HISTORICAL FALLOUT:

BRITISH NUCLEAR TESTING IN AUSTRALIA AND THE NATURE OF SCIENCE

JOHN TOWNSEND

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PREFACE

This paper was submitted as a requirement for the History Extension course in the 2006 New South Wales Higher School Certificate while I was studying at Canterbury Boys' High School in Sydney's inner west.

My research of these events is the result of a passion for Australian history and the belief that not enough is known, or acknowledged, by the public about events within our nation's past: including many during the nuclear testing conducted at the Monte Bello Islands, Emu Field, and Maralinga between 1952 and 1967 by Great Britain. These produced such a number of issues relevant to the study of the philosophy behind historiography, that it would be a difficult to cover all in such a limited period. This led to a focus upon what the 1985 Royal Commission[1] dubbed the "Marston Controversy."[2]

Throughout my research on this event, I explored the influence of the respective agendas and paradigms of 'historians'[3] upon their research as well as the parallels between the natural and social sciences. Rather than merely studying the remaining

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[1] Full title: the Royal Commission into British Nuclear Tests in Australia. This inquiry was chaired by J.R. McClelland and was established on 5th July 1984, with the final report presented on 4th December 1985.

[2] McClelland, J.R. et. al. Report of the Royal Commission into British Nuclear Tests In Australia (Volume 2). Canberra: Australian Government Publishing Service, 1985, pp. 434.

[3] Historians are characterised in a post-modernist perspective. They are not were not limited to academics who have been educated in historical practice, but also include those who play a role in the development of historiographies, such as government departments, spectators of the events, the media, and, of course, scientists.

written material, I consulted sources from a variety of other mediums, such as oral history and audiovisual material. In order to maintain a balanced perspective, sources from both the British and Australian perspectives were obtained, and individual participants, as well as relevant government departments, such as Australian Radiation Protection And Nuclear Safety Agency (ARPANSA), Department of Education, Science and Training (DEST), and British Defence Research and Support Staff (BDRSS), were consulted.

The central concerns of this essay concentrate on the reliability of 'scientific' data as a historical source, and the extents to which personal influences or agendas of individuals (be they historians or researchers) affect the resultant historiographies. In addressing these issues, this essay presents the prominent events during Australia's nuclear testing era and the 'Marston controversy', analyses the background of the 'historians' to present possible reasons for their opinion, and makes comparisons between the perspectives. Scientific data is also treated in a similar manner to the historical sources, thus making a connection between the methodologies and the subjectivity of the natural and social sciences.

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4 Listed alphabetically

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Finally, a huge thanks to the staff of the State Reference Library (NSW) and Mitchell Library in Macquarie Street, Sydney for their assistance in locating documents buried within their archive, and for allowing access to their library stacks to sift through copies of Hansard.

ACRONYMS AND ABBREVIATIONS

NB: Most government organisations referred to originate within the United Kingdom (UK), Australia (A), or New Zealand (NZ). International organisations (I) are mentioned also. As government departments have changed names over time, references to their successors have been provided, where possible.

AIRAC	Australian Ionising Radiation Advisory Council (A)
Al.	Aluminium alloy
ARC	Agricultural Research Council (UK)
ARL	Australian Radiation Laboratory [now ARPANSA] (A)
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency, Melbourne (A)
AWRE	Atomic Weapons Research Establishment, Aldermaston (UK)
AWTSC	Atomic Weapons Test Safety Committee (A) [also referred to as the **Safety Committee**].
BDRSS	British Defence Research and Supply Staff, Canberra (UK)
CSB	**[***Contact Surface Burst*] describes a nuclear detonation that occurs while the device is in direct contact with the ground's surface.
CSIR	Council for Scientific and Industrial Research [now CSIRO] (A)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (A)
DEST	Department of Education, Science, and Training (A)
G1	Code name for the first explosion of 'Operation Mosaic' at the Monte Bello Islands (Trimouille Island) on 16th May 1956.

G2	Code name for the second explosion of 'Operation Mosaic' at the Monte Bello Islands (Alpha Island) on 19th June1956.
ICRP	International Commission on Radiological Protection (I)
MRC	Medical Research Council (UK)
MRTAC	Maralinga Rehabilitation Technical Advisory Committee (A)
MS	Mild steel.
MoD	Ministry of Defence (UK)
NRAC	National Radiation Advisory Council (A)
NSB	[*Near Surface Burst*] describes a nuclear detonation that occurs while the device is in close to the ground's surface.
TR	Technical report

GLOSSARY

Activity	Attribute of an amount of a radionuclide. Describes the rate at which transformations occur in it. Unit Becquerel, symbol Bq. 1 Bq = 1 transformation per second.
Alpha Particle	A particle consisting of two protons plus two neutrons. Emitted by a radionuclide.
Alpha Radiation	Radiation that consists of alpha particles.
Annales	A 'school' of thought named after the French scholarly journal *Annales d'histoire économique et sociale*. The founders of this journal became associated with the method of historical enquiry that involves a 'cross-pollination' between the respective social sciences. For example, an historical work whereby the author engages psychoanalysis (from the Behavioural Sciences) of the protagonists in order to explain their actions.
Atom	The smallest portion of an element that can combine chemically with other atoms.
Atomic Number	The number of protons in the nucleus of an atom. Symbol Z.
Becquerel	See 'Activity'.
Beta Particle	An electron emitted by the nucleus of a radionuclide. The electric charge may be positive, in which case the beta particle is called a positron.
Beta Radiation	Radiation consisting of beta particles.
CAT Scan	A three-dimensional image of a cross section of the body made with x-rays that is useful in diagnosing disease (for example, in detecting tumors). CAT stands for computerized axial tomography, the name of the method used to produce the image.
Decay	The process of spontaneous transformation of a radionuclide. The decrease in the activity of a radioactive substance.
Dose	General term for quantity of ionising radiation.
DNA	Deoxyribosenucleic acid. The compound that controls the structure and function of cells and is the material of inheritance.

Element A substance with atoms of all the same atomic number.

Fission Nuclear fission. A process in which a nucleus splits into two or more nuclei and energy is released. Frequently refers to the splitting of a nucleus of uranium-235 into two approximately equal parts by thermal neutron emission of other neutrons.

Gamma Ray A discrete quantity of electromagnetic energy without mass or charge. Emitted by a radionuclide.

Gamma Radiation Radiation consisting of gamma rays.

Half-life The time taken for the activity of a radionuclide to lose half its value by decay. Symbol $t_{½}$.

Ion Electrically charged atom or grouping of atoms.

Ionisation The process by which a neutral atom or molecule acquires or loses an electric charge. The production of ions.

Ionising radiation Radiation that produces ionisation in matter. Examples are alpha particles, gamma particles, x-rays and neutrons. When these radiations pass through the tissues of the body, they have sufficient energy to damage DNA.

