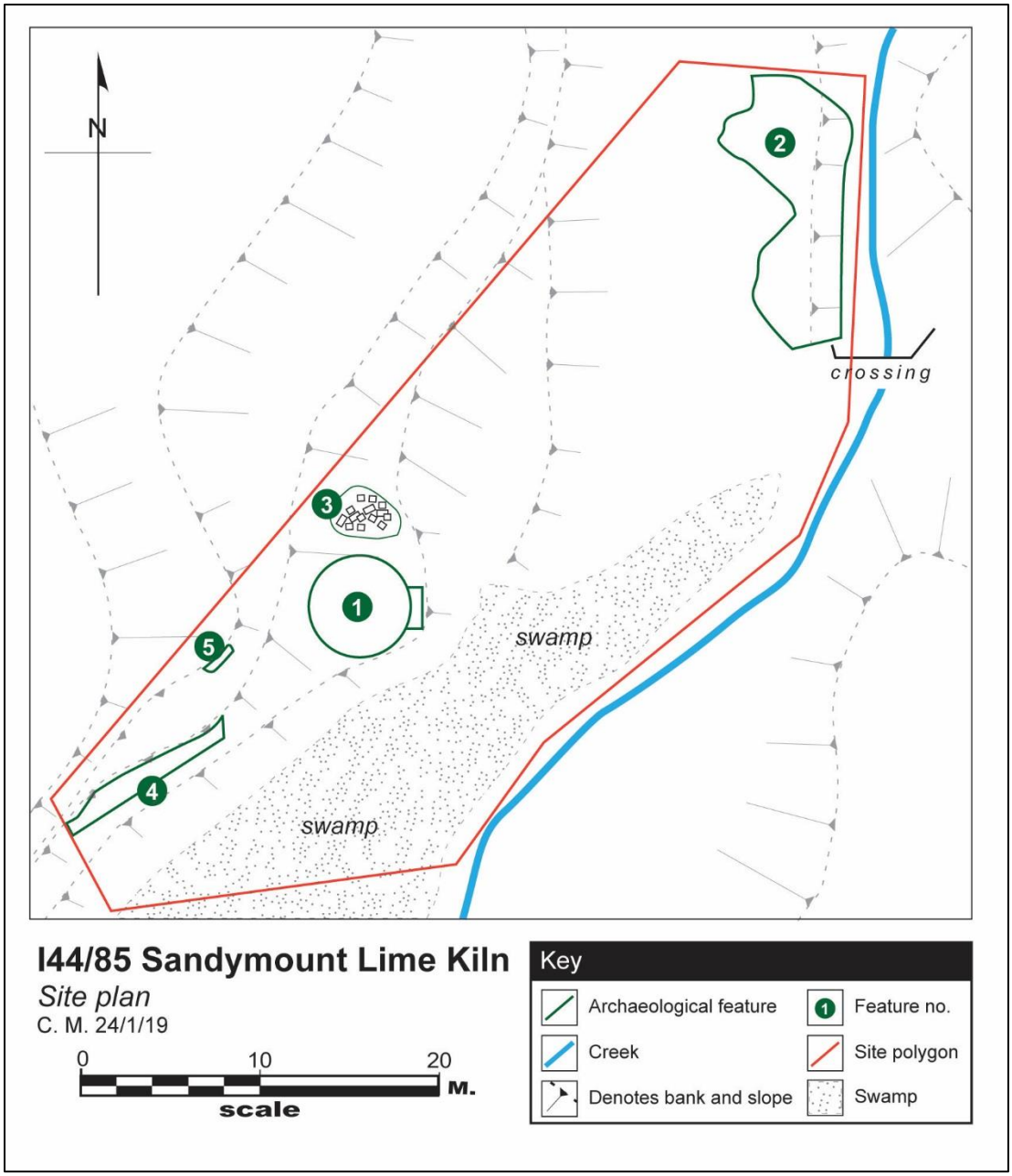

Figure 3. Site plan for I44/85. The red line demarcates the site boundary.

Features

There are five archaeological features in the site complex which include: two limestone quarries; working discard area; tailings dump; and the lime kiln. The features numbered in the site plan (Figure 3), are briefly discussed in Table 1 with photographs and dimensions. These features allow a site polygon to be drawn demarcating the boundary of the site complex. The swamp directly to the east and south of the lime kiln was also included in the site polygon, as this is likely an area that has been modified either for

water management, or the removal of outcropping limestone. The swampy area directly east of the large quarry is likely an area where limestone was quarried from, however, the extent of this large outcrop is unknown. Roads and access routes between the features lie within the boundaries of the site polygon. The historic routes linking the kilns to Sandymount Road and Hooper's Inlet are not discussed in this report. The masonry ruins of the lime kiln are the focal point of this report and will be further discussed with section drawings and annotated photographs exhibiting areas that will need to be stabilized or maintained.

Table 1. Archaeological features within the Sandymount Lime Kiln site complex (I44/85).

