A simple surveyor's error condemned the White Terrace, Wonder of the World

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Abstract

The loss of the Pink and White Terraces, the New Zealand Eighth Wonder of the World, was declared by a government surveyor S. Percy Smith on 14 June 1886, four days after the Tarawera eruption when he approached ~4,000 m from his supposed site of Te Tarata, the White Terrace(s). This research follows his loss claim through three parliamentary reports, an audit, five government survey maps and four artworks prepared by Smith from 1886–1894. His evidence is for the first time examined with the aid of a unique survey by Ferdinand Hochstetter, first published during 2016–2023. Alterations across Smith's survey map series, indicate he changed his location for the White Terrace without mention and invented features to support his case, while he was being audited and with government ministers sceptical of his claim. The Māori in Rotorua disclaimed Smith's report but given interracial conditions at this period, colonial bias meant their advice was not in official reports. Reports of Smith's adventitious pre-eruption bearings on the White Terraces are reproduced. The research extends the first evidence-based altimetry for the Rotomahana Basin. Hochstetter's survey location of the White Terrace is strengthened by error ellipses. LIDAR imagery is included for the White Terrace location to assist passive seismic surveying. It also shows the course of the true Kaiwaka Channel, confirming Smith also misidentified the outlet of Lake Rotomahana. It is concluded Smith had no substantive evidence for his claims and engaged in research misconduct. Hochstetter's and recent surveying rebuts his reports.

1.0 Introduction

In c. 5,000 BCE, an underwater hot spring broke the surface in New Zealand. The high spring commanded the region when Māori immigrants arrived by the fourteenth century. They named it Te Tarata, likely after a flowering tree in their new land. It is better known as the White Terrace(s). The Tūhourangi sub-tribe of Te Arawa claims the land to this day.

In 1886 the Tarawera eruption transformed the Pink and White Terraces area with small two lakes excavated to form a new larger lake and a deep layer of ejected mud around the crater. No geologist saw the eruption. Reports from surveyors were collected in an official report by the General Survey Office, which concluded the terraces were likely blown into the air. Other voices, both Māori and colonists never accepted this. While there were early reports that

sinter was evident around the crater, others failed to note any. The chief Māori conclusion was that no pieces of White Terrace were seen by them from 1886–1936. No pieces are held today by the traditional landowners (Bunn, 2025).

Occam's Razor suggests the simplest of competing explanations is likely correct. The abscence of siliceous sinter fragments around the Rotomahana Basin is likely due to the White Terrace not *being blown into the air* as claimed by surveyor Stephenson Percy Smith (1840–1922) but buried under the deep layer of lake-bed ejecta from the Rotomahana eruption in 1886, as reported by the landowners.

This paper reports foundational research into the long-running debate in New Zealand over the state of the Pink and White Terraces, the New Zealand Eighth Wonder of the World. This paper is the nineteenth and final publication from our research since 2014, to resolve the debate. From 2016, Ferdinand von Hochstetter's (1829 –1884) unique 1859 survey across the Rotomahana Basin and the Pink and White Terraces has been reconstructed by Nolden and Bunn. The genesis of the terraces' debate was on 14 June 1886 with Smith's claim that the terraces were destroyed (Bunn & Nolden, 2016, 2018, 2023). This claim has not been well scrutinised before now.

First, we review Smith's reports, maps and artwork evidence. Next, his earlier, lost terrace bearings are reconstructed. His elevations are compared with the latest altimetry. The White Terrace error ellipses from Hochstetter's 1859 survey assist the investigation. New LIDAR images of the area are presented, showing surficial drainage and vegetation patterns. Lastly, LIDAR of the true Kaiwaka Channel, (the outlet of old Lake Rotomahana), depicts watercourses connecting Lakes Rotomahana and Tarawera consistent with Hochstetter's survey.

For six generations the loss of the terraces was accepted by much of the public and most (but not all) in the earth sciences— the meagre evidence to support the claim has never been formally challenged, due to the lack of geographical coordinates for the terraces. Hochstetter's survey publication over 2016–2023 provided these and prompted this examination of the claim the Pink and White Terraces were destroyed in the 1886 Tarawera eruption.

The historical record comprises three parliamentary reports by the General Survey Office and two by university staff (Smith, 1886, 1887, 1894; Hutton, 1887; Thomas, 1888). These include five maps and four landscape artworks claiming locations for the White Terrace, a

global tourist attraction. Documentation from the debate had been collated by Ron Keam (1932–2019) to c. 1987 but without survey evidence, there was little motivation to explore the matter (Keam, 1978, 1988).

The Smith-Keam paradigm so formed came under challenge in 2016 and there is now rebuttal and refutation evidence of the 1886 government assumption the terraces were destroyed (Bunn & Nolden, 2023; Bunn, 2024). This curiosity-driven research reviews the cartography, survey reports, geospatial records, altimetry, error ellipses and LIDAR of the northern shore of today's Lake Rotomahana where the Smith-Keam and new Hochstetter paradigms confront. The competing claims provide White Terrace spring locations only 400–500 m apart, yet this gap is the difference between a terrace destroyed and a terrace buried and potentially recoverable. In this paper, the claims by surveyor Smith are investigated and fresh interdisciplinary evidence is tendered to remove uncertainty. The author notes claims of scientific misconduct by Smith for his later work in ethnography (Taonui, 2005).

The research is more important than correcting the historical record. The economic and cultural value of resolving this long-running debate is immense. Global tourism is booming and favoured venues e.g. Venice and Kyoto are over-crowded and raising tourism taxes to discourage visitors. An *old-then-new* world attraction like the Pink and White Terraces would attract a tourist boom for New Zealand. Forecasts made in 2014, inflated to today predict an increase of $\leq$ 600,000 overseas tourists annually with a boost of NZD22,000,000–NZD24,000,000 annually to Rotorua (PAWTL, 2014). For traditional landowners, the Rotomahana Basin was made off-limits by a Māori tapu (a ban) after the eruption. The loss of homes and livelihood caused a diaspora, one they endured for generations. The White Terrace, even in a damaged and non-functioning state as is the terrace at Pamukkale, Turkey— remains a tourism magnet.

2.0 Methodology

This foundational research draws together published and unpublished survey research, altimetry, LIDAR and forensic cartography. The analysis begins by examining the claims from 1858–1910 by government surveyor Percy Smith. This focuses on his parliamentary reports, survey maps, artwork, survey bearings and reminiscences (Smith, 2011). Keam's 1988 book Tarawera, the definitive lay guide to the eruption was helpful. This summates correspondence amongst the personalities involved and comments on the politics and

conflicts that affected public reporting and debate. A database of Australasian media reports was useful (Bunn, 2024).

2.1 Percy Smith's mistake: Star Hill for Steaming Ranges (aka Tarata Peninsula), cartography and photography

Smith's activities in the Rotorua district, his reports, maps, artwork and dealings with his political masters are examined, from 1858 to 1894 when he filed his last official report and 1910 for perhaps his final interview (Williams, 1910). His preliminary opinion on the White Terrace location contrasts with his later reports and maps and his 1910 disclosure.

2.2 Lost bearings on the White Terrace

Hochstetter's 1859 expedition provided the only known survey bearings of the Pink and White Terraces, but there were later bearings. None are known to survive. An attempt is made to reconstruct one set.

2.3 Altimetry, the new Steaming Ranges datum

Like all nineteenth century altimetry, that for the Rotomahana Basin is imprecise. Colonists attempted to extrapolate the elevation of Lake Rotomahana from its fall into Lake Tarawera and barometric readings taken there. The author builds on the first evidence-based altimetry for Lake Rotomahana, extending the lake-level evidence to the landform called the Steaming Ranges (aka Tarata Peninsula, Pinnacle Ridge and Pinnacle Rocks), using photointerpretation and geometry (Bunn, 2022). This avoids reliance on a changing lakes' datum.

Note: to assist reading flow, the Steaming Ranges and the later term Tarata Peninsula are simplified to "the Ranges".

2.4 Hochstetter's survey location for the White Terrace with LIDAR and error ellipses

Survey error ellipses are published for Hochstetter's 1859 survey observation stations. These are extended to calculate error ellipses for the surveyed White Terrace Spring coordinates. LIDAR with reflectance colouring provides improved insight into the terrain and possible subsoil features.

2.5 The true Kaiwaka Channel course with LIDAR

New LIDAR imagery of the White Terrace survey location from the Bay of Plenty Regional Council strips vegetation and gives a first detailed view of the true Kaiwaka watercourse in the isthmus.

3.0 Results

3.1 Smith's Mistake

In this section, we see Smith's ideas develop about the White Terrace status via his sketches and maps. To assist the reading flow, I summarise each section. Table 1 lists the 16 sources where Smith made claims about the White Terrace site.

Table 1

	Smith's Reports and Maps with a White Terrace Location				
Year	**Month**	**Publication**	**Location**	**Figure**	**Notes**
1858	n/a	Sketch	North tip of lake	1	Pre-eruption.
1873	n/a	Notebook 40.	Lost	15	Reconstructed.
1886	13 June	Sketch	Unsighted	2	
1886	14 June	Sketch	Star Hill	3	First location.
1886	14 June	Lithograph	Star Hill	4	Included in main 1886 report.
1886	14 June	Google Earth	Three sites	5	The 14 June locations on Google Earth.
1886	19 June	Report	Star Hill	n/a	
1886	12 July	Lecture	Star Hill	n/a	
1886	12 August	Survey map	None	7, 9	T cipher beside Steaming Ranges.
1887	March	Bearing audit	n/a	n/a	Probably Steaming Ranges-Pinnacle.
1887	July	Main report	Steaming Ranges	10	First mention of second terrace location.
1887	July	Main map	None	10	An invented finger-point but no terrace.
1887	August	Map Harding	Steaming Ranges	11, 12	Introduced a lake/terrace caricature.
1894	n/a	Map Smith	Steaming Ranges	13, 14	Repeats the caricature.
1894	n/a	Smith Artwork	Steaming Ranges	n/a	Second terrace location.
1910	March	Smith Interview	Steaming Ranges	n/a	First reference to terrace stream datum.

Smith's 1858–1910 Reports and Maps with White Terrace Locations (Published reports).

