*Appendix I: Historical account of the Charles Spencer No. 9 photograph*

The following is an account by one of us (RFK) on the relevance of the Charles Spencer No. 9 photograph to the location of the White (and therefore also the Pink) Terraces in present-day Lake Rotomahana, and the interpretation of local geological features.

When I acquired the remnant Rotomahana pre-eruption negatives of the late professional photographer Charles Spencer in early 1951, it quickly became apparent to me that the images did indeed preserve quantitative information that should assist in determining an accurate pre-1886-eruption location for the Pink and White Terraces - a subject that since childhood had intrigued me - and thereby perhaps resolve once and for all a historical mystery concerning these iconic New Zealand features. And, as a bonus, geological and geophysical information might also emerge, allowing one with increasing confidence to understand better the pre-history of this part of a fascinating region of this country.

Over the next decade, I also obtained important pictorial information from the work of numerous other early photographers. Of special value was a panoramic set of five photographs by Alfred Burton taken in the course of a single day during October or November 1885. Measurements made on topographic features visible in this set, combined with information from a particular image by Josiah Martin, and also with information from images by several photographers taken from positions near to Koingo Geyser, elevated closely above Rotomahana’s eastern shoreline, enabled what is believed to be a relatively accurate map of the whole pre-1886-eruption Rotomahana basin to be constructed. This quantitative investigation was originally performed in about 1959, and an up-dated product was published on page 27 of Keam (2016).

Of particular value has been the chance near-alignment of the images of certain readily identifiable geographical features within Charles Spencer’s photograph 9 (C.S. 9), exposed during his first professional visit to Rotomahana in 1881. The alignments permitted an approximate position of the 1881 camera location to be determined on a four-inches-to-the-mile map (NZMS Map number 86, Sheet N 85/3, Waimangu, First Edition, published in November 1950). This led to a comparison with the natural scene being able to be checked by E.F. Lloyd and the author on 22 May 1951. Images from both the C.S. 9 negative and a panorama by the author on that 1951 date are presented here (Figs. 5A and B) and can be directly compared. Because of minor topographic changes wrought by the eruption, and because the precise C.S. 9 location was not reachable by reason of its being confirmed to be submerged a short distance offshore Te Tarata Peninsula in 1951, the match is not perfect, but one can estimate the location discrepancy very closely: and the separation recognised at the time appeared to be only about 10 to 20 m.

Consider now three illustrations. These photographs all look approximately north-eastward across the White Terraces, towards Mt Tarawera, to show, rising beyond approximately the central section of the Terraces, a hill which, because of its appearance (and in the absence of any previously established name), I have labelled “Flat Top Hill” (see Fig. 3). The C.S. 9 camera location clearly was situated high on this minor eminence, and perhaps at the very edge of the hill crest, as one might expect would have been chosen by Spencer in order for him to capture the most comprehensive picture possible from this neighborhood. Indeed, contrasting the minimal foreground shrubbery that is to be seen in C.S. 9 (Fig. 5A) with that appearing within Burton Bros 3888 (Fig. 3, or the first of the above-mentioned three illustrations) one notices in the latter that the foreground vegetation on the slope proceeding away from the camera was much nearer and significantly more prominent. Thus, in C.S. 9, it is the almost precipitous short drop to the land surface immediately in front of the camera that has allowed such a clear forward view and confirms for the instrument’s positioning a hill-crest location. Flat Top Hill is again clearly seen in the Charles Spencer photograph C.S. 77 (SM Fig. 1A) and just how flat, and how distinctively abrupt and bounded a crest Flat Top Hill possessed is emphasized by what is shown in a much closer view in the 1865 Kinder photograph (SM Fig. 1B).

From Hochstetter’s map of Rotomahana and its vicinity, Flat Top Hill undoubtedly identifies as having been the small isolated elevation situated immediately north of the north-western extremity of Pinnacle Ridge. Its shape demands attention and raises the question as to what geological processes had led to it evolving into such a form.

It is suggested that Flat Top Hill was the remnant form of a formerly taller edifice whose upward extension had consisted entirely of tephras and/or homogeneous fine-grained sediments that had been progressively eroded down to zero elevation above a ‘high-standing’ Greater Lake Tarawera at the level of Flat Top Hill's flat pre-1886-eruption summit. And one does not need to look further back than the immediate pre-Kaharoa eruption era to find such a situation existing, and (apart from certain very brief changes connected with that eruption itself), with the lake-level up till that time known to having been subjected to just a very gradual rate of lowering (Hodgson and Nairn, 2005).

Careful comparison of Flat Top Hill and the profile of the White Terrace in BB3888 shows that the horizontal Upper Platform of the latter matched almost exactly the horizontal plane of the former. To within a meter or so of deposited siliceous sinter, the Upper Platform shared the same horizontal plane as the erosional surface of Flat Top Hill. Moreover, both shared that same horizontal plane with that of the whole Burton Brothers’ suite of five negatives comprising the panoramic series exposed from just north of the Pink Terrace. A horizontal line drawn appropriately across any image of any/all of the suite of relevant photographs mentioned (and for that matter any photograph still to be discovered, e.g., among images taken at appropriate locations on the White Terrace, or that might be recognized turning up by chance elsewhere of scenes within the Rotomahana Basin), would share such properties.

It should be mentioned here that there exists one other such important plane, namely the horizontal plane at the level of Lake Rotomahana. With this, least squares fittings incorporating such a fact permit consistency checks, and the promise of eventual three dimensional topographic mappings to be able to be performed.

During the 1886 eruption the western side of Flat Top Hill, just including the site of C.S. 9, became a location marginally inside the edge of the great Rotomahana Crater (see Fig. 1). The un-shifted remainder of the hill was buried to an as yet uninvestigated depth by an approximately smoothly varying thickness of ejecta. Its slightly up-domed resulting shape maps today as an almost polygonally shaped projection protruding above the current level of Rotomahana along its northern shore and forms Te Tarata Peninsula. Illustration BB 4121 (Fig. 3B) exposed ca. October 1886 looking approximately south-eastward from a Rotomahana crater-rim position, shows this. Further away, to the right and thus more southward, can be seen The Pinnacle - an 1886-steaming remnant of massive intruded rhyolite that had been a feeder channel intruded during the formation of Pinnacle Ridge sometime before 7000 years B.P. Further away again, and across Rotomahana Crater in the image, more plumes of steam appear rising from Banded Hill - the site of part of pre-1886-eruption Te Rangipakaru rhyolite dome. Ironically, the camera position, which clearly was situated at the edge of Rotomahana Crater, lies geographically close to the site for Te Tarata cauldron that is being advocated by Bunn and Nolden (2017).