Feature Number/Description	Photographs
Feature 1: **Lime Kiln** The lime kiln ruin is a masonry structure made from local limestone, as well as volcanic tuff and brick. Very coarse lime mortar was used as a binding agent for the masonry work. The structure has three main chambers: the charging bowl, firebox, and drawing eye. The lime kiln has been built into the side of a hill facing east. The structure is approximately five metres long (east to west), two metres wide (north to south), and six metres high. A more detailed examination of the condition of the lime kiln is offered below. GPS coordinates: E2326615; N5479510	 **Figure 4. The drum or charging bowl of the lime kiln (looking north).**

Feature 2:
Tailings dump

The tailings dump is approximately 25m north east of the lime kiln on the bank of the small creek which cuts through the valley. A lot of this feature has been overgrown and is below the subsurface. It is possible these tailings continue further north and south below the surface, and along the eastern bank of the creek.
A steel pin approximately 30cm long and 3cm wide was observed set into the southern face of this feature.
The tailings dump is a light grey colour and likely contains discarded materials from the kiln. Unburnt coal was observed in the matrix of the material. Cobble sized limestone fragments were also observed in this feature.
The tailings dump is approximately 16m long and 10m wide. The feature is vulnerable to weathering and trampling damage from cattle.

GPS coordinates:
E2326639; N5479534

Figure 5. Tailings dump north-east of the lime kiln (looking south).

Feature 3:
Working discard Area

The working discard area is approximately five metres north of the lime kiln on the east facing hillside, below a flat working bench to the north-west of the kiln. A tree growing in this area is preventing access. Quarried limestone is observable in this area and is likely limestone which was discarded instead of being broken down further into charge for burning. Several blocks of limestone exhibited fine dressing likely for use in the lime kiln structure.
This area is approximately five metres in diameter. This feature is vulnerable to damage from cattle as wool was observed scattered around the area from livestock taking shelter under the tree.

GPS coordinates:
E2326623; N5479520

Figure 6. Pieces of limestone charge discarded near the lime kiln. Finely dressed limestone was also observed in this area.

Feature 4: **Limestone Quarry (large)** Approximately 15m south-west of the kiln is a large limestone quarry. The quarry area is approximately 15m wide by 7m high. The quarry could extend further south however this area was obscured by vegetation. The outcrop likely extended out to the area east which is now a swamp. Large quarry cut limestone boulders are scattered around the base of the quarry. This feature is vulnerable to damage from weathering, vegetation and cattle. GPS coordinates: E2326600; N5479504	 **Figure 7. Limestone Quarry (large): note the quarry cut limestone blocks at the base of the quarry and the tree growing out of the quarry face.**
Feature 5: **Limestone Quarry (small)** Approximately 10m south-west of the kiln is a smaller limestone quarry. The quarry area is approximately 1.8m wide by 1.2m high. Tool marks are exhibited on the top of this outcrop and other markings are likely tool marks which have been weathered. This outcrop is above the charging bowl of the lime kiln and is likely a remnant of the main outcrop used to quarry limestone. This feature is vulnerable to weathering and cattle damage. GPS coordinates: E2326598; N5479497	 **Figure 8. Limestone Quarry (small) to the south-west of the lime kiln (looking west).**

Lime kiln

The lime kiln is a masonry structure made mainly from limestone, however volcanic tuff and bricks have also been used in its construction. The limestone is locally sourced with a large outcrop to the south of the kiln and a smaller outcrop to the south-west (see Figure 3). The volcanic tuff was not observed to outcrop in the immediate area, however, the material is quite commonly found as scattered fieldstone on the peninsula. The bricks used are mainly on the inside of the structure, however they were also noticed to fill random gaps within the cladding.

The structure has been built into the side of a hill facing east, in a valley leading down to Hooper's Inlet (see Figure 2). The structure can be divided into three main chambers being: the charging bowl, firebox and drawing eye, and will be discussed further below.

A. Western elevation

The western elevation for the lime kiln (Figure 9) exhibits the top of the structure which is a large cylindrical drum (approximately 2m diameter) called the charging bowl, where limestone 'charge' was loaded in layers for burning. This section of the structure also