The evidence shows the roots of Smith's 1886 mistake lay in 1858 when he first visited the lake and sketched it in Figure 1. He was an eighteen-year-old Assistant-Surveyor. He placed the White Terrace (Tarata) at the northern lake tip and the Rangipakaru landmark (a hill and solfatara) is labelled.

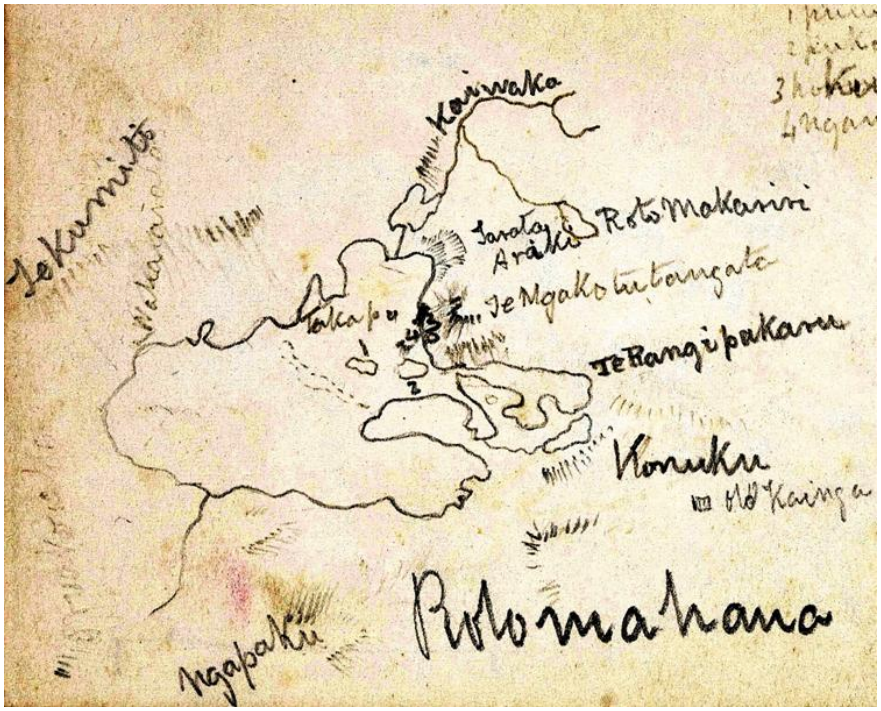

Fig. 1, Sketch map of Lake Rotomahana, 1858 (Smith).

The key to Smith's mistake lies in how he interpreted the altered landscape. As a surveyor, he focussed on high ground to observe and take bearings. In Figure 1 he knew Te Rangipakaru lay across the lake, east of Hape-o-toroa Hill while the Ranges and White Terrace lay to its north. From Hape-o-toroa Hill (at 8 o'clock in Figure 1), he knew Mt Tarawera lay northeast and the White Terrace lay somewhere along that alignment (Smith, 1953).

Summary: 1858 Smith's first visit. He sketches Lake Rotomahana, the terraces and Te Rangipakaru.

3.1.1 13 June 1886 sketch map in Figure 2.

On 13 June, Smith attempted (unsuccessfully) to approach the eruption. He sketched the country from Pareheru looking northeast to Mt Tarawera in Figure 2 (Smith, 1886).

He included a White Terrace position though intervisibility was blocked by Hape-o-toroa Hill. June 13 is close to the winter solstice. The solar altitude was 23.06° by mid-morning as he sketched into the sun. He may have already concluded the loss of the terrace as his first position has a thermal fog cloud.

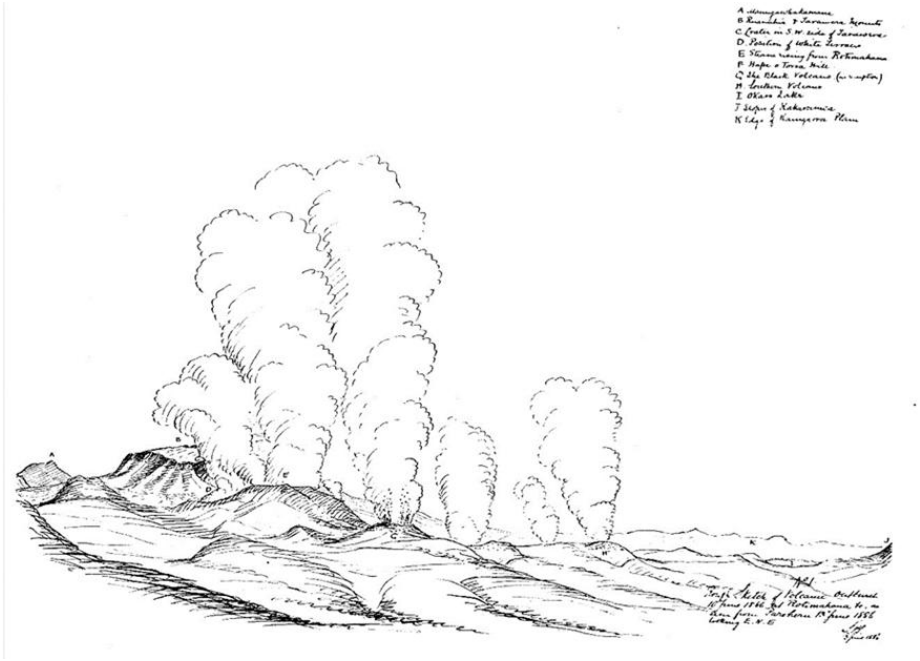

Fig. 2, Sketch map of Lake Rotomahana, 13 June 1886, (Smith).

Summary: Smith tries to visit the eruption crater and instead makes an eruption sketch at a distance. He posits a location for the White Terrace.

3.1.2 14 June 1886 sketch map in Figures 3, 4, 5.

On 14 June he closed with the crater and ascended Hape-o-toroa Hill, making a second sketch towards Tarawera in Figure 3. He included point “D” as the *Former position of White Terrace* and included it in the sketch title.

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168 Fig. 3, Sketch map of Lake Rotomahana, 14 June 1886, (sharpened), (Smith).

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170 The Survey Office prepared a lithograph of Figure 3 for their official report. This is Figure 4
171 and shows the issues with Smith's first and second terrace locations. The difference between
172 the red/yellow and white arrows decides whether the White Terrace is erupted or buried.

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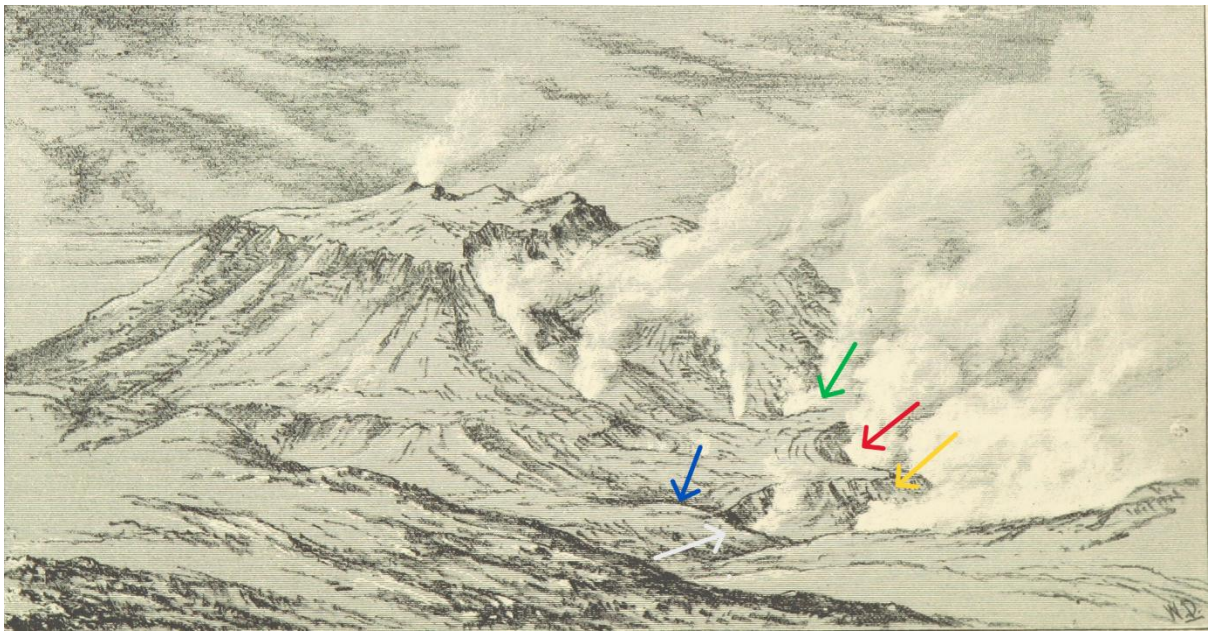

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Fig. 4, Lithograph of Figure 3, 14 June 1886. Red arrow is Smith's first location Yellow arrow is his second, White arrow is Hochstetter's survey location. The blue arrow is the crater overflow. The green arrow is the Lake Rotomakariri location (General Survey Office).

Figures 3 and 4 are the first visual evidence of Smith erring over June 13–14, 1886. Given the orientation of Ruawahia Peak, Koa and the Chasm, his position is on the northeast of Oruakorako Hill. The perspective is reproduced using a geographic navigation tool i.e. Google Earth Pro™ in Figure 5. Here the Chasm is lying to the right of Ruawahia Peak and beneath Tarawera Peak with Koa Peak to its right. In Figure 3 Smith marks the White Terrace site 'D', east of the overflow 'E'. They are divided by a finger-like spur. Another spur projects into the crater behind 'D'. Given Smith marked E as the crater-lake overflow (blue arrow) as early as 14 June and afterwards declared this was also the Kaiwaka Channel, it is surprising he forgot that White Terrace and Kaiwaka abutted— they were never divided by a spur. As well, he marked the lost Lake Rotomakariri as 'C', beyond the second spur, and point 'I' as being over the path to the Ariki inlet. By 14 June, Smith identified four features along the north crater as pre-eruption features. This was a long bow. Five days later these sketches were in his eruption report to parliament, where he pronounced the White Terrace destruction:

"The spot where once was situated the most beautiful object of its kind in the world, the White Terrace, is now, I believe, occupied by a crater forming a sort of horse-shoe bay in the side of the greater crater of Rotomahana … exact localities cannot at present be identified. Should this horse-shoe crater hereafter prove to be not exactly where the White Terraces stood, it is, at any rate, quite close to it, and its exact position does not affect the question as to whether the terraces are in existence or not. If not there then they are either buried deep under the stones and sand or have sunk into the main crater." (Smith, 1886).