Molecule The smallest portion of a substance that can exist by itself and retain the properties of the substance.

Non-ionising Radiation Radiation that does not produce ionisation in matter. Examples are ultraviolet radiation, light, infrared radiation, and radiofrequency radiation. When these radiations pass through the tissues of the body, they do not have sufficient energy to damage DNA directly.

Nucleus The core of an atom, occupying little of the volume, containing most of the mass, and bearing positive electric charge.

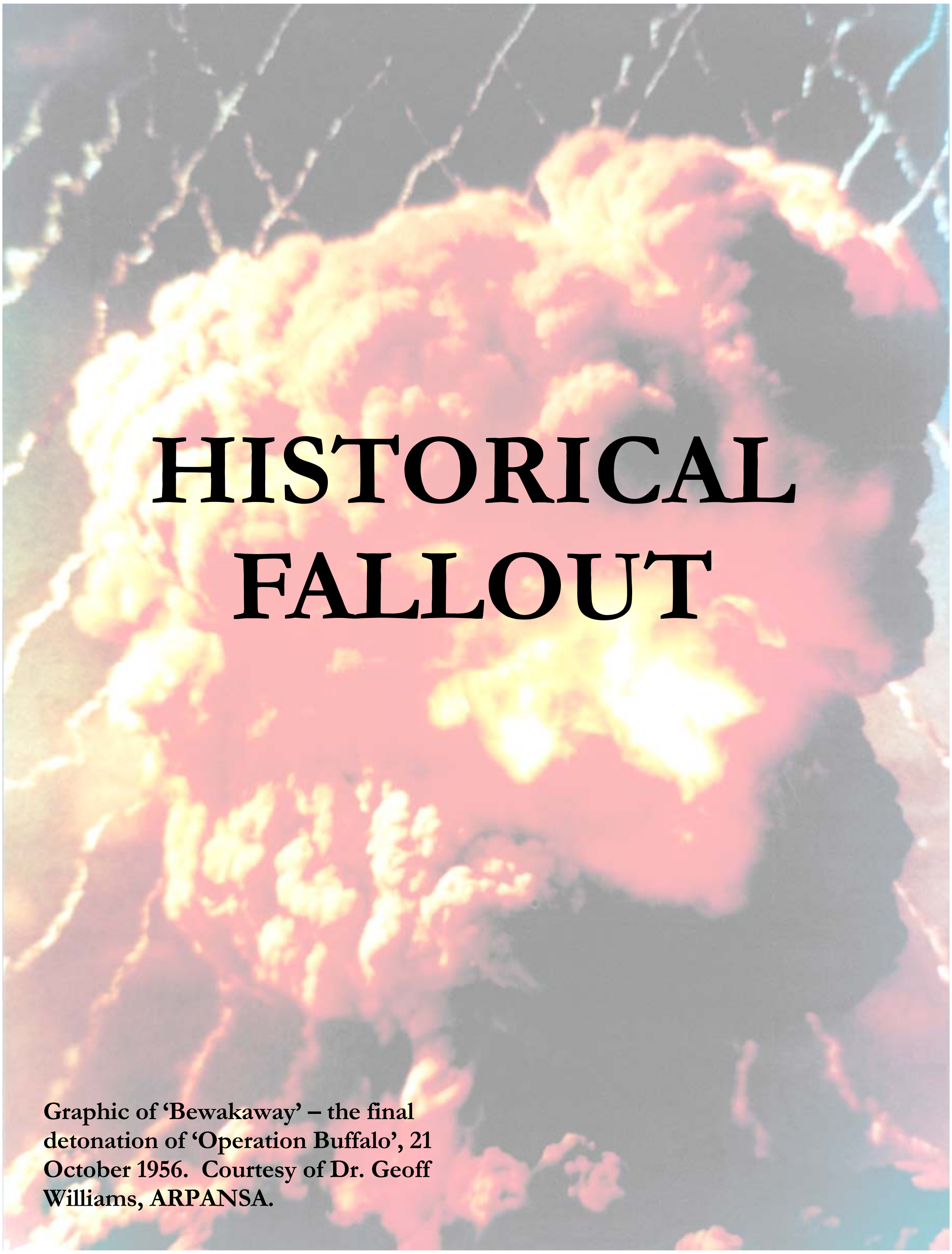
Nuclide A species of atom characterised by the number of protons and neutrons and, in some cases, by the energy state of the nucleus.

Proton An elementary particle with unit mass approximately 1.7×10^{-27} kg and unit positive electric charge.

Radionuclide An atom with an unstable nucleus that undergoes radioactive decay.

Radiation The process of emitting energy as waves or particles. The energy thus radiated. Frequently used for ionising radiation except where it is necessary to avoid confusion with non-ionising radiation.

Radioactive	Possessing the property of radioactivity.
Radioactivity	The property of radionuclides spontaneously emitting ionising radiation.
Revisionist	An advocate of doctrines, theories, or practices that depart from established authority or doctrine.
Sievert	The unit of measure for the effective dose of radiation (dose to specific organs based on their sensitivity to radiation)
Structuralism	A paradigm of historical research that whereby the historian is concerned with presenting a 'true' account of the events in question from which the personal opinions are absent. This often leads to an historical work that merely refers to the events and does not adequately analyse their implications or context.
Structuralist	One whose views adhere to the structuralist paradigm. See structuralism.
Thermal Neutrons	Neutrons that have been slowed to the degree that they have the same average thermal energy as the atoms or molecules through which they are passing.



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Graphic of 'Bewakaway' – the final detonation of 'Operation Buffalo', 21 October 1956. Courtesy of Dr. Geoff Williams, ARPANSA.

HISTORICAL FALLOUT

There has been an exhaustive epistemological debate within the academy, with much of this discussion concerning the credibility of arguments and establishment of supposed 'facts'. Those of the conventional sciences, for example, base their 'discoveries' upon empirical research and independent observation from experiments, which are, in effect, a microcosm of specific real world events or factors.

Due to these attributes, scientists are perceived to hold the intellectual 'high ground' when compared with those of the social sciences, who supposedly base research upon their subjectivity, therefore being regarded as formulating arguments inherent with bias. This faith in 'scientific method' to yield an objective and comprehensive result has led to an adoption of similar methodologies within the social sciences, emulating the focus on objectivity and the use of empirical data. Within the subset of 'historical research', for example, this contributed to the development of the Structuralist historical paradigm of Leopold von Ranke and his belief that the historian's task is "'simply to show how it [history] really was' (wie es eigentlich gewesen)"[5], a belief which has become an obsession with many Anglophone historians.