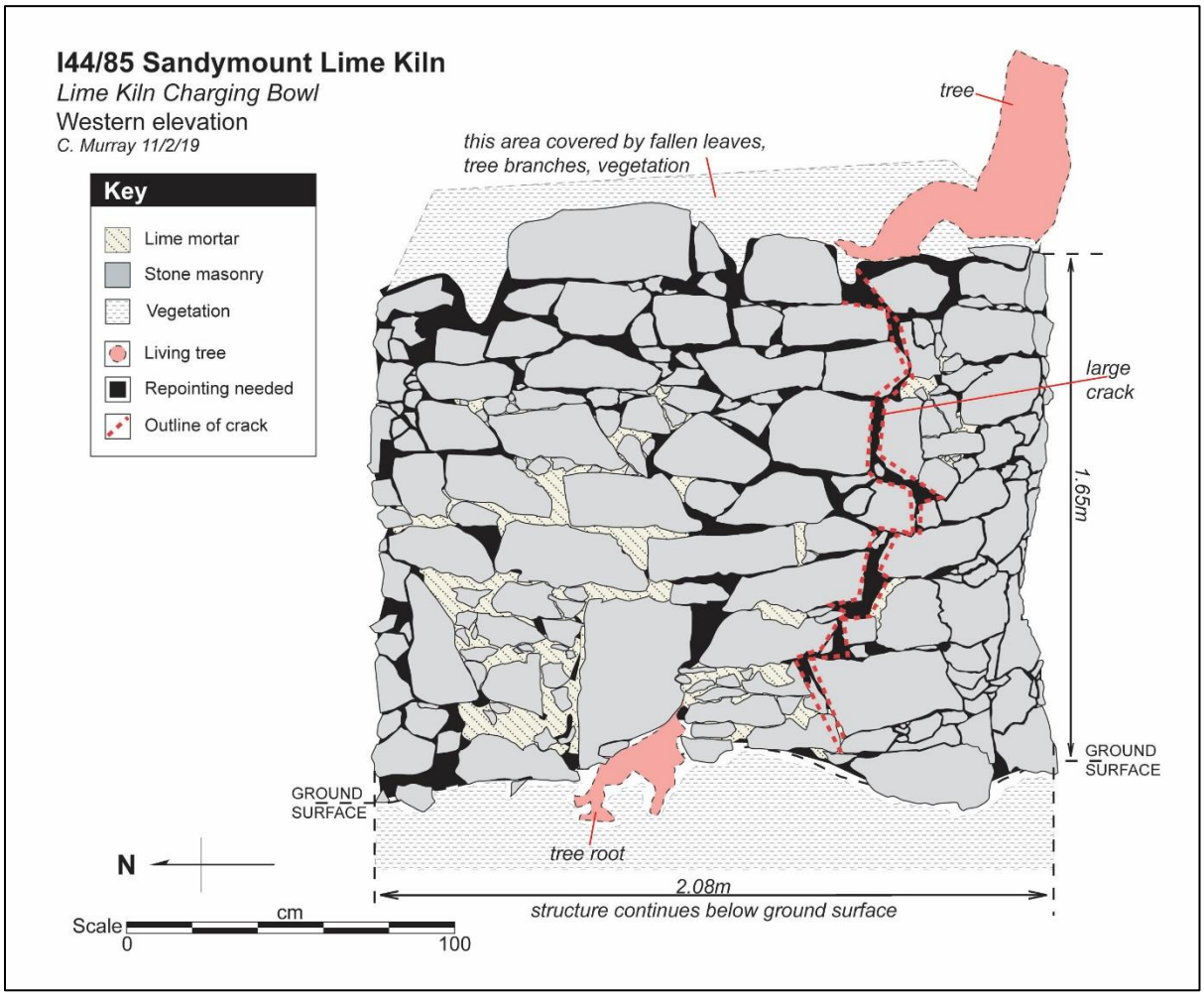

Figure 9. Lime kiln: Western elevation exhibiting the top section of the structure (charging bowl). A large crack is exhibited in the masonry and a tree is growing on top of the drum with a large root protruding through the base of the masonry.

functions as a chimney releasing smoke and gases produced from the lime burning process. The charging bowl is clad in large limestone blocks laid using the random rubble masonry technique where rough stones are used as they are quarried (or found) and only minimal dressing occurs (Salmond, 1994:49). The inside of the bowl is interpreted to be lined with fire bricks, similar to those observed in the firebox (see Figure 21).

A large crack is observable in the eastern face of the charging bowl which is highlighted by the red dashed line in Figure 9 and is also shown in the photograph Figure 10 (left). The crack is approximately 8cm at its widest span and is also being pushed out obliquely at approximately 5cm. A tree growing out of the top (southern section) of the charging bowl (Figure 10) is likely responsible for the crack with a root base that is pushing the top of the bowl out to form a bulge. This bulge is exhibited along the southern edge of the charging bowl in Figure 9. A root growing through the masonry at the base of the central eastern face (see Figure 11: left) has made a large void in the masonry approximately 15cm wide by 45cm high.