Smith considered other possibilities including that the terrace lay buried. The horseshoe bay is marked 'D' in Figure 3 with branches enclosing his first White Terrace site (red arrow). Smith's 19 June report engendered public grief at the loss of their world wonder. We follow the development of this horseshoe bay in Smith's later mapping.

In Figure 5. Smith's position is reproduced on Hape-o-toroa Hill-Oruakorako Hill, 3,500–4,000 m from his first terrace position, where he looked through thermal fog around eruptions.

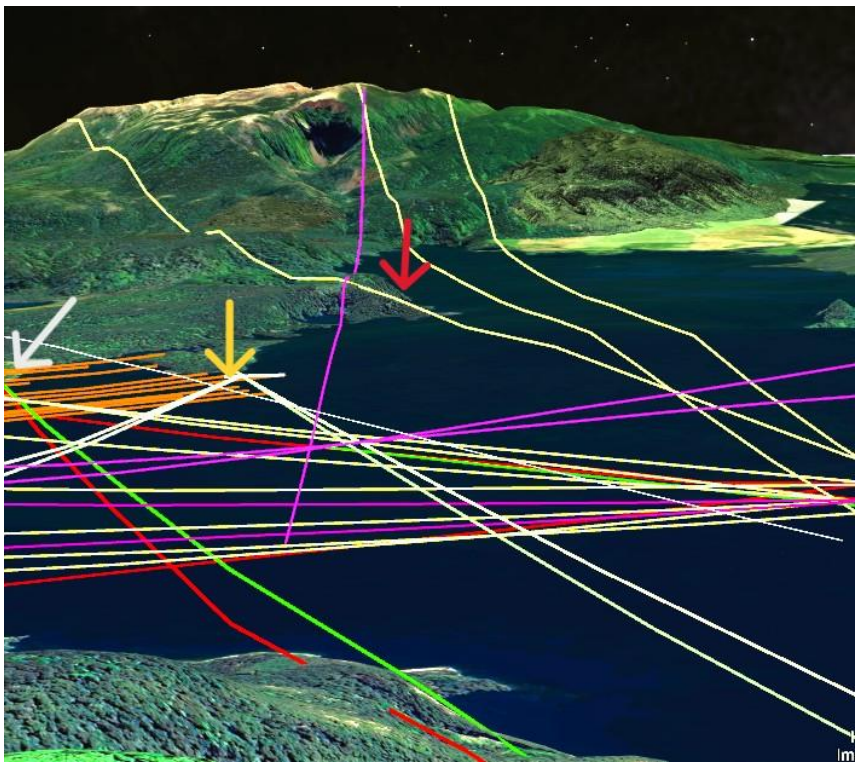

Fig. 5, White Terrace locations—View from near Smith's 1886 site. Red arrow is his first 14 June location. Yellow arrow is his second 1887 location. The white arrow is Hochstetter's survey location (Bunn & Nolden 2023, Google Earth).

Te Rangipakaru hill was out of shot in Figures 3 and 4, obscured by thermal fog but is in Figure 5. Smith found high ground on the north crater. This lay beside a horseshoe bay. Coincidentally, the White Terrace spring was surrounded by a horseshoe embankment (Bunn, 2023c). Smith would recall the ranges sloped down north of the terrace. This tallied with what he saw. He concluded Star Hill (named weeks later and at 406 m today) was the Ranges. Instead, these lay buried in the foreground with the terrace.

These two promontories are in all later maps i.e. the Ranges and Star Hill the larger promontory with four spurs jutting into the crater. These are in Smith's 1886 watercolour map, his 1886 published version, the 1887 version by Alpha Harding (? –1945) for Algernon Thomas (1857–1937) and Smith's 1893–1894 versions. Despite their significance, Smith does not label the Steaming Ranges on his maps. The recent availability of his 1886 watercolour map enables the first analysis of Smith's error as it developed over the series of

five crater survey maps and four artworks between 1858 and 1894. In Figure 6 Smith's Figure 3-4 *earthquake cracks* extend west from Star Hill.

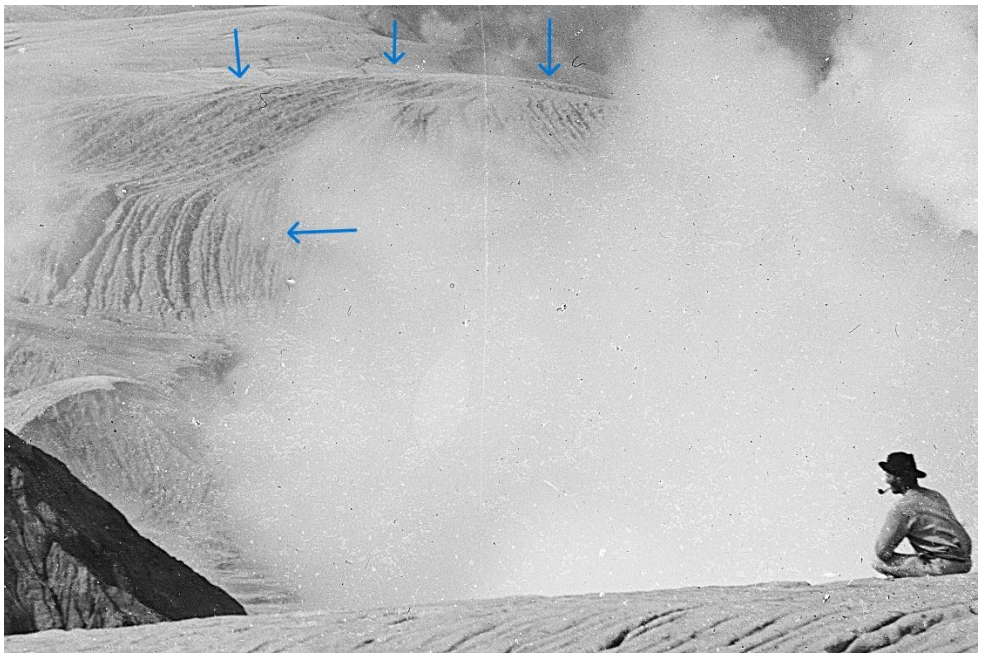

Fig. 6, Smith's earthquake cracks (blue arrows) marked G in Figure 3. (Te Papa Tongarewa).

Summary: On 14 June Smith had his first view of the crater. He observed it had eaten south and west. Seeking a hill with a horseshoe bay for the west-opening terrace, he mistook Star Hill for the Ranges.

3.1.3 19 June Preliminary Report to Parliament

Smith did not return to Rotomahana after 14 June. He decided (correctly), that the crater was excavated south and west, leaving the country to the north intact save for deep ash: "[The eruption] has … eaten back southwards and westwards from the shore of the former lake a distance of over half a mile."(Smith, 1886, 2). This led him to locate the White Terrace and other sites in Figures 3–5. His report that Star Hill abutted the White Terrace was wrong.

3.1.4 Lecture 12 July at the Auckland Institute

Smith and J. A. Pond (1846–1941) presented preliminary eruption findings in this lecture three weeks after Smith filed his report to parliament. Smith reiterated his initial opinion on the White Terrace:

"… the evidence … goes to show that the site of the terraces is now occupied by a horse-shoe shaped recess or bay … Nearer to us than this recess could be seen a gentle declivity, forming a very shallow valley, in which once ran the Kaiwaka Stream, the former outlet to Lake Rotomahana …" (Pond and Smith, 1886).

Summary: Between 14 June and 19 July, Smith speaks only of the Star Hill site.

3.1.5 Watercolour survey map 12 August 1886 in Figures 7 and 9

This map contains vital evidence. On 26 July, Smith returned to Rotomahana for 18 days with a survey party. His survey map disappeared into Keam's collection, possibly from the Hamilton Lands and Survey office where he'd fossicked as it closed. Figure 7 is a section of the 1:16,000 linen map. By contrast, Hochstetter stayed at the lake for three days and completed three survey maps.

Fig. 7, Watercolour survey map of Rotomahana Basin 26 July–12 August 1886. The spurs have yellow arrows. The Ranges have a blue arrow (Turnbull Library).

Smith would first choose a vantage point for his easel. The map baseline runs from northeast Oruakorako Hill following the eruption rift bearing to Ruawahia. An auxiliary line may run

from Makatiti to Hill 498 (it may be a fold). This crosses the baseline by Star Hill. Pencil lines are grid lines or bearings on Te Kumete and Tarawera massif (Bitelli, 2014).

In his reminiscences, Smith describes the survey. He had a theodolite and compass, a barometer, a clinometer and a chain or pacing for distances. He possibly used a plane table. A sketching frame would transfer scaled observations. He would identify key landmarks e.g. Hape-o-toroa, Ruawahia, Chasm and Te Kumete. The surveyors Smith, Eric Charles Goldsmith (1848–1912) and Ernest Feltus Adams (1865–1957) would mark up a grid. Goldsmith and Adams's names did not appear on this map, nor the published version. They were recognised in Harding's 1887 version. The party is shown in Figure 8.

Fig. 8, Smith's survey party on 27 July 1886 below the Chasm, Rear row, Eruiti and Charles Turner. Front row, Smith (fourth from left), Adams, Goldsmith, Blythe, Lundius and a dog (order unknown). Charles Spencer exposes the plate (Te Papa Tongarewa).

They would triangulate features using bearings and distances. The crater would be estimated or paced and aligned with the grid. Shading and hachures were added, emphasizing the changes in topography. Elevations were marked and placenames e.g. The Pinnacles (plural) and Star Hill. This Pinnacles was already named Cathedral Rock, by Joseph Warbrick (1862 –1903) on 13 June when he was first to approach the northern crater. Smith abandoned fieldwork on 14 June. This is questionable for the government surveyor charged with

reporting to parliament, as several parties approached the western and northern crater over 13–14 June through ground Smith declared impossible (Smith, 1886 p.170). From 15–17 June Smith stayed in his Rotorua hotel or Kaiteriria and visited Te Wairoa. He returned to Auckland on 18 June. His report is dated 19 June.