However, in his landmark thesis "The Structure of Scientific Revolutions"[6], T.S. Kuhn stated that history should not idealise scientific method, for many conclusions are "the product human idiosyncrasy"[7]. Scientists, Kuhn argued, bring their own "paradigms"[8] to their research; that is, the previously conceived 'laws', theories, and 'models' of their field. Therefore, rather than there being a hierarchy between the faculties in terms of objectivity, each is

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[5] Carr, E.H. What is History? Basingstoke, Hampshire (UK): Palgrave, 2001: pp.3.

[6] Kuhn, T.S. The Structure of Scientific Revolutions. Chicago: The University of Chicago Press, 1996.

[7] Ibid., pp. 2

[8] Ibid., pp. 10

the embodiment of the other as the final result will be affected by the researcher's own individual paradigm. The historiographies surrounding the British nuclear tests within Australia between 1952 and 1967, especially those of the 'Marston Controversy', detail the manipulability of science, and its history, therefore vindicating Kuhn's thesis.

During these nuclear tests, historiography played an important role in securing public support for the continuation of the program between 1952 and 1967 (as well as allaying public fears of radioactive contamination arising from close-in or long-range fallout[9]). Historiography also has been used by historians either to rationalise the actions of the main protagonists, such as the governments or scientists involved, or to fulfil a historian's own agenda.

Indeed 'science' has been employed by historiographers to produce agenda driven 'truths'; however, the debates upon these events are not merely limited to the credibility of history, but also that of science itself. Not only was science used to 'prove' the argument of the AWTSC that there was no risk of fallout contamination and that the Australian population was safe, but attempts were made, it has been argued, to suppress the results of a research paper by a biochemist of the CSIRO[10] were, it has been argued, suppressed. This ethical violation in scientific practise occurred because the conclusions made in this paper suggested that the continent was, indeed, contaminated despite the guarantees of the AWTSC and respective governments involved. This manipulation of 'history' in what was later referred to as the "Marston Controversy"[11] was resultant of the almost 'religious' faith held in scientific results as being absolute truths[12]. The results of science should, as has been

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[9] See Appendix 3 for explanation on radioactive fallout.

[10] Hedley Ralph Marston

[11] McClelland. op. cit. pp. 434

[12] Conflict between organised religion and those who have a near 'fundamental' faith in science and, therefore, wish to discredit these beliefs can be observed in Lawrence Krauss' article which is reproduced in appendix 4.

done in this historical investigation, be treated with the same caution as any other historical source.

Much of the direct historiographical manipulation began with the formation of the Atomic Weapons Tests Safety Committee by the Australian Department of Supply in July 1955. This was the result of media pressure and public outcry following a catastrophe in one of the US thermonuclear tests in the Bikini Atoll, 'Bravo', on the 1st March 1954. The test itself produced a yield of 15 megatons[13], twice the expected yield, and, as a result, twice the radioactive fallout. This, in combination with unexpected wind conditions, resulted in the contamination of the crew of a Japanese vessel, the 'Lucky Dragon', which was fishing outside the restricted area about 75 miles away from Bikini. This was a highly public incident: the crew suffered from radiation sickness, and the ship's radio operator died soon after the ship returned to port in Japan.[14] The issue of fallout was not of great concern during the preceding British nuclear weapons tests[15], as there was the assumption that there was only a risk of on-site fallout. To allay public fears, the Safety Committee was established, primarily comprising of five physicists with the inclusion of the government meteorologist (it is not certain whether such an inclusion of British nationals by the Australian government of the time was the result of pressure from the UK, or the "anglophile"[16] sympathies of Prime Minister Robert Menzies). The "vested interest[s]" held by the members of the Safety Committee may have influenced to them stopping at nothing to ensure in "the continuation of atomic…testing in Australia"[17].

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13 Equivalent force to a detonation of 15 000 000 tonnes of TNT. *Generally*, the yield of an fission detonation is measured in terms of kilotons [(Kt.) equivalent force to 1000 tonnes of TNT], while fusion detonations are measured in terms of megatons [(Mt) equivalent force to 1 000 000 tonnes of TNT].

14 Arnold pp.76

15 i.e. 'Operation Hurricane' and 'Operation Totem'

16 Ibid. pp. 12

17 Cross pp.34

This was evident in the events following 'Marcoo', the second explosion of 'Operation Buffalo' at Maralinga.

By this time, Hedley Marston and his team were well into their task of sampling radioiodine in the thyroids of livestock across Australia on the request of the British MRC and ARC. Following 'Marcoo' on 4th October 1956, there was a report on the front cover of "*Adelaide News*…reporting that Mr. Hamilton[18]… had asserted in federal parliament that the thyroid glands of cattle on a station in the Northern Territory in the Hamilton Downs area were 'radioactive' [as] they had given Geiger counts of 3000 following the explosions [sic.]."[19] It is not known whether this information was a 'leak' from Marston or one of his team, but in the same edition of the paper another article was found stating that "Experts make overnight tests – NT Sheep 'Not Radio-Active', according to the Safety Committee chairman"[20] Prof. Leslie H. Martin. The public were assured that "skilled men were sent out by the British Medical Research Council worked through the night testing thyroids, and found no evidence of any" radionuclides.[21] In retrospect, one physicist later had the "cynical view that it was too dark for them to read their Geiger counters"[22], but whatever the reason, it is obvious that the 'Safety Committee' had concerns other than the safety of the Australian population and that any findings of radioactivity by these 'skilled men' – if there were any at all – were not passed on to the public.

The 'Marston Controversy' itself was another public relations disaster that was further evidence that the AWTSC had some interest in 'suppressing' information that disproved their claims of safety, and the continuation of the

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18 MP – Country Party, Western Australia

19 Cross pp.64 – 65

20 Ibid. pp. 65

21 Ibid.

22 Oral history, courtesy of F.P.J. (Rob) Robotham.

British nuclear weapons testing program. After completing the manuscript for his paper detailing the results of his survey, he had copies sent to the director of CSIRO and LH Martin, the director of the AWTSC, for clearance prior to publication in January 1957. The report seriously implicated the Safety Committee (which, later that year, came under the leadership of Prof. Ernest William Titterton, British - born physicist, open supporter of the continuation of the development of nuclear weapons and first person to 'press the button' on an atomic bomb in July 1945) and made inferences between the levels of radiostrontium contamination of Australia, based on his survey of radioiodine. Although the paper was eventually published, the Safety Committee went to great lengths to not publish it, and even discredit its content.