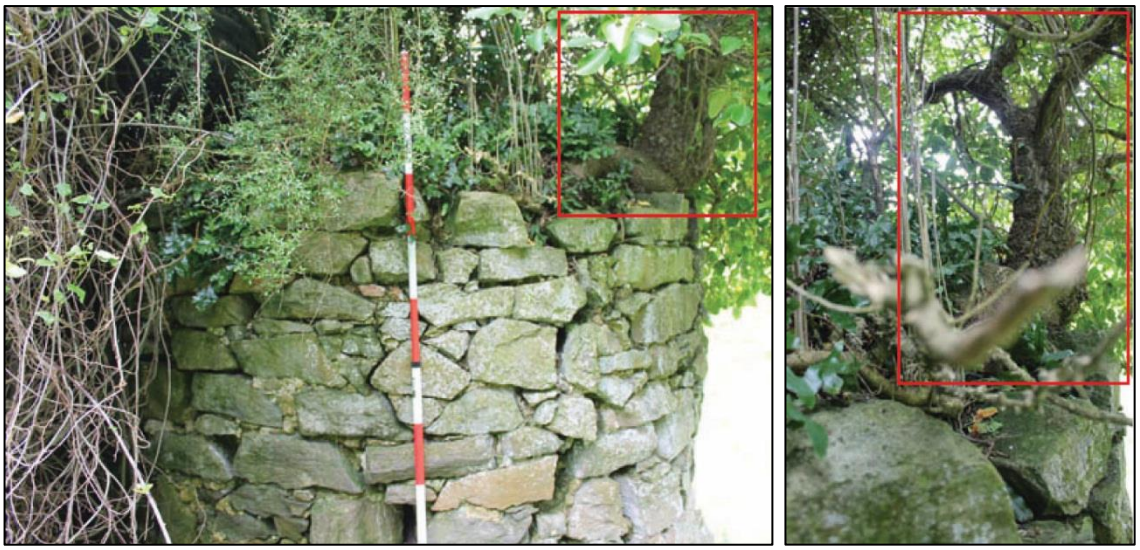

Figure 10. Tree growing out of charging bowl (outlined in red): looking east. Note the crack to the right of the stadia pole (left); looking south-east (right).

The limestone used in the masonry is in good condition, the tree has likely protected this part of the kiln from weathering. However, the pushing out and loosening of the masonry by the tree base has allowed erosive processes to remove the mortar. Remnant limestone mortar is still visible in the eastern face (see Figure 9), but most of this section of the lime kiln will need repointing. The top of the kiln is covered in vegetation (see Figure 11; right), so a total wall thickness was not attainable. The top

course of stone work is sitting quite loosely with most of the mortar having been removed. The vegetation is aiding in keeping the masonry fixed in place but will need to be removed and the top courses repointed.

Figure 11. A large tree root (outlined in red) pushing through the masonry and making a large crevice (left); Vegetation growing out of the charging bowl (right).

B. Southern elevation

The southern elevation for the lime kiln (Figure 12) exhibits the southern face of the charging bowl, and the southern outer wall of the firebox. The full length and height of the structure can be viewed from this angle; however, a lot of the structure has been built into the hillside and is below the ground surface. The approximate height of the structure is 5.85m, and the length is 5.37m. Due to the instability of the structure and the obscuring of details by vegetation covering, only approximate measurements can be offered until the vegetation is removed and the structure is stabilised.

The hillside has been modified for the structure and is dipping at 35° to the east. The ground level of the hill traverses from the western base of the charging bowl at its highest point and is truncated by stone masonry which is retaining the hillside at approximately one metre above ground level. The soil around the southern base of the structure is mainly dry and firm, however, some areas are bare from cattle trampling, and vulnerable to erosion.

Three trees growing in or close to the structure are exhibited in Figure 12 as the red shaded circles with numbers one to three. Tree number one (in the charging bowl) has been discussed above (see Figure 9 and Figure 11). Tree number two in Figure 12 is growing out of the arched roof of the firebox. It has destroyed a large section of the roof and is pushing the southern wall out on an angle of approximately 22° to the

south (see Figure 13: left). Tree number three in Figure 12 is growing at the eastern base of the structure, in the entryway to the drawing eye chamber (see Figure 13: right). This tree is destroying the apex of the stone arch entryway to the drawing eye compartment and has likely got a root base which extends under the foundations of the structure.

The masonry work observed in the southern face of the charging bowl is quite well preserved. The darker areas in Figure 12 behind the stone work are areas that need repointing. The top stone courses of the structure need to be stabilized and capped when the vegetation is removed, to inhibit water from entering the masonry. The crack in the western side of the charging bowl has been discussed, however, a larger crack on the eastern side can be observed in Figure 12 (outlined in the red dashed line). The crack is better observed looking north-west (Figure 14: left) displaying a large gap of about 20cm halfway down the charging bowl. Looking at the crack from the south (Figure 14: right) exhibits the oblique sideways movement of the crack which protrudes in a south-east direction approximately 5cm. The sideways movement of this crack suggests the drum is being pushed out by the trees root base rather than structural failure. This should be confirmed by an engineer prior to any physical conservation work being undertaken, as any foundational weakness could be hazardous to those working on the site.

The stone work in the roof of the firebox was largely obscured by vegetation. The outer southern wall of the firebox has been pushed out by tree growth (Figure 13: left). The stonework in the outer southern wall is very unstable and needs to be stabilized (see Figure 15). The larger quoins which are missing in this section, are likely the blocks strewn down the hill just south of the firebox entry. A large slab which is the entryway platform to the firebox and the roof of drawing eye compartment is interpreted to be concrete. A dressed limestone step was observed leading up to the concrete platform.