In Figure 7, there are fundamental changes from his 14 June sketch map:

a) The horseshoe bay has Star Hill and crater at its head and two points to the east.

b) The Pinnacles (aka Cathedral Rock) are shown. On 14 June it was obscured by thermal fog.

c) Star Hill is named.

d) The words *Former course of the Kaiwaka* are pencilled below a low point on the rim.

e) Four spurs project into the crater. The western pair are of similar size, shape and elevation, as in the 14 June sketch. The largest depends from Star Hill, the high point. The hill remains so at 406 m a.s.l. Beyond these spurs lay the pond named Rotomakariri New Lake. This all agrees with the 14 June sketch and establishes the spurs as those drawn by Smith on 14 June for his 19 June report.

f) In the 14 June sketch, the eastern branch of the horseshoe bay is higher than the west. In bathymetry by iXSurvey™ Melbourne, the Star Hill spur remains conspicuous. The Ranges are today ~50 m lower, uniform and easily missed when navigating the lake.

g) The White Terrace location is unnamed, a notable omission given its highlighting in earlier maps and with the parliamentary report of its loss relying on Star Hill.

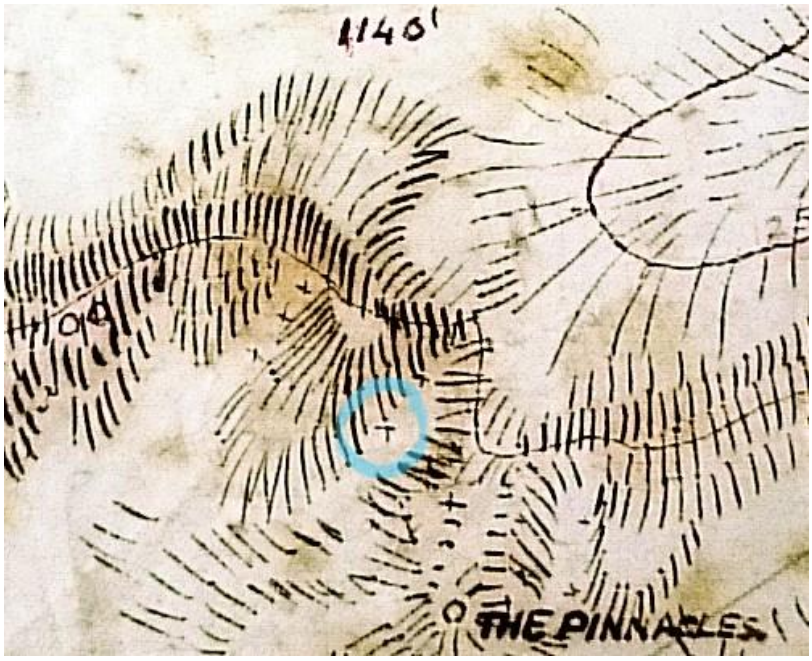

Fig. 9, Section of 12 August 1886 watercolour survey map of the northern Rotomahana crater showing the inserted letter "T" (Smith).

h) In Figure 9, Smith entered the letter T amongst the hachures below the Ranges. This T is coincidentally where Harding placed his White Terrace a year later. While there are "+" and "x" marks on this map referring to vents as on Hochstetter's 1859 maps, this is the only "T" mark and this is supported holographically. The hachure above the T ends with an ink dot and is unrelated to the T. Based on the nearby toponym THE PINNACLES (in ~15-point typeface), the T is in 11-point typeface and indistinguishable unless one examines that spot. It seems to be a cipher to record the spot but not share it. From Oruakorako, the Ranges present a west-facing bay as at the White Terrace. In 2017, a PAWTL2 team member repeated Smith's mistake i.e. assuming the embayment was the White Terrace embankment.

The cipher implications require consideration given Smith's two White Terrace sites. Neither is supported by Hochstetter's survey, topographical or seismic research (Bunn & Nolden, 2016, 2018 & 2023; Bunn 2023a, b). Smith misled parliament on 19 June and never admitted this in the nine later publications of Table 1. This is research misconduct by Falsification, under the 2002 National Science Foundation section 689.1 criteria: *Falsification means manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record* https://www.federalregister.gov/documents/2002/03/18/02-6179/research-misconduct

Summary: There is a conflict between the June and July maps and Smith's later publications depending on this survey map. The T cipher indicates Smith's new terrace position while concealing the switch. This is the third time Smith's research has been questioned i.e. first, the 1887 audit: second, his ethnography for fabrication and now his White Terrace claims (Taonui, 2005).

3.1.6 Smith's 1887 official eruption report and map in Figure 10

In his official 1886 eruption report, (published July 1887) there is little evidence Smith recognised features in plain sight e.g. Te Rangipakaru, the Ranges or any of the streams debouching into the crater. He coined names for the previously named streams, Hangapoua and Waiahinekahu. There is one glimmer in his 1887 report: "immediately to the north of the central lake there are some rugged pinnacles of black rock, rising to the height of the crater rim. These have a special interest as marking the site of some of the hills that formerly stood close to the White Terraces. The exact position of the [White] terraces cannot be identified, as the ground around where they formerly stood has been blown away; [sic] but they were close to and north-west of, the pinnacles" (Smith, 1887).

Hochstetter's survey and map show the White Terrace lies northwest of the Pinnacles (and not due north as in Smith's and Harding's maps). These maps contradict Smith's report text. Smith's unpublished watercolour map was developed for the eruption report with three-colour printing in Figure 10. Of seven contributors only Smith is credited. The northern crater is reworked. The Terraces' sites are again omitted. The Pinnacle is renamed. This is further misleading as there were twin sets of Pinnacles: north and south of the crater (Bunn, 2023a). This northern Pinnacle was later exploited by Keam, inventing locations for the Pink and White Terraces based on its hypothetical location. More presciently, Keam speculated the Rotomahana phase of the Tarawera eruption started in the Waikanapanapa Valley which Nolden & Bunn's georeferencing shows is where the Pinnacle was located before the eruption. To avoid doubt, the northern Pinnacle is not pre-eruption (Bunn & Nolden, 2023).

In Figure 10, east of the Ranges and Pinnacle is Smith's invented promontory between the Ranges and Star Hill. This forms two new bays. The promontory does not exist in any other map, today's Topo50 map or bathymetry. It has a red arrow.

Also in Figure 10, the three eastern spurs are greyed-out and the elevation indicator moved to obscure them. The two new bays obscure the change to the White Terrace site between 1886 and 1887. No White Terrace or T is shown. This amounts to further falsification.

Summary: The Figure 10 map assisted the switched White Terrace location in the 1887 report body, by avoiding a terrace location and altering the topography. The White Terrace shifted ~1,100 m west from Star Hill to lie northwest of The Pinnacles (renamed Pinnacle) in his report, but not on his map. These constructions in the author's view are research misconduct i.e. falsification of data.

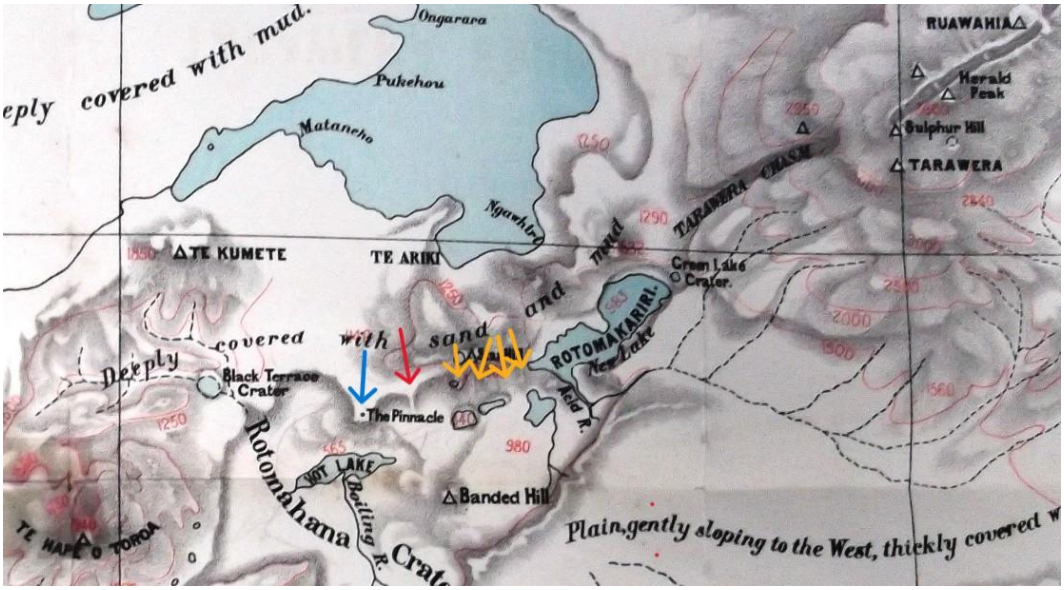

Fig 10, Section of July 1887 three-colour survey map around the northern Rotomahana crater showing the Ranges (blue arrow), Smith's invented promontory (red arrow) and the four spurs (yellow arrows), (Smith).

3.1.7 Harding's 1887 map for Thomas in Figure 11

Conflict between the Survey office, academics and government led to separate reporting with the Survey Office holding all survey data. Thomas visited the region from 1886–1887, postponing his report till 1888. He accessed Smith's 1886 watercolour map and added findings with Harding. The hachures of Figure 7 and the spurs return, but not the invented promontory.

Smith's report including his Figure 10 map was published in July with Thomas's Figure 11 monochrome version following in August. The major difference is a caricature of the old lake, placed over the crater. This invention has passed without comment for over a century.