Firstly, its publication was delayed until August of 1958[23]. In these 20 months, the Safety Committee attempted to discredit Marston's experiment by interviewing his staff in order to discover and exploit any flaws in the methodology of his monitoring[24], denounce the dangers of radiostrontium as "hysterical propaganda"[25], and appeal to friends of Marston, as well as Sir W Penney (head of the British nuclear program) to write to Marston and convince him not to publish. However, Marston did publish, and his experiment adhered to official guidelines; but the paper's impact was significantly reduced as it was only published after the final testing operation on Australian soil 'Operation Antler'. It is also likely that the Australian government, possibly at the request of the Safety Committee or the British government, influenced the mainstream press in not reporting on Marston's paper. The only media outlet to cover this story was a small rural newspaper, '*Stock and Land*'. It is highly unlikely that *all* other media outlets simply missed

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23 .Marston, H. 'The Accumulation of Radioactive Iodine in the Thyroids of Grazing Animals Subsequent to Atomic Tests'. Australian Journal of Biological Sciences. August 1958: 382 - 383

24 Cross pp. 120

25 Ibid. pp. 121

this story, especially after the public debate that ensued in '*Stock and Land*', and the fact that a friend of Marston was editor-in-chief of Adelaide's *News* at the time.

It must also be noted that Marston, himself, did not hold an objective 'high ground' either. Roger Cross, in his "Fallout: Hedley Marston and the British Bomb tests in Australia" states:

> *"Why wasn't Marston satisfied with the actual data he collected?...The answer is not hard to find. His scientific judgement was coloured by his personal feelings towards Leslie Martin and Ernest Titterton…Even without making the contentious link between iodine and strontium, he had enough concrete evidence to make a good case against the Safety Committee…But what he wanted were scalps!"*[26]

Therefore, once again, science was affected by the subjectiveness of the scientists involved in a similar manner to that of historians and historiography.

In retrospect of the events, two historians, Lorna Arnold and Roger Cross, have provided significantly differing perspectives on Marston's work. In Arnold's "A Very Special Relationship"[27] she castigates Marston's paper for two reasons:

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[26] Cross pp.113

[27] Op. Cit.. Arnold.

> *"first, because of comments that Marston made, and did not make, on his data; second, because of the paragraphs he included on other fission products, especially strontium – 90, in which he drew erroneous inferences from his iodine – 131 results, with no supporting experimental data"*[28]

Arnold also criticises him for his atmospheric sampling, the strongest source of evidence demonstrating the presence of significant fallout contamination of one of Australia's major cities, stating, "even if it gave a correct picture of fallout over Adelaide, it was still irrelevant to a report on iodine 131 in animal thyroids"[29]. Another example of her general views in relation to the British nuclear testing program can be seen in one of her appendices on radioactive fallout[30]. She uses what should be a factual addition to her work to justify the composition of the AWTSC in alluding to a requirement for meteorologists and physicists to oversee test safety:

> *"All these four factors* [the size of fallout particles, the distribution of the material, the height and extent of the cloud and meteorological conditions] *work together* [in determining the dispersal of radioactive fallout]*; hence the importance of both theoretical predictions and meteorological forecasts in identifying the safe conditions for firing."*[31]

However, she does not recognise a possible need for members of other scientific disciplines, such as biologists for matters relating to living organisms and the effects of exposure to the various levels of radiation on tissues, or

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[28] Ibid. pp. 194

[29] Ibid. pp. 196

[30] Ibid. pp 304 – 309. A portion is reproduced in Appendix 3 of this paper.

[31] Ibid. pp. 307

chemists to analyse the assimilation pathways for radiation, to be present. Arnold's argument may be a result of her own paradigm not only because of the involvement of the British government in her research, but also states that she "has not seen the Australian documents, but have found no attempt in Britain to suppress his [Marston's] results."[32] Therefore, she shapes her historiography of the events on paradigms evident in her source collection. It is apparent that, because of this research flaw, her argument, to a certain extent, lacks historicity. Moreover, the credibility given to her work, combined with publications of data by the Safety Committee, has led to the dominant historiography resonating with these views.

Roger Cross, on the other hand, has provided a revisionist[33] perspective upon the 'Marston controversy' in challenging the similar conclusions of Arnold, Symonds[34] (the author of the 'official' Australian perspective on the events, largely from Australian government documents), and J.R. McClelland's Royal Commission.[35] He relies extensively upon sources such as personal correspondences, as well as official records from Australia and Britain, and oral history from surviving scientists, including those who knew the main protagonists. This has led to his argument focusing largely upon the 'psychoanalysis' of those involved, a characteristic that dominates the French Annales 'school' of thought. Cross' identity as an Australian historian may have led to him referring to Marston as a grand nationalistic figure, one who "epitomises much of the Australian dream"[36], as well as a distinct attack upon those of the Safety Committee, and Lorna Arnold for her "Anglophile"[37] perspective on the 'Marston controversy'. As Cross is an Australian historian,

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[32] Ibid. pp. 198

[33] The term 'revisionist' is often connoted as derogatory. In this case, however, it refers to the fact that Cross' source is consistent with the definition listed in the Glossary on page xiii.

[34] Symonds

[35] op. cit. McClelland, J.R.

[36] op. cit. Cross, R., pp. x

[37] Ibid. pp. 165

his argument may be a product of his subjectivity and connection with the events in question. However, considering the extent of his research into this small subset of the entire British nuclear weapons program, especially in comparison with those before him, it is evident that his research may have allowed his conclusions to be closer to the 'truth' his predecessors. In addition, he does not specifically allege a 'suppression' of facts by the British, but allows the reader to decide for themselves. However, his historiography on the events is still subject to the main paradigm of his research, that of 'psychoanalysis'.

From analysing some perspectives on the British nuclear testing program in Australia, as well as that of the 'Marston controversy', it is evident that historiography is the result of the paradigms brought by the 'historian'. The Safety Committee, intent on continuing the tests, made an effort of discrediting scientific 'evidence' that would not support them, and the nature of Marston's conclusions were based on his intention to implicate members of the AWTSC for their lack of credibility, as well as historians, such as Cross and Arnold, whose historiographies have been based upon their own paradigms. Furthermore, as this details the simple manner in which scientific 'evidence' can be manipulated for the scientist's own cause, TS Kuhn's theory on the subjectiveness of science, at least in this case, is proven.