The southern outer stone wall of the drawing eye compartment was obscured by vegetation. The ground is around this wall has been filled in about a metre high against the wall which is part of the entryway to the drawing eye compartment (see Figure 16: right). The floor level inside the drawing compartment was noted to drop another 80mm below ground level.

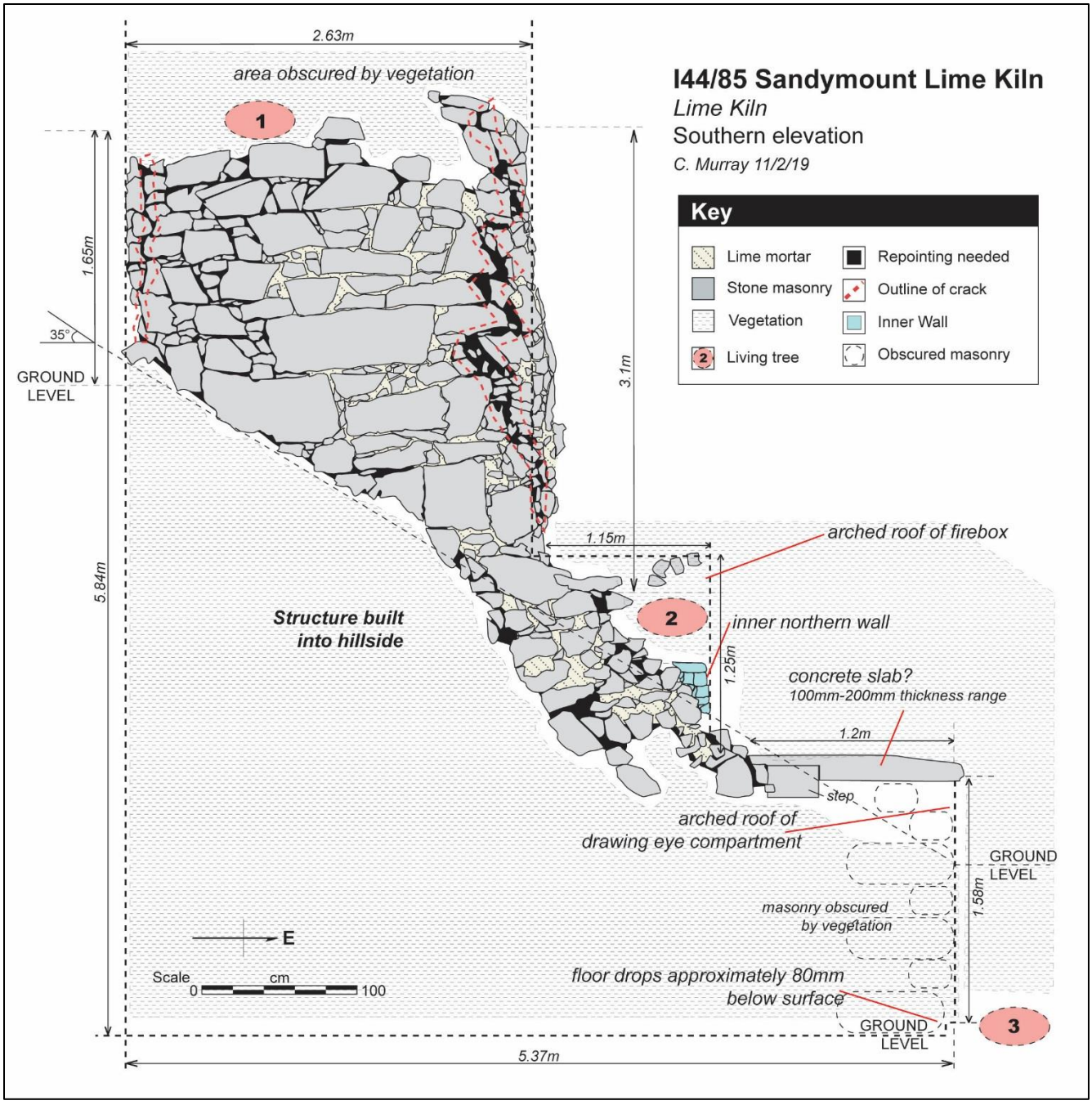

Figure 12. Southern elevation of the lime kiln.

Figure 13. Tree growing out of the firebox roof, looking west (outlined in red: left); Large tree growing in the entryway to the drawing eye chamber, looking west (right).

Figure 14. Large crack in the south eastern face of the charging bowl, looking north west (left); a view from the south of the drum exhibiting oblique movement of the crack (right).

Figure 15. Outer southern wall of firebox: looking north (left); firebox southern wall end, looking north-west (right).

Figure 16. Large concrete slab (outlined in red) which is the platform to the firebox entryway (left); the ground level drops one metre at the junction of the drawing eye entryway stonework (right).