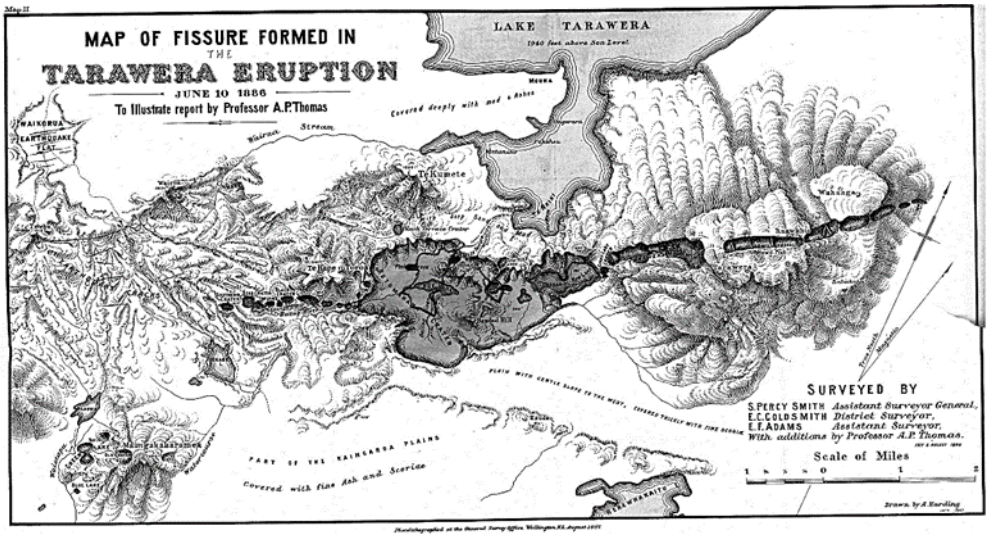

Fig. 11, Harding's map of the Tarawera eruption, August 1887 (Smith, Harding & Thomas).

Figure 12 is a section of Harding's Figure 11 map. Key points:

a) The Ranges (unnamed) and Pinnacle (named) are included.

b) Black Terrace Crater is shown, (Black Terrace lies northwest).

c) The invented promontory is removed.

d) The four spurs in Figures 7 and 9 are reinstated (yellow arrows).

e) The Ranges have a blue arrow.

f) The overflow label is printed and Awaporohe Stream is sketched.

g) A caricature of old Lake Rotomahana bearing no resemblance to Hochstetter's or Petermann's maps overlays the crater. The terrace locations are wrong—Pink Terrace is tipped north and White Terrace is pushed south. The caricature may derive from an 1869 sketch by John Kinder (1819 –1903) in the Hocken Collection. It also resembles a sketch by Edward Weller (1819–1884), (Weller, 1886). Kinder's map is a sketch of Augustus Petermann's (1822 –1878) map. The caricature was likely inserted for Smith. It

covers his T and prevented Thomas from inserting a terrace site. In Thomas's report, he demurs on the Pink and White Terraces, though appearing among the sceptics (Warbrick, 1934), viz.

"The sites of the Pink and White Terraces, … have been identified with sufficient closeness by the surveys of Mr. Percy Smith, … Fragments of the sinter of which they were composed have been found amongst the débris around. The White Terrace was situated a little to the north of some bold, jagged rocks … the name of Pinnacle Rocks …" (Thomas, 1887, 52). This is the fourth Pinnacles name.

Given the politics, Thomas avoided criticising Smith: " … in many important respects the conclusions arrived at in the present report differ from those expressed [by] other writers in papers published …. As these, however, with the exception of … Mr. Percy Smith, profess to have the character of preliminary reports, … it has not been thought desirable, … to make special reference to their divergent views." (Thomas, 1887, 70).

Harding's *northerly* position for the White Terrace contradicts Smith's claim the White Terrace lay *northwest* of the Pinnacle. Research in 2023 showed the White Terrace does lie *northwest* but outside the crater as in Hochstetter's survey (Bunn, 2023a, b; Bunn & Nolden, 2023). In Figure 12, the true White Terrace site is ~1,200 m from Smith's Star Hill site. Alfred Warbrick (1860 –1940) dynamited Star Hill crater to permit boat access. It remains a Waimangu Volcanic Valley attraction.

Fig. 12, Section of July 1887 watercolour map of the northern Rotomahana crater showing the Ranges (blue arrow) and four spurs (yellow arrows), (Smith).

Summary: Harding's map is a monochrome production of Smith's 1886 and 1887 maps, produced for Thomas. It has a lake caricature with incorrect terrace locations. It differs from Smith's official report map.

3.1.8 The 1893 Rotomahana Basin map, Figure 13.

In 1893, Smith returned to Rotomahana as Surveyor-General. He gave his third report to Parliament in 1894 (Smith, 1894). This included his fifth map and fourth artwork of Rotomahana. The fifth map is derived from his 1886 watercolour map (and Harding's) with a modified legend e.g. a singular Pinnacle and with the 1893 waterline. Printed in three colours it includes Harding's caricature and orients north. In Figure 13, the White Terrace (white arrow) lies north of the Pinnacle, contradicting Smith's eruption report. In 1893, the Pinnacle lay in shallow water. This had an unintended consequence. Harding's lake caricature, coupled with the shoreline shows Smith's White Terrace spring would lay buried between the waterline and crater rim. Smith gives a rim elevation as 1,140 feet (347.47 meters). The crater base elevation nearby was between 840 feet (256.03 meters) and 980 feet (298.70 meters). The first evidence-based altimetry of the old lake established the base of the

White Terrace lay at 301–303 m a.s.l. and the spring at 326–333 m at the eruption (Bunn, 2022).

The four spurs are reinstated, (yellow arrows). Smith's invented promontory is dropped. In Figures 12 and 13, Smith's 'earthquake cracks' extend from Star Hill, as in his 14 June map with cracking above his White Terrace in Figures 3 and 4. Misplacing White Terrace is one of several errors. Pukura and Puai Island names are transposed. The map scale is wrong. The monochrome version has a different aspect ratio to the three-colour version. Datums checked included Kumete-Star Hill and Pinnacle-Star Hill.

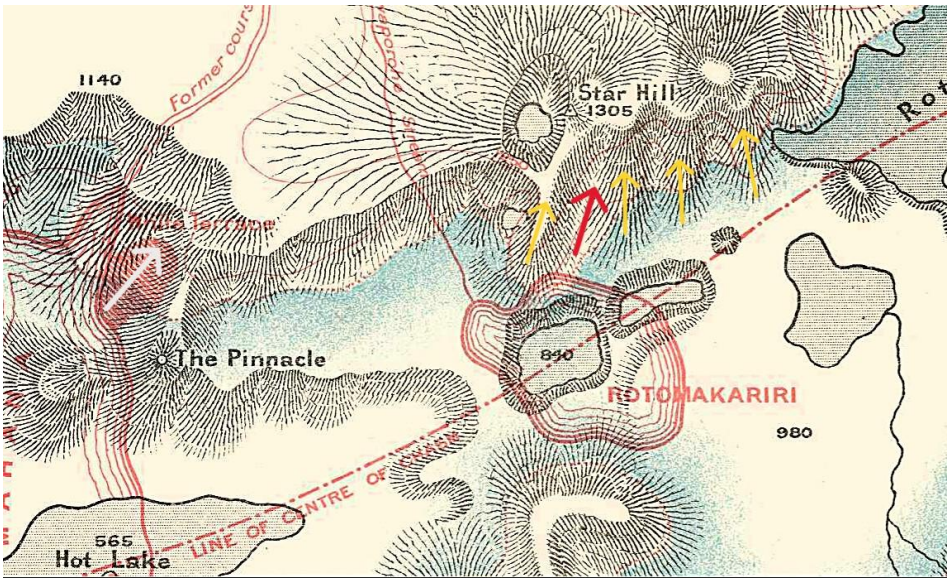

Fig. 13, Section of Smith's 1893 watercolour map around the northern Rotomahana crater showing the first (red arrow) and second (white arrow) Smith locations for White Terrace and the spurs (yellow arrows), (Turnbull Library).

Summary: This final Survey Office three-colour map was developed from Smith's 1886 watercolour map as was Harding's. This 1893 version repeats the lake caricature. It has key differences to Smith's official report and labelling errors.

3.1.9 Smith's fourth, final Rotomahana artwork in Figure 14.

Figure 14 is a lithograph by George Neville Sturtevant (1858–1937) from a photograph by Frank Smith (1846–1922). This was an aerial oblique view; hence it is impossible to form geographic terrace coordinates, only that it lay between the Pinnacle and crater. In Figure 14 Smith reiterated his second location for White Terrace, giving intersections from margins. He advised the terrace was " very close to the letter D on the picture". The intersecting lines show D lies in the lake between the Pinnacle and Ranges.

Smith included a point for the Kaiwaka Channel downstream from today's overflow. As measured (Bunn, 2023a), this clashes with historical records showing the Kaiwaka descended a mile. Smith's Kaiwaka would be a third longer than it was in life. Figure 14, taken from Oruakorako Hill shows Star Hill dominates the shoreline. The Ranges merge into the shoreline, explaining Smith's June 14 mistake and August 12 T cipher. At no time did Smith adduce primary evidence for this second location, only opining the Pinnacle was a waypoint.

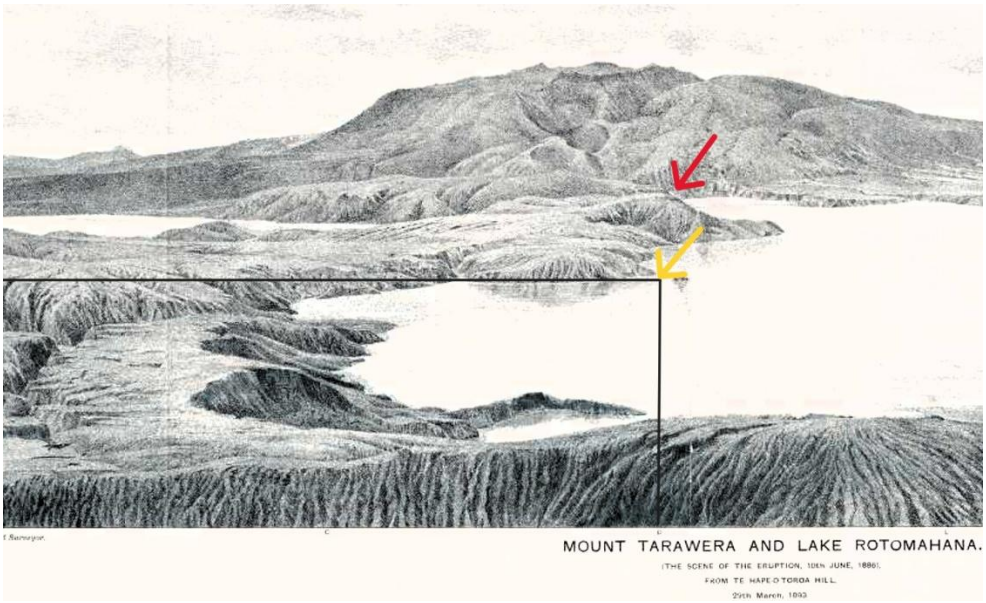

Fig. 14, 1893 lithograph of the north Rotomahana crater showing Star Hill above Smith's first White Terrace (red arrow) and second (yellow arrow) location. (Sturtevant & Smith).