APPENDIX 1: BRITISH ATMOSPHERIC NUCLEAR WEAPONS TESTS IN AUSTRALIA

OPERATION and Location	Date and TIME (GMT)	Site	Type	Geographical Coordinates	Height at detonation (m)	Approx. Yield (kt)
HURRICANE; Monte Bello Is., WA	3 Oct. 1952 0000Z*	Lagoon of 12m depth off *Main Bay*, Trimouille Island.	CSB; in HMS Plym	Lat. 20°24'30"S Long. 115°33'50"E	-2.7	25
TOTEM; Emu Field, SA	14 Oct. 1953 2130Z	T1.	NSB: MS Tower.	-	31	10
	26 Oct. 1953 2130Z	T2.	NSB: MS Tower.	-	31	8
MOSAIC; Monte Bello Is.	16 May 1956 0350Z	G1: Trimouille Island.	NSB: Al. Tower.	Lat. 20°23'00.06"S Long. 115°32'47.98"E	31	15
	19 June 1956 0214Z	G2: Alpha Island.	NSB: Al. Tower.	Lat. 20°24'26.42"S Long. 115°32'03.36"E	31	60
BUFFALO; Maralinga Range, SA	27 Sept. 1956 0730Z	One Tree.	NSB: Al. Tower.	-	31	15
	4 Oct. 1956 0700Z	Marcoo.	CSB: at ground surface.	-	0.2	1.5
	11 Oct. 1956 0557Z	Kite.	Airburst: freefall.	-	150	3
	21 Oct. 1956 1435Z	Breakaway.	NSB: Al. Tower.	-	31	10
ANTLER; Maralinga Range, SA	14 Sept. 1957 0505Z	Tadje.	NSB: Al. Tower.	-	31	1
	25 Sept. 1957 0030Z	Biak.	NSB: Al. Tower.	-	31	6
	9 Oct. 1957 0645Z	Taranaki.	Airburst: Balloon System Borne.	-	300	25

Figure 1: List of British Atomic Weapons Tests within Australia. [Adapted from MoD Report No SFS/A/26 with some inclusions of data from TR049.]

For clarity, this time is conventionally quoted as 0001Z on 3 October 1952 (GMT): the firing time was almost exactly midnight 2/3 October 1952 (GMT). See "ACRONYMS AND ABREVIATIONS" for definitions of NSB, CSB, MS, and Al.

APPENDIX 2: MAPS OF THE ATOMIC WEAPONS TEST SITES

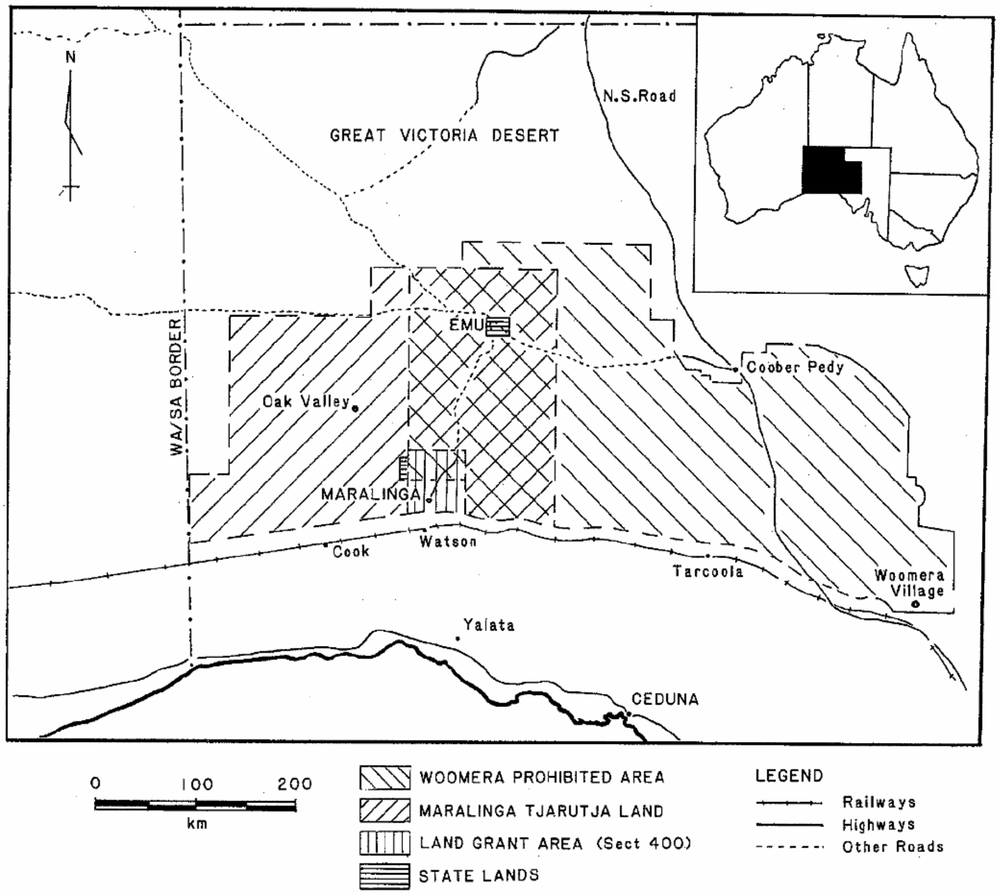

Figure 2: Map of southern Australia showing the locations of Maralinga, Emu Field, and areas under Commonwealth control. [Reproduced from ARL/TR085: pp. 24].

NB: Areas marked "STATE LANDS" (sections 1486 and 1487) were added to Maralinga Tjarutaja Land in 1998.