C. Eastern elevation

The eastern elevation is largely obscured by vegetation. Illustrations of this elevation cannot be completed until the vegetation is cleared. The eastern face of the charging bowl has a large oblique crack running from the top down to below the surface. This crack has been discussed above and can be viewed in the southern elevation of the structure (see Figure 12) as well as the photographs in Figure 14. The stone masonry work in the eastern face of the charging bowl is well preserved (apart from the crack) with only some minor repointing needed. The base of the eastern face of the charging

bowl was obscured by vegetation and the area was not accessible due to the instability of the structure.

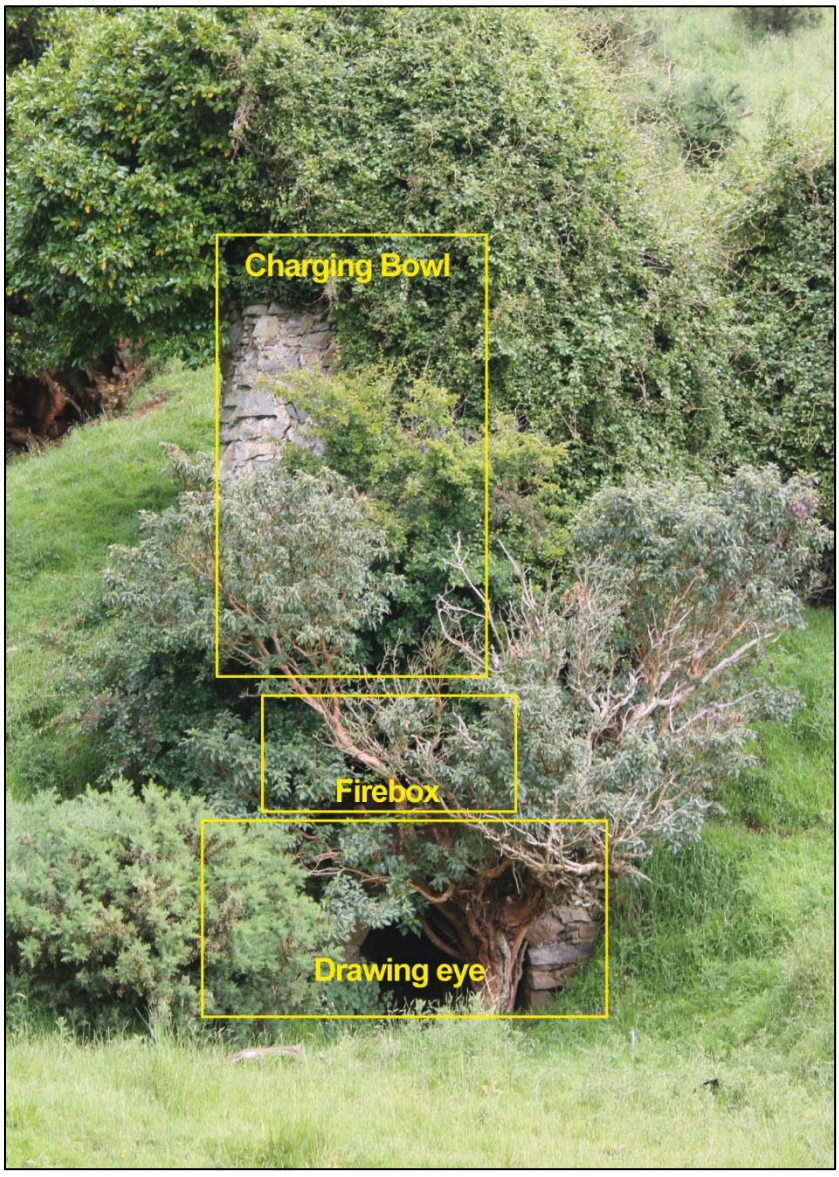

Figure 17. Vegetation covering almost the entire eastern face of the lime kiln, looking west.

The stonework for the drawing eye compartment entryway is approximately 1.58m high and the entryway is 1.5m wide. The external stonework sides and base masonry are laid using the random rubble technique (Salmond, 1994:49; see Figure 18). Cut limestone blockwork with roughly hewn faces forms the archway over this entrance and is largely complete. The stone masonry work that has not been damaged by tree growth

has remnant lime mortar still binding it together, however, repointing will be needed in the blackened areas exhibited in Figure 18. The base of the entryway was obscured by vegetation and soil. Erosion of the surface around the entryway caused by cattle trampling was observed and could be a contributing factor to slumping.

The inner floor of the drawing eye compartment was noted to drop below the outer ground level by approximately 80mm. The floor is covered in vegetation and the remains of a dead sheep. The drawing eye chamber displays an arched ceiling made from large limestone blocks which make up the inner northern and southern walls (see Figure 19: left). This stonework is in good condition but will need some minor repointing done. The northern inner wall and some of the ceiling was noted to have a green mold growing on it. The inner western wall of the drawing eye compartment, as well as the drawing eye chute, are made from bricks (Figure 19: right). The brickwork is in good condition with only minor repointing needed.