Summary: Smith drew his second terrace location. Star Hill dominates the shoreline showing how it became his first terrace site and the Ranges was his second. There was no primary evidence given for either, though we deduce he looked for a hill with a horseshoe bay.

3.1.10 In 1910, Warbrick was active in the media lobbying for government action to drain the lake. In reply, Smith gave probably his final interview. In the Brisbane Telegraph newspaper (and Taranaki Herald), he referred to his 1886 survey:

" …their sites were not covered by water as at present but dry land. To the best of our belief, **we located the site of the white terraces, as then marked by a little stream, which was rising from the dry bed of the crater**. The whole country was so altered by the eruption …" (Williams, 1910), [ARB Bold]

Apart from the Pinnacle (a waypoint), this *little stream* is the only primary evidence Smith gave for his second terrace site: "… it was absolutely impossible to define exactly the original position of the terraces…"— yet he marked the T cipher in 1886 and published this stream evidence 24 years later. The stream appears on no map.

In 2023 the author conducted the first topographical survey of pre- and post-eruption streams in the Rotomahana Basin, with data from Hochstetter, Smith and the New Zealand River Pilot (Bunn, 2023a). No streams enter or leave the lake along the northern shore. On his 1886

watercolour map, Smith sketched six crater streams, all entering from the south. One was named Acid River. These streams carried into his 1887 maps where a second was labelled Boiling River. Others remained unnamed. He sketched the Black Terrace Stream in his 1887 report. It and the Haumi were omitted from his 1886 survey. The Haumi was blocked upstream for decades. This 1910 disclosure is an egregious omission for this was his only evidence for his 1886 claim the White Terrace was destroyed— yet he did not bother to include this in any map, report or reminiscences— until 24 years after the eruption. History may thank Alfred Warbrick for extracting this disclosure.

Summary: In 1910 Smith tells a reporter of the only evidence he had of the White Terrace location— a stream in the 1886 crater. He had not mentioned this stream in any map, report or his reminiscences. It is a serious omission that further undermines his narrative on the alleged loss of the White Terrace.

3.2 Smith's lost bearings on Te Tarata, the White Terrace

In seeking solutions for Smith's falsification, he took a pair of unpublished bearings on the White Terrace in 1873 and repeated these for the 1887 audit. In T*arawera,* Keam mentions these 'adventitious' bearings, indicating they were not part of a survey. Keam elected not to publish them.

The bearings were taken from points *west* and s*outhwest* of Hape-o-toroa Hill. (Keam 1988, 335–336). Their included angle is acute, giving an inaccurate two-bearing intersection. Keam left clues to locate Smith's observation stations. The stations were near the ejecta field boundary. They were not on Hape-o-toroa or Rainbow Mountain.

In the March 1887 audit, Smith took a check bearing from one or both sites en route to Rainbow Mountain [from Rotorua] with his superior James McKerrow (1834 –1919) and top civil servants auditing Smith's 1886 eruption report. This audit was ordered by Minister (later Premier) John Balance (1839–1893), who inspected Smith's terrace sites and disagreed with him. Balance carried pre- and post-eruption photographs by George Valentine (1852–1890) and believed the White Terrace survived, hence the audit (Keam 1988, 335). This was two weeks after Thomas, Edward Payton (1859–1944) and Warbrick met at the White Terrace site and disagreed with Smith's claims (Warbrick 1934).

Smith apparently survived the audit but the matter simmered until 1910 with a fresh investigation ordered by Minister Thomas Mackenzie (1853–1930) who stated: “I have never been satisfied that the terraces were destroyed … I requested the departmental officers in the district to report … I deemed it advisable to widen the scope of the investigation …" (Marlborough Express, 1910). The matter was still debated in the press in 1922 when Smith died.

Returning to the 1887 audit, the reports and Keam’s clues narrow the stations to the Rotorua-Taupo road in Figure 15. Only two sections provide the reported sightlines to the White Terrace. The western sightline is a gap between Kumete Ridge and Hape-o-toroa-Oruakorako Hills. The only sighted peak is Tuminui Hill at 671 m and an eruption observation point (Bunn, 2024). Pareheru is in line.

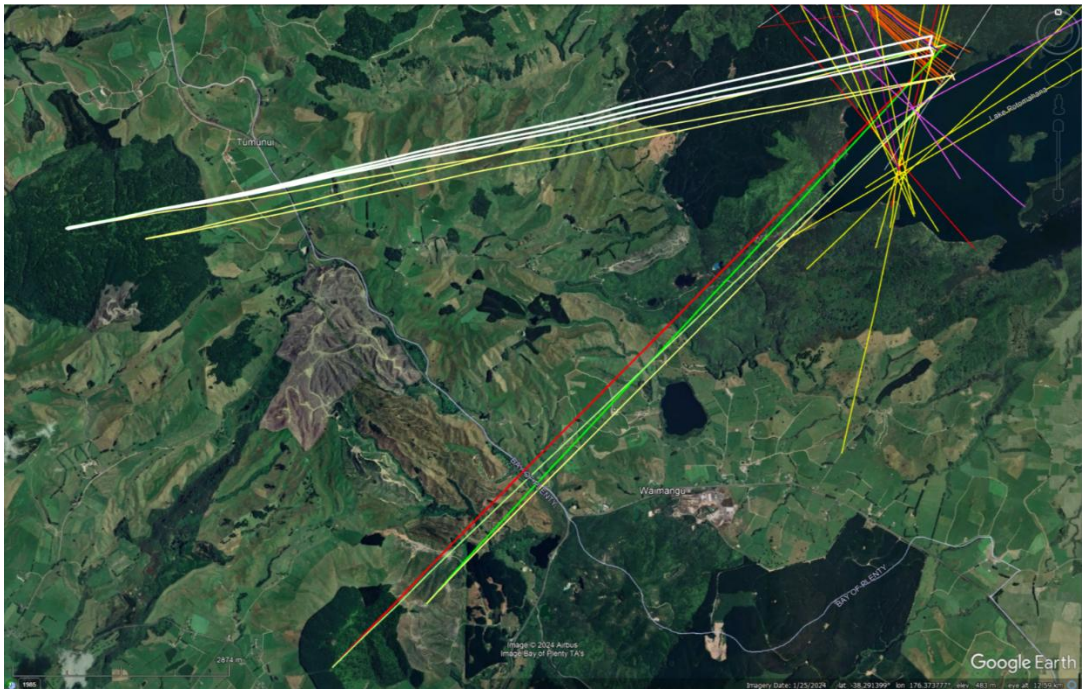

Fig. 15, Rebuilding Smith’s 1872 and 1887 bearings from Tuminui and Maungaongaonga to White Terrace, the white, yellow and green rays (Google Earth & Bunn).

The only southwest candidate is Maungaongaonga after elevation profiling from its twin peaks to Smith’s and Hochstetter’s terrace locations. There is no sightline at lower elevations. The stations’ included angle is 33°–35º in Figure 15. The bearing passes over Hape-o-toroa and crosses the crater as Surveyor-General McKerrow noted (Keam 1988, 336). Given government angst and with Survey Office management ordered into the field audit, both

peaks would be checked. The bearings traverse 10 km. The points were close to the ejecta field. The White Terrace was close to the crater (Hochstetter's survey places it <100 m), (Bunn 2023a). The audit team viewed the crater and Smith's depth is consistent with today's bathymetry. McKerrow decided Smith had been right. Frankly, it is hard to imagine another conclusion. Smith was relieved for his claimed accuracy was ± 50 m (Keam 1988, 336). This seems optimistic given the acute included angle. It seemed odd to Keam and this author that Smith never mentioned the audit or these check bearings.

3.3 Altimetry, the new Ranges datum

One difficulty after the eruption was the altimetry of the vanished pre-eruption lake. There was no way to identify buried features and calculate how deeply they lay. This seems straightforward but was beyond generations of earth scientists. Geologists estimated the Rotomahana elevation from estimates of Lake Tarawera. This required the Tarawera elevation (changing continually) and the fall between the lakes. For the fall, geologists opted for a guess by Keam, which was wrong (Bunn, 2022). How deeply the terraces may lay buried was an open question.

To redress this, we begin with the pre-eruption data, trace the 1886 eruption changes and the 1886–2024 attempts to calculate the White Terrace altitude and depth today. Next, we transfer the elevation datum from water to land.

The Māori did not record altitude in quantitative terms. In their navigation system, elevations were described relative to other landmarks, their shape or spiritual significance. Descriptive elements indicated a hill's height, prominence, or role in the landscape, e.g. *maunga* (mountain) could signify an ordinal elevation.

The first formal altimetry (for the topographic map height above sea level) was by Ferdinand Hochstetter (1829−1884) in 1859 as part of the first survey across central New Zealand. It was the first to include a photographer rather than an artist. Hochstetter used a Kapeller aneroid barometer.

He measured Lake Rotomahana at 1088' (331.6 m.) and Lake Tarawera at 1040' (317 m.) a.s.l. (above sea level). Early aneroid barometers had considerable error.

The second attempt was probably made by surveyors A.C. Turner (*fl.* 1877) and Henry Mitchell (*fl.* 1877) in c. 1877, but no records exist (Lawn, 1977; Smith, 2011).

The third attempt was during 1886–1887 by Smith at 1080’ (329.2 m.). Smith, (and eyewitnesses) recorded the descent of the Kaiwaka Stream as 40 ft (12.2 m), comparable to Hochstetter (14.6 m) and today’s altimetry. In 1894, Smith reduced his altitude to 1,010 ft (307.8 m.), (Smith, 1894).

The fourth attempt was by Jean Malfroy (1839–1897). James Healy OBE (1910–1994) reports Malfroy’s 1891 estimate was 10’ (3 m) above Tarawera i.e. 965.5’ (291.5 m) using Healy’s graphical correction. Malfroy arrived in Rotorua two days after the 1886 eruption and hence could not make a pre-eruption altimetry (Andrews, 2011). There is no corroboration for Malfroy. Healy supported Smith over Malfroy (Healy, 1975). The author found no support for Malfroy until 2016 when Keam published a guessed 1–2 m inter-lake gap.