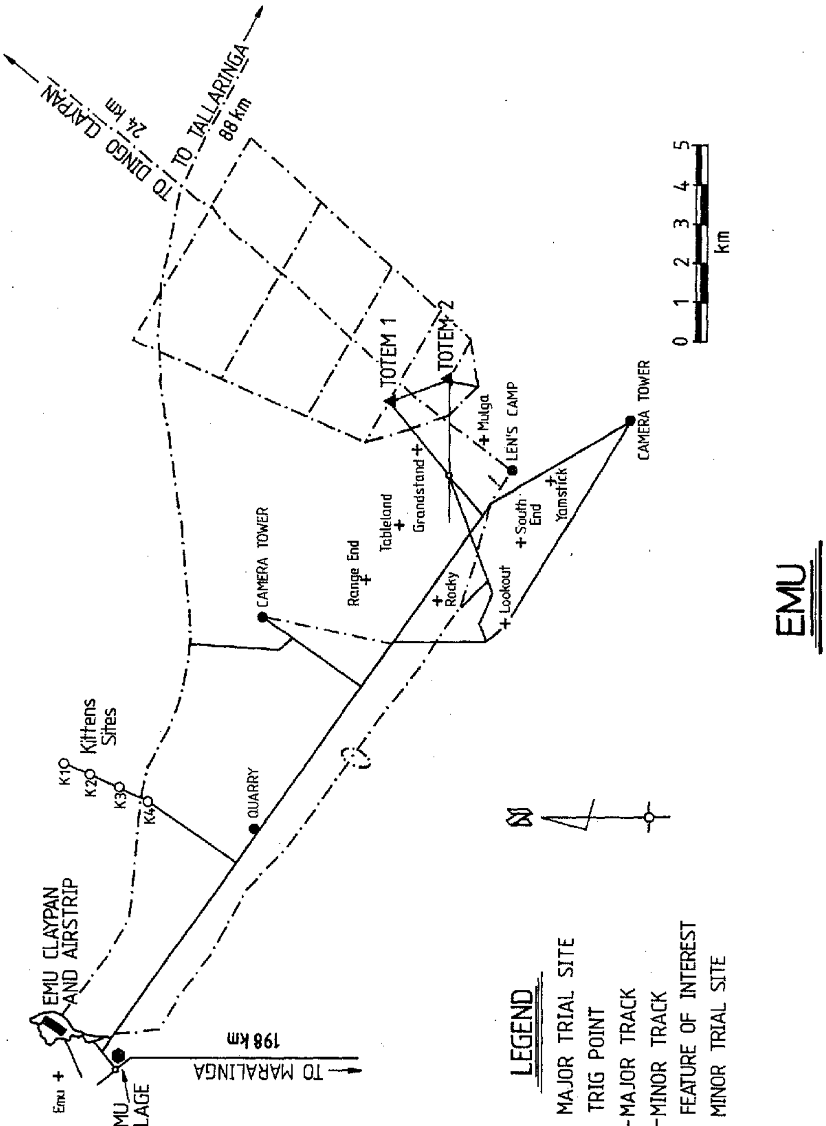

Figure 3: The Emu area showing major and minor test sites and main features. [Reproduced from ARL/TR087: pp.9]

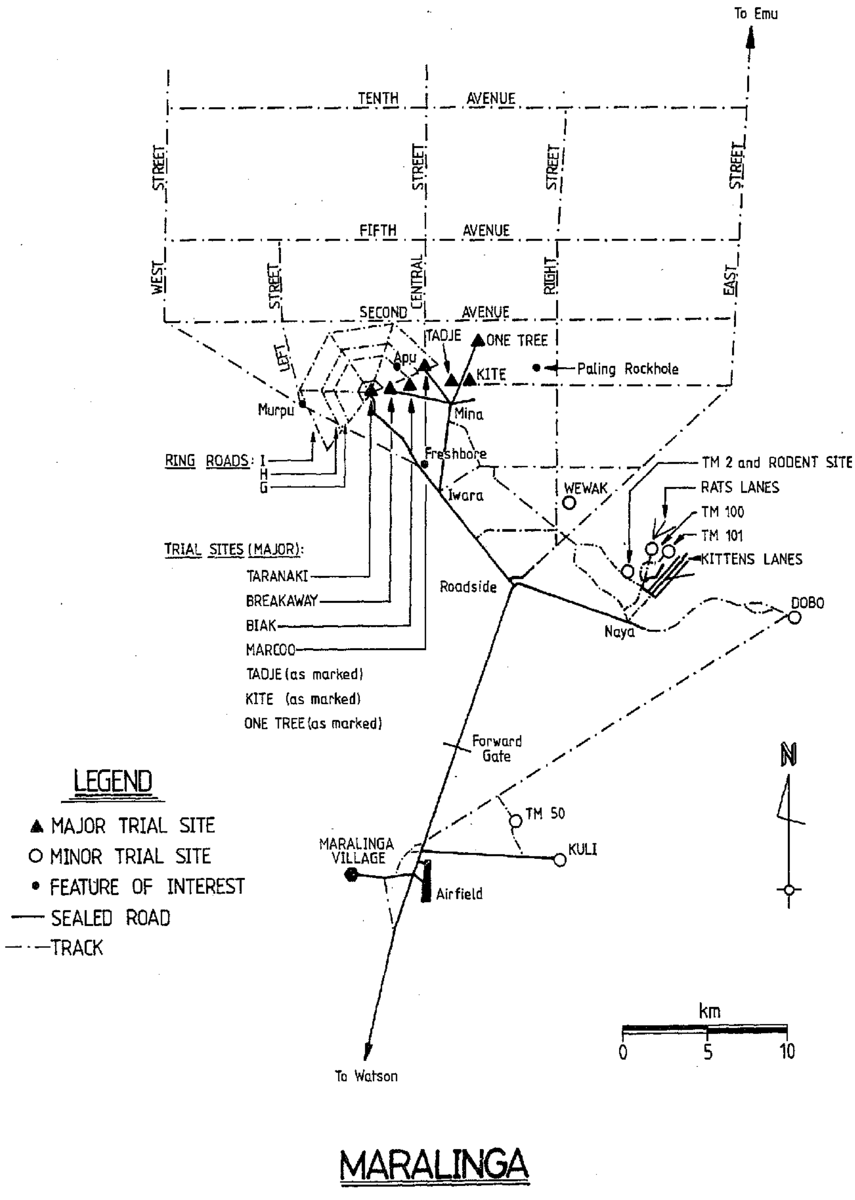

Figure 4: The Maralinga area showing major and minor trial sites and main features. [Reproduced from ARL/TR087: pp.8]