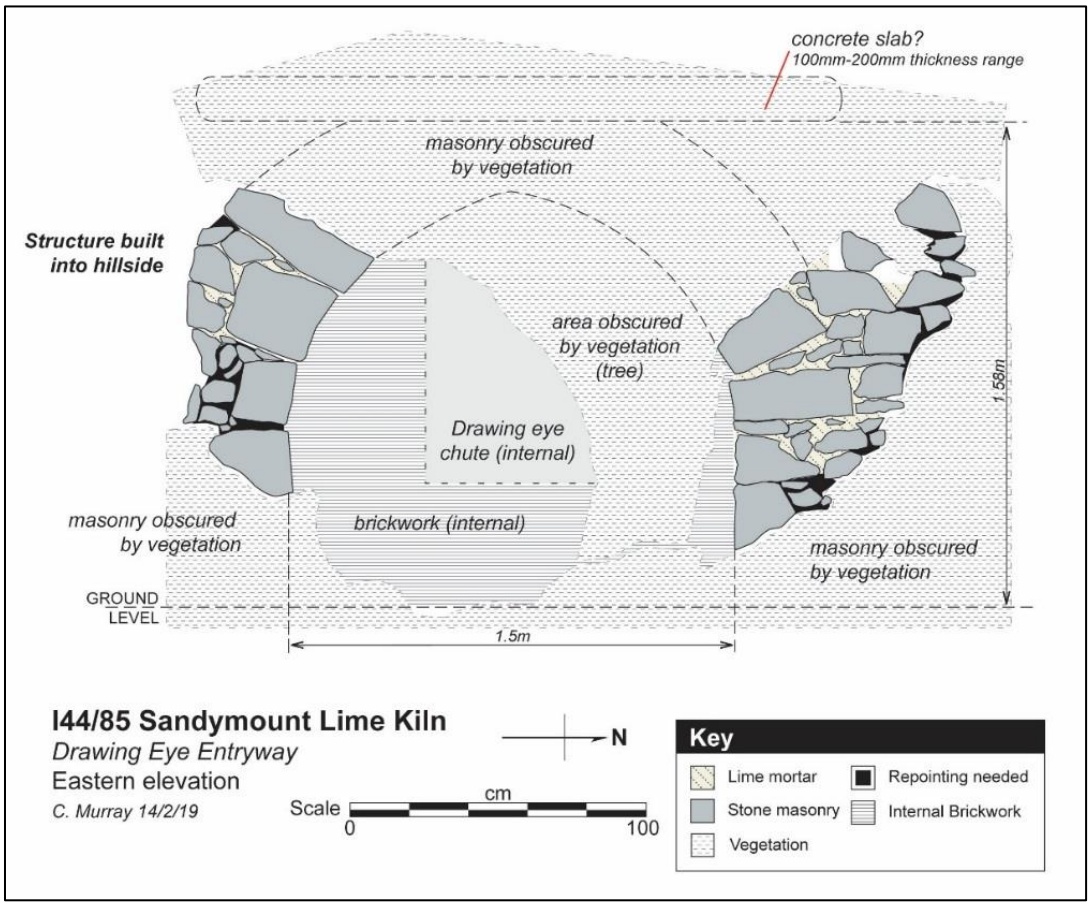

Figure 18. Eastern elevation of the entryway to the Drawing Eye chamber.

Figure 19. Inner drawing eye compartment: large dressed limestone blocks exhibited in the southern inner wall and the arched roof (left); the drawing eye chute and brick surround (right).

The stonework for the firebox entryway has largely been destroyed by a tree growing out of the roof (see Figure 20). This tree has been discussed above and can be viewed in Figure 13 (left). The southern wall of this section of the lime kiln has been pushed out by the growing tree and is leaning approximately 22° to the south (see Figure 13: left and Figure 18). The larger stone quoins which would have secured the northern wall end have fallen away and could be the blocks that are lying directly south of the compartment. Large pieces of lime mortar still hold the remaining section of the southern wall together, however the wall will need to be stabilized. The area directly to the south of the leaning south wall exhibits heavy cattle trampling which has eroded the bank. The cattle damage in this area is contributing to the erosion of the slope and could be causing minor slumping which is affecting the structure. The northern exterior wall of the firebox has incorporated bricks into the lower course work (Figure 20) with some minor repointing needed in the lower courses. A lot of the stone work in the upper courses of this section of wall have become dislodged from tree growth and will need to be stabilized. The stone arch entryway has been destroyed by tree growth, however, the interpreted line of the archway can be observed in Figure 20. The firebox roof was obscured by vegetation so the condition could not be attained.

The interior of the firebox exhibits a mixture of stone and brick masonry. The lower courses of the northern and southern walls (which remain) are brick with the higher courses using larger dressed limestone blocks. A sprung arch made from firebricks is observable in this chamber (Figure 21), some of the central bricks are damaged and may need to be restored. Along the western inner wall of this chamber are three stoke

holes with brick arch surrounds. The centre stoke hole is open and the two holes either side look to have been sealed. The floor of the interior of the firebox is dirt with a few scattered pieces of limestone (Figure 21).