The fifth attempt was made in 1975 by Healy of 307.7 m. (Healy, 1975). This was probably derived from Smith’s 1894 figure. Later, Healy published the sixth attempt i.e. a *corrected* figure of 300.7 m, derived from graphical curve-fitting and incorporating Smith’s inter-lake gap of 12.2 m. and a Tarawera elevation of 956.5’ (288.5 m.), (Healy, 1975). Healy also provides a 303.4 m estimate by Malfroy for the new lake.

In the seventh attempt in 1988, Keam considered Smith’s data for Lakes Tarawera and Rotomahana i.e. 1040’ and 1080’. He pointed out that as the pre-eruption and 1971 Tarawera elevations did not differ by 60’, then most/all of Smith’s 1887 data may be erroneous (Keam, 1988, 400). He failed to note Smith’s final 1894 altitude for the lake was 1010’ and less 40’ for the Kaiwaka, then Tarawera pre-eruption would be ~970’ (295.7 m.) This is realistic as over the past century, Tarawera has a range of 297.5 m–298.5 m. For most of 1971, Tarawera had an elevation of 298 m hence Smith’s data are reasonable (Keam, 1988).

In 2016, Keam published the eighth attempt of 291–292 m. for Rotomahana as a guess without evidence (Keam, 2016). Keam thus plagiarised Malfroy. These two are outliers from the consensus 40’–48’ (12.2–14.6 m.) difference in inter-lake elevation. Keam failed to acknowledge Malfroy or Healy. Phillip Andrews in Healy’s obituary provides a reason*: ”A few geologists from a later generation tended to undervalue Healy, a methodical and cautious scientist, slow to publish.”* (Andrews, 2011). Keam may have been one. In the first evidence-based Rotomahana altimetry in 2022, the author dismissed Keam’s guess as failing

Hitchens's Razor. Given Keam's standing at Rotomahana, earth scientists accepted his guess and joined his error.

Over 2017–2024 the author investigated the basin altimetry and in 2022 published the ninth attempt, the first this century with empirical evidence. The 1858–1886 Lake Rotomahana elevation was 303 m a.s.l. with a rise and fall of ±1−2 m (Bunn, 2022). Healy's final attempt of 986.5' (300.7 m) is within today's error margin.

All surveys have error and at Rotomahana the causes include the eruption, landform change, erosion, deformation and subsidence. Also, sea level datums were not well established in the nineteenth century. What was needed was pre-eruption altimetry with a fixed datum. Herein, a landform datum is developed. Apart from erosion and subsidence, this forms a more stable datum than lake levels.

We begin with the one feature that received multiple measurements—the White Terrace. It's height above the lake was estimated between 25 m and 30 m. The 1859–1886 period covers the development of photography. The White Terrace has a similar appearance over that time and its growth helps explain the height range. Records fail to show how measurements were made. Did they include the spring platform and the apron below the basins? A chain to measure the length and a clinometer for the terrace angle was one method. Taking the length at 240 m and the angle as 9°, the sine function gives a height of 37.5 m. As the terrace grew, the angle decreased.

The next step is to measure the embankment height above the terrace. Figure 16 is the author's panorama of the Steaming Ranges. The angle of view is ~ 60°, a maximum for a panorama with a natural appearance.

Fig. 16, Steaming Ranges two-plate panorama by Burton in 1885–1886, probably with twin cameras. The seam is unfeathered for verité. (C.010654, C.010659 Te Papa, Bunn).

The Ranges are aligned north-south with dimensions from Hochstetter's survey Folio (Bunn & Nolden, 2023). They were ~1,600 m long and 574 m wide in the north, narrowing to 400 m behind the White Terrace. Figure 16 shows they were highest around the White Terrace. Hochstetter reported them at 200' (61 m) high. Keam suggested 50–60 m. The appropriate datums are peaks at the entrance to the White Terrace spring (Bunn, 2023c). Using similar triangles, in Figure 16 Lucy's Isle (Ruihi's Isle) is 4 mm high. Taking the south peak at 42 mm high, the embankment is estimated at ~38.4 m. Adding 25 m–30 m for terrace height— the embankment was 63–68 m above the lake. The photointerpretation is reasonably consistent with Hochstetter and Keam and delivers an elevation datum for buried pre-eruption architecture.

When Figure 16 was exposed, the lake was ~ 301 m a.s.l. (Bunn, 2019). Therefore, the embankment would be 364.4–369.4 m a.s.l. on eruption eve. Today's elevations in the area are 340–360-380 m a.s.l. Smith's 1886 altimetry nearby was 347.47 m. This indicates some loss of embankment during the eruption. Late photography shows it fretting. Given eruption surges, the embankment was unlikely to survive intact though it shielded the terrace.

Geographic coordinates for the White Terrace spring centre from Hochstetter's survey are 38.2557° S 176.4342° E in the WGS84 geographic coordinate system.

Summary: There was no evidence-based altimetry for old Lake Rotomahana. This foiled efforts to estimate the depth of ejecta around the lake and how deeply the terraces may be buried— and excavation cost. The first evidence-based altimetry was published in 2022. It is applied to the Ranges using photointerpretation and geometry to calculate the embankment height around the terrace. This delivers an improved altimetry with a pre-eruption ground datum.

3.4 Hochstetter's survey location for the White Terrace with LIDAR and error ellipses

The relocation of the buried White Terrace site was only possible with the unearthing and curation of the Hochstetter Collection Basel by Dr Sascha Nolden. The datasets in Hochstetter's 1859 diary and 1860 survey Folio enabled reverse engineering of his survey. The interdisciplinary methodology developed over the past decade includes holography,

transcription, translation, photointerpretation, altimetry, geospatial analysis, cartography, georeferencing, LIDAR, passive seismic, geometry and trigonometry (Bunn & Nolden, 2023). Nolden and Bunn first resected Hochstetter's observation stations (Station 21 and Puai Station). The bearing datasets from these delivered declination-adjusted reciprocal bearings which established the loci for each station. Error ellipses were formed about the loci.

Next, Hochstetter's bearing to the White Terrace Spring centre was projected from the Station 21 locus and this intersected with the Spring on Hochstetter's 1859 map when it was scaled and georeferenced on Google Earth. This validates Hochstetter's survey data and map. Measures included: Station 21 to Puai Baseline = 830 m. Station 21 to White Terrace = 1,769 m at azimuth 22.2°. Puai to White Terrace = 950 m at azimuth 26.0°.

The Station 21 error ellipse has a major axis of ± 44 m at azimuth 326.0°. The minor axis was ± 13 m at azimuth 60.0°. For Puai Station the major axis was ± 28 m at azimuth 345.0°. The minor axis was ± 9 m at azimuth 70.0°. Given the recent availability of enhanced LIDAR images from the Bay of Plenty Regional Council, it was decided to leverage the stations' data to estimate the error ellipse for the White Terrace spring location in Figure 17.

Fig. 17, Error ellipses for Hochstetter's survey location of White Terrace. Inner ellipse for his two-minute compass. Outer ellipse for his 10-minute compass. LIDAR courtesy of Adam Richardson at Bay of Plenty Regional Council. (Bunn and Nolden, 2023).

The approach took the stations' error ellipses and amplified and scaled the error components to account for angular uncertainty, based on the survey baseline, azimuths and the terrace distances. The station ellipses were decomposed with trigonometry to separate the north-south and east-west components. These were merged and aligned along the azimuths to the White Terrace spring centre, to compute the resulting major and minor ellipse axes.

The derived White Terrace ellipse's major axis is 105.9 m at azimuth 346.6°. The minor axis is 13.4 m at azimuth 76.6°. The ellipse one-sided errors are ± 52.9 m for the major axis and ± 6.7 m for the minor axis. Hochstetter possessed compasses with two-minute and ten-minute increments. Figure 16 has nested ellipses to help account for these. For the ten-minute compass, an angular error of ± five minutes was allocated (half an increment) and for the two-minute compass ± one minute was similarly allocated. The ellipse is elongated from the northerly alignment of the observation stations and terrace (Mikhail & Gracie,1981; Deakin, 2005).

In Figure 17 the error ellipses are superimposed on LIDAR imagery of the White Terrace spring location overlain on Google Earth. The central red dot is the sixth-revision survey location of the White Terrace Spring centre. Given the altimetry, the White Terrace embankment cannot be deeply buried and the surface may indicate what lies beneath. For example, at ten o'clock on the error ellipses lies a high point with both north and south drainage. This may correspond to one of the entrance peaks (Bunn, 2023c). The white high-reflectance region covers a low vegetation area lying east-west. This follows the terrace orientation and length. When this area was investigated in 2017, under the fourth revision of Hochstetter's survey the spring coordinates lay 128 m from today's site on a 240° azimuth. The limited vegetation clearing permitted by the Department of Conservation at that time for ground-penetrating radar (GPR) site access does not encroach on the high-reflectance LIDAR region in Figure 17. These findings will direct future seismic testing.

Summary: With new LIDAR imagery of the White Terrace survey location, the error ellipses for Hochstetter's White Terrace location are calculated in Figure 17. These enclose an area

along the shore. The local high point within the ellipse has suggestive drainage patterns for exploration as does vegetation density.

3.5 The true Kaiwaka Channel course with LIDAR

One consequence of Smith's mistaken White Terrace location is his declaring a low-lying section of the northern crater was the Kaiwaka Channel, the old lake outflow. Recent seismic research shows no evidence of the Kaiwaka Channel here (Bunn, 2023b). Smith's mistake created a potentially hazardous legacy. Given the high-risk eruption dam formed on the isthmus between Lakes Tarawera and Rotomahana, attention has focussed on this overflow, not on the true Kaiwaka course in Figure 18.