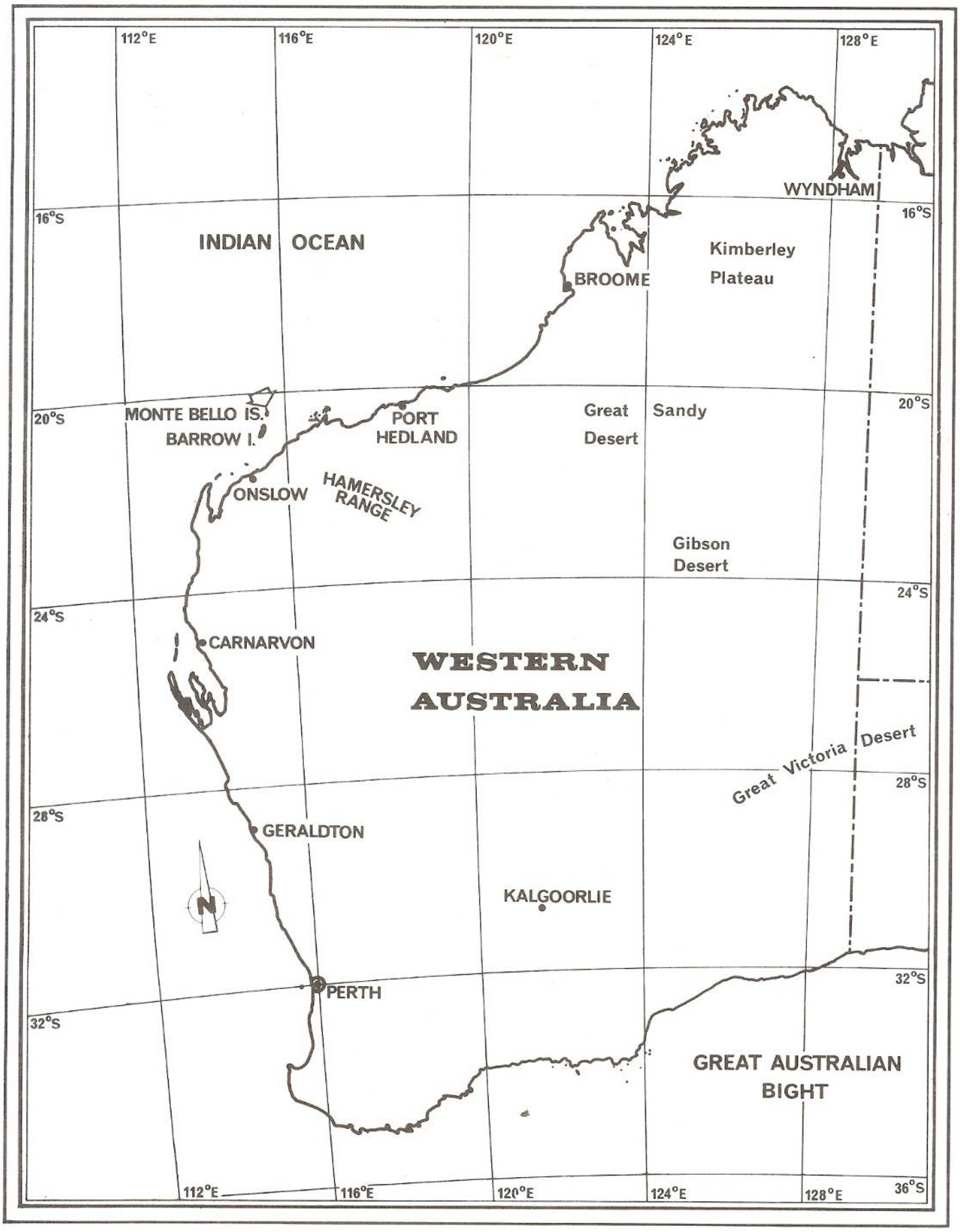

Figure 5: Map of Western Australia showing the location of the Monte Bello Islands. [Reproduced from ARL/TR096: pp. 40]

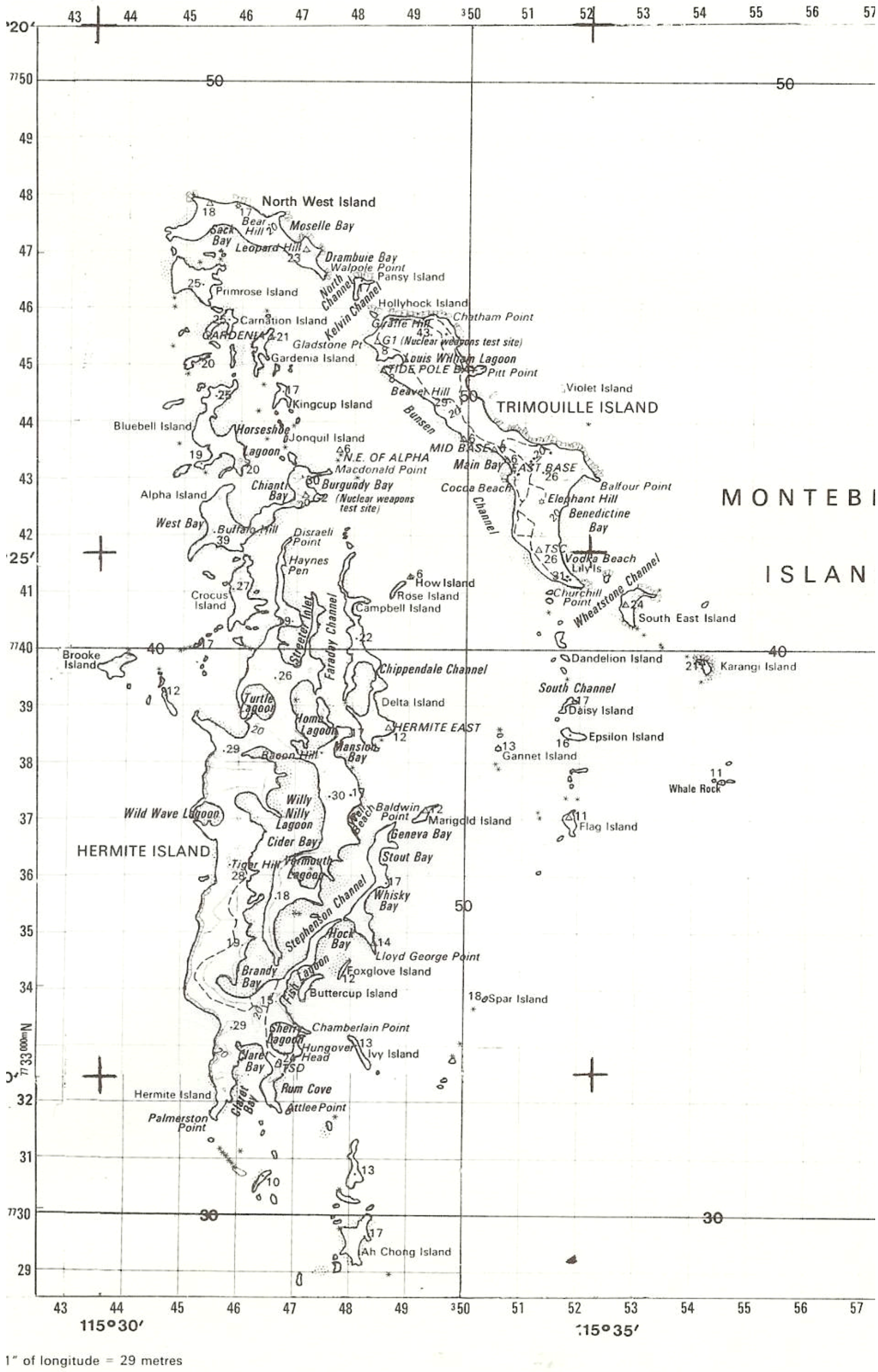

Figure 6: Map of the Monte Bello Islands.
[Reproduced from ARL/TR096: pp.39]

APPENDIX 3: NOTES ON ATOMIC FALLOUT

Source: Arnold, L. (1987), pp. 305 – 309

WHAT FALLOUT CONSISTS OF

The luminosity of the fireball of a 20-kiloton burst in air dies out in about 10 seconds and a radioactive cloud forms and rises rapidly. It is lighter than the surrounding air and rushes upward at a speed of some 200 miles per hour[38]. In a few minutes it spreads out into the characteristic mushroom cap. The cloud, which may remain visible for an hour or more before being dispersed by the winds, is mainly air and water droplets condensed from water vapour in the air, but it also contains the vaporised materials of the bomb or device – the fission products, the unconsumed uranium and plutonium (or either of these), and the casing components. Below the cloud is the stem of the mushroom. Both cloud and stem contain considerable quantities of dirt and debris, unless the explosion is over 500 to 600 ft[39] (in the case of a 20-kiloton burst); if the explosion is at 450 ft[40] or less, the fireball may actually touch the ground. In this case soil becomes contaminated with radioactivity, or is made radioactive my neutron induction, and is carried into the cloud.