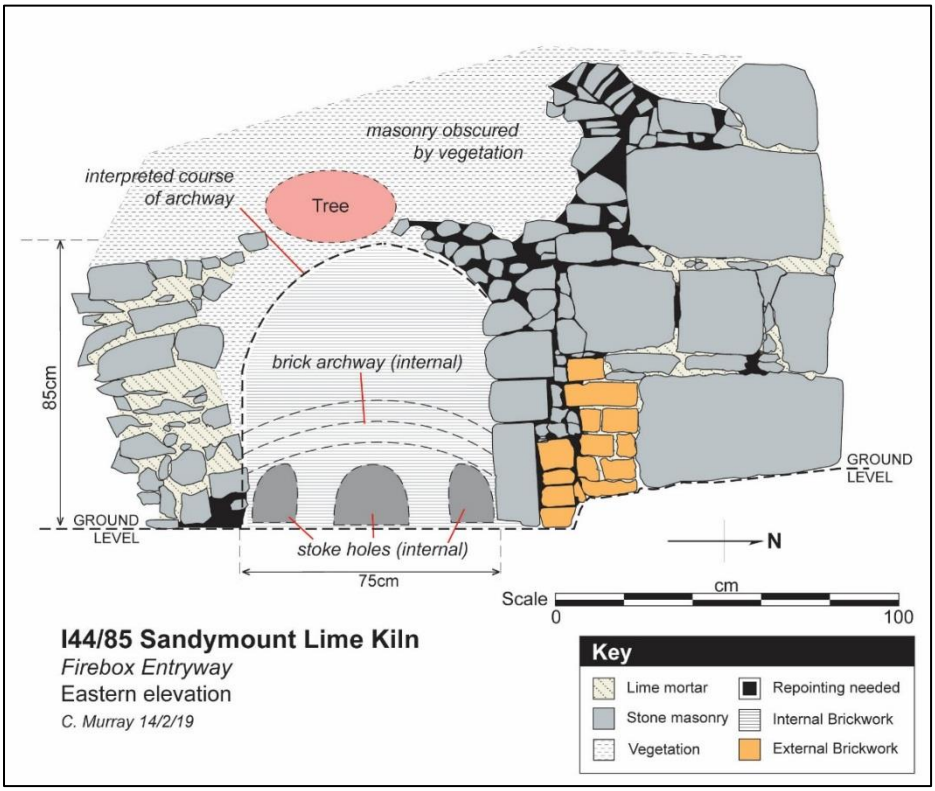

Figure 20. Eastern elevation of the firebox.

Figure 21. Firebox interior exhibiting the sprung arch and stoke holes.

D. Northern elevation

The northern elevation of the structure is entirely obscured by vegetation (see Figure 22), so elevations were not able to be drawn. The northern face of the charging bowl is covered in a vine as well as the foliage from the tree growing out through the top. The vine has spread down over the tree which is growing out of the roof of the firebox. The vine and higher ground level is also obscuring the outer northern wall stonework of the drawing eye and firebox compartments.

Figure 22. Looking directly south toward the lime kiln: the stadia pole is at the entryway to the firebox (left); the vegetation covers the entire charging bowl and working discard area (feature 3) – note the stadia pole in the bottom left of the image (right).

Conclusion

The physical condition of site I44/85 was the objective of this report, and focused on the lime kiln, also briefly discussing the other features associated with the kiln. The condition of the lime kiln was observed from all four elevations and noted to be obscured by vegetation on the northern and eastern sides. These elevations can be drawn after the vegetation is removed. The condition of the masonry work in the three chambers of the lime kiln was examined and processes observed and interpreted to be associated with deterioration of these sections was discussed.

The three trees which are growing in and around the lime kiln were observed to be damaging the integrity of the structure and need to be removed. The masonry around the trees in the firebox and drawing eye chambers will need to be secured before their removal as the trees are holding some of the masonry blocks in place. Prior to tree removal, advice should be sought from an engineer as to whether the root base of the tree growing in the entryway of the drawing eye chamber may compromise the foundations if it is removed. Erosion around this area should also be checked as it could be a contributing factor to slumping if it is occurring. There is also suggestion that slumping directly south of the firebox may be occurring which should also be checked by the engineer as this could be a contributing factor to the large cracks in the charging bowl and the lean on the southern wall of the firebox. A well braced scaffold should be placed around the structure prior to any remedial work being done.

To stabilize the charging bowl, reinforcement with a steel brace, capping of the top courses and repointing in the stonework will need to be done. The large cracks should be mortared and monitored after tree removal to examine if there is any movement in the cracks. The oblique movement of the crack should also be monitored after tree removal, as pressure from the tree’s root base is the likely cause of the bulging out of the drum causing the crack to move outward as well as apart.

The southern wall of the firebox will need to be restored as it is danger of collapsing. The stone masons can replicate the masonry work from the northern wall of the firebox, which is still in a relatively good condition. A temporary fence should be put around areas of the lime kiln which are vulnerable to damage from cattle.

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