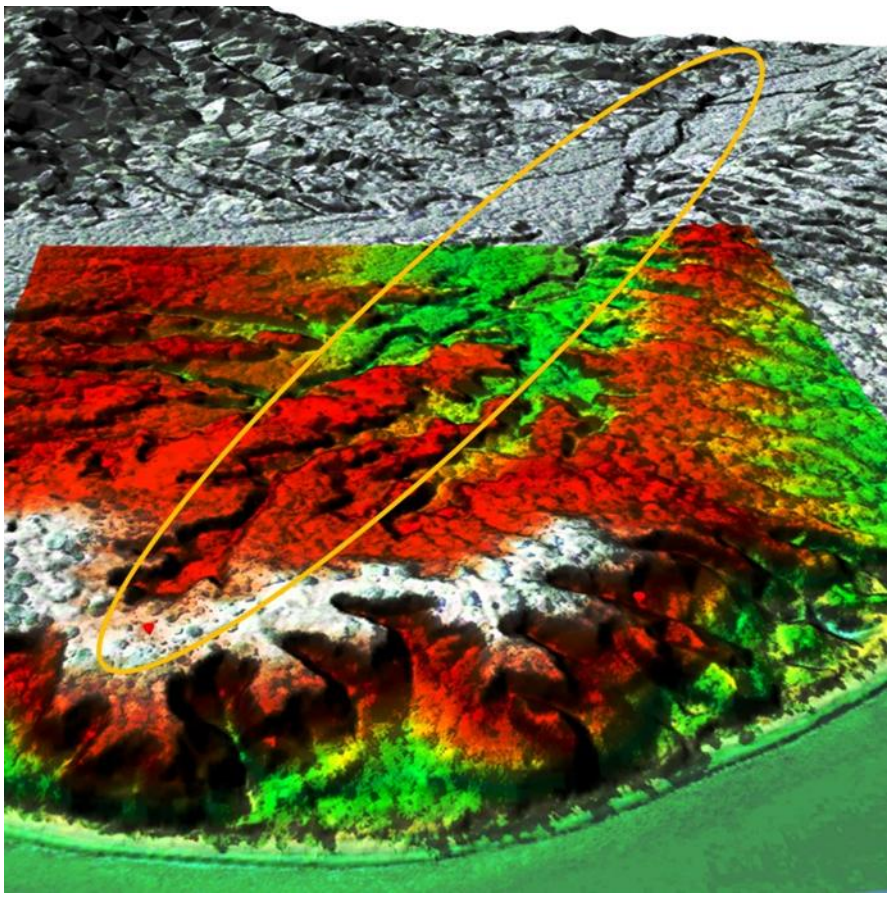

Fig. 18, Shaded LIDAR image of north Rotomahana shore. White shading shows high reflectance areas. The true Kaiwaka Channel course is in yellow outline. The left red dot shows the White Terrace-Kaiwaka Channel entry. (LIDAR imagery courtesy of Adam Richardson at Bay of Plenty Regional Council; Bunn and Nolden, 2023).

In Figure 18, LIDAR shows deep drainage channels below the red dot (the White Terrace-Kaiwaka intersection). These watercourses along the true Kaiwaka course are deeper and wider than those below the said lake overflow, reflecting greater surface and sub-surface flow. These connect with the lower Kaiwaka Channel, draining into Lake Tarawera as it did before the eruption. Heavy vegetation over this watercourse, indicates sub-surface water. Reviewing the ecosystem may show a preference for phreatophytes (White et al, 2014).

The Kaiwaka Channel is the low point in the dam and forms a large rubble drain. Since 1886, this carved piping under the isthmus increased the risk of dam failure for Tarawera residents who would receive little warning of a ~3–5 m tsunami.

Summary: Hochstetter's and seismic surveying show Smith mistook the crater lake overflow for the Kaiwaka Channel. The true Kaiwaka lies west as a massive, buried rubble drain in the low point of the isthmus separating Lakes Tarawera and Rotomahana. The isthmus is an accidental dam in the highest risk category. Smith's mistake led officials to focus on the wrong section when evaluating the risk of a dam breach. LIDAR shows deep drainage channels over the true Kaiwaka, connecting with the downstream Kaiwaka Channel on its original course. The LIDAR, seismic, altimetry and topography help triangulate Smith's other mistake.

4.0 Discussion

One difficulty in this research is the interrupted cartographic record. We have no Māori maps of the lake. The first map of Lake Rotomahana was by Smith in 1858. In 1859 we have three sketch and watercolour survey maps from Hochstetter and a flawed-but-artistic version from Petermann. That is all the large-scale pre-eruption cartography, apart from a map by Kinder in c. 1869 (a tracing of Petermann's). Between 1859 and 1886 there were no new large-scale maps.

After 1859, we benefit from photography. While this offers advantages over artwork, e.g., photogrammetric optics and photointerpretation enabling the restoration of Ngāhutu and Te Rangipakaru into the historical record, it introduces new errors, e.g., the absence of avian life and thermal fog clouds from long exposure times.

Researchers must also consider the dynamic environment. For example, in the 1843 visit by Ernst Dieffenbach (1811–1855), he commented on Rotomahana being "a deep lake of a blue

colour, surrounded by verdant hills … the lake covered with waterfowl, among which were the beautiful Porphyrio, ducks, and snipes, and also gulls, which feed upon a small fish that abounds in the lake (Dieffenbach, 381-382). Sixteen years later Hochstetter found it a ”small, dirty-green lake—with its marshy shores, and the desolate and dreary-looking, treeless hills about it” (Hochstetter, 1867, 407) … and the fish had fled. During that time Te Whakataratara, the solfatara beside the Pink Terrace burst its embankment, a putative reason for the altered water quality and finned fish flight.

Also, the terraces were developing, especially the White Terrace which unlike the Pink Terrace was not confined in a narrow gully. By 1886 the White Terrace was extending south and the extension was called the *Red Terrace.* Final pre-eruption photography shows the ridge separating the White Terrace from Ngāhutu was collapsing and had the 1886 eruption not occurred, Ngāhutu and White Terrace may have become a binary attraction.

5.0 Conclusions

Despite Smith sketching Lake Rotomahana and the White Terrace in 1858, his 13 June 1886 location for the White Terrace was speculative due to poor intervisibility. The 14 June claim was specific and he was in a better but distant position, and compounded his mistake. He mistook Star Hill, the highest landmark along the shore for the Ranges. This was probably due to sighting the first pair of four spurs projecting into the crater from Star Hill. Due to thermal fog, the eastern points weren’t visible. He assumed the high ground at Star Hill was the high ground of the Ranges and the White Terrace lay between the two points he could see. In six weeks, when he returned with his survey party, he would realise his error and for whatever reasons, decided not to admit it. Almost certainly, one factor was his intervening report to parliament. He would not wish to be sanctioned by his department head and minister for misleading parliament, although he had to defend this accusation in 1887.

A mystery is solved by the T cipher in his 1886 watercolour map, edited from later editions. Harding placed the White Terrace spring over this T in his 1887 map. This cannot be a coincidence. The T is a letter and not an unfinished hachure. Presuming the T is for Terrace or Tarata, it is a signpost Smith was not confident he could locate the White Terrace after his attempts on 13–14 June 1886. The T went unnoticed until the author examined Smith’s 1858–1894 Rotomahana maps, artwork and reports. It is suggested the T was a cipher by Smith as an *aide memoire*. This T bridges Smith’s June and July-August locations for the White Terrace spring. It is unlikely to represent the stream Smith disclosed in 1910, which

was his only evidence for the White Terrace location, though oddly, he never marked this on a map. The T helps explain why and how Smith migrated the Tarata Spring location west, whilst avoiding public scrutiny and oversight. This, while the public was grieving for the lost wonder and debating his report— parliamentarians were sceptical and he was being audited. During 1887 when he prepared his major report to parliament in July, he knew some government ministers were sceptical of his claim and that Hutton, Brown and Thomas were preparing reports. Brown later resigned and Hutton and Thomas reported separately. Also, Smith would be aware that Payton was publishing a book and would along with Warbrick be sceptics. He was probably aware they lobbied Thomas at Rotomahana and Thomas had sympathy with their views (Bunn, 2024). Thomas was however dependent on the Survey Office for maps and survey data for his eruption report. Smith was open to assisting the academics while McKerrow his supervisor was not (Keam, 331–335). The politicking impacted the 1886–1893 map-making. It explains the highlighted Survey Office authorship of Harding's map, emphasising the map was by them and not Thomas. Four Survey Office authors are named "with additions by Professor A. P . Thomas". It likely explains the insertion of the caricature lake—this *inter alia* prevented Thomas from inserting Warbrick and Payton's location. Thomas avoided discussing this in his report.

One omission by Smith is photography. His 1886, 1887 and 1894 reports lacked photography when e.g. prints could have been pasted into the small-circulation report. Instead, he provided rushed, misleading sketches in his 1886 report though photographer Charles Spencer (1854–1933) was available and soon reached the crater. Half of Smith's 1887 major report comprised sketches of such poor quality that his office initially declined to publish. In 1893, he returned to Rotomahana and Smith's brother Frank took "a splendid view of the scene over the eruption" (Smith, 2011). Halftone printing might have offered more interest in his report.

Given Smith's evident research misconduct, today's researchers can have little confidence in either of his White Terrace locations. Before 2016, when the first pre-eruption Rotomahana survey was published, earth sciences workers relied on his material under the Smith-Keam paradigm (Bunn, 2023b). Today, that paradigm is untenable. Recent work relying on his claims has spurious concordance (de Ronde et al 2018). The evidence herein and published by Bunn and Nolden between 2014–2023 shows Smith wrote the historical record as if he had one evidence-based location for the White Terrace. The evidence herein indicates he did not: only hunches that changed.

In summary, of the five maps Smith produced between 1858 and 1894, the most important omitted a White Terrace location. His 19 June 1886 report has a different location to his subordinate Harding's 1887 map. Harding's White Terrace site contradicts Smith's report text. The 1894 map and lithograph don't assist the burden of proof. His 1910 crater stream disclosure further clouds the issue. Why Smith engaged in misconduct is unclear, apart from being unwilling to admit a mistake. It is relevant his later work has also been found to contain fabrication (Taonui, 2005). Given his top management position in the Survey Office, this amounts to research misconduct. There are enduring consequences of his concealed mistake at Rotomahana.

No survey activity has been published at Rotomahana since the 2018 passive seismic surveying. (Bunn, 2023). It remains vital for this lost Eighth Wonder of the World, that topographic research be developed to the stage where further sub-surface imaging and drilling or excavation can be considered by the traditional landowners.

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Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the author.

Author contributions

The author confirms being the sole contributor of this work and has approved its publication.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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