The contents of the radioactive cloud depend therefore on the size and make-up of the bomb or device; its efficiency – i.e., what proportion of the fissile material is used in the chain reaction and what is left; and the amount and nature of the extraneous material drawn up into the cloud. Thee latter

[38] Approximately 322 km/h

[39] Approximately 152 m – 183 m

[40] Approximately 136 m

depend on the height of the burst, the yield, the nature of the soil, and the support structure (e.g., a steel or aluminium tower).

The particles are variable in size and weight, and the fission products are a mixture of more than 200 isotopes (mostly radioactive) of 36 different elements. The range of half-lives is enormous, from fractions of a second to many years, and the pattern of radioactive decay is extremely complex; overall, radioactivity decreases by a factor of 10 after every multiplication by 7 of the elapsed time (i.e., by 10 in the first 7 hours, by 00 in the first 49 hours and so on. This is called 'the rule of seven').

After an underwater detonation – like the *Baker* shot in the United States' 1946 trials at Bikini (Operation *Crossroads*) – seawater and material from the seabed are drawn up into a spray dome, as it falls back into the sea, may create a gigantic wave or cloud of dense and highly radioactive mist. This is called a 'base surge'. It apparently only occurs in deep water, and did not do so at *Hurricane*, which was a shallow water test[41].

The term 'fallout' refers to the radioactive material resulting from the explosion, and its magnitude depends on the process by which it is dispersed and deposited on the earth.

FIRING CONDITIONS

Firing conditions were intended to ensure that early fallout beyond the prohibited area did not cause contamination that might deliver radiation doses

[41] The reason for this 'shallow water test' was to determine the affects of the detonation of a nuclear device from the hull of a ship in a harbour, as there was a fear of such an attack; hence, the detonation inside the hull of HMS Plym off main bay, Trimouille Island.

above the level permitted for members of the public. This was the main purpose of theoretical prediction and meteorological forecasting.

If the wind direction varies at different altitudes – i.e., if there is windshear – fallout will be dispersed and will be thinly and widely spread over a comparatively short distance. But if there is little or no windshear (which is unusual) the fallout will extend much further, along the centre line of the wind, and will be more concentrated in a long narrow plume.

The meteorological conditions required for firing include suitable wind directions to carry fallout away from any inhabited areas, suitable wind speed, ample windshear, and absence of rain. Since the trials director received the forecast several hours in advance of firing, he needed to be confident that favourable conditions would last throughout the firing phase and, ideally, for 24 hours after firing.

HOW FALLOUT IS DISPERSED

The distribution of the fallout material in the cloud depends on four factors in conjunction:

(1) *The size of the particles*, since (other things being equal) large heavy particles fall more quickly, and closer to ground zero, than do light particles. The more delayed the deposition, the more the short-lived radioactivity will have decayed and the more diffused the material will be.

(2) *The distribution of the material* in the cloud and its stem. Gases and very fine particles will usually rise to the top of the cloud, but some may be trapped in the lower layers. The various layers of the stem and cloud

are affected by winds at the corresponding altitudes, therefore the distribution of the particles is important.

(3) *The height and extent of the cloud*, which depends on the force of the explosion and also the meteorological conditions that may affect its rise. Fro a 20-kiloton explosion, the cloud is likely to be 15 000 to 30 000 ft[42]. Accurate estimates of the cloud height were very important because they indicated the winds that were of concern; particles in the stem are transported by low level winds, and particles in the mushroom cloud by higher level winds at various altitudes. Clouds from kiloton explosions normally remain in the troposphere (the lower layer of the atmosphere extending to about 11 miles[43] above the Equator and 4 miles[44] at the poles) in which 'weather' occurs. It is divided by the tropopause from the upper layer, the stratosphere; clouds from megaton explosions (or very high altitude explosions) pass through the troposphere into the stratosphere.

(4) *Meteorological conditions*, especially wind structure and precipitation. In some meteorological conditions, a secondary cloud may be created as well as a primary cloud. Inversion conditions – in which a layer of the Earth's surface is cooler than the overlying layer – may trap cloud, or part of it. If the cloud encounters a rain area, material from the cloud will be washed out and deposited on the ground.

All these four factors work together; hence the importance of both theoretical predictions and meteorological forecasts in identifying safe conditions for firing.

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[42] Approximately 4.572 km – 9.144 km

[43] Approximately 18 km

[44] Approximately 6 km

Categories of fallout

Fallout has been categorised in various ways – as, e.g., on-site, local, early, close-in, intermediate, long range or global. Four categories are noted below.

(1) *On-site fallout* This is fallout in the test-site area around and immediately downwind of ground zero, and it consists of the largest particles. In practise it is almost entirely an external radiation hazard, and then only for participants carrying out re-entry sorties (with protective clothing, health escorts and other safety .

(2) *Global fallout* After a megaton explosion most of the fission products enters the stratosphere where they become widely distributed, and where they may remain for many months or even a few years. There is no precipitation (in rain or snow) from the stratosphere and the air mixes only very slowly with that of the troposphere. There is some transfer across the equator, but most global fallout reaches the Earth in the hemisphere in which it was created. The bigger the explosion the wider (and thinner) the diffusion of the fallout. Long retention in the upper atmosphere allows time for radioactive decay of all shorter-lived radioisotopes. (None of the British tests in Australia was n the megaton range.)

The effects of fallout

There are several ways in which fallout can affect people and the 'pathways' have been intensely studied. People may be exposed to external beta or gamma radiation. They may inhale radioactive airborne particles. They may ingest fission products that have entered the food chain; e.g., by drinking milk from cows that have grazed on pasture contaminated by fallout. Two fission products that caused special concern were strontium-90 and iodine-131. Strontium-90 is a long-lived radioisotope (half life of 28 years) which is akin to calcium and therefore tends to concentrate in bone. There it can cause bone tumours, or by irradiating the bone marrow, leukaemia. Iodine-131 is a short-lived radioisotope (half-life 8 days); if ingested by grazing cows it passes into their milk and thence into the bodies of people drinking the milk. It then tends to concentrate in the thyroid and gives to a risk of thyroid cancer; it is a particular risk for young children.

Global fallout has resulted in the very small radiation exposures to very large numbers of people. The total dose that people have received in the past and will receive in the future, from all the fallout weapons tests carried out hitherto, has been calculated as about 4 millisieverts for each member of the world's population[45]. This is a total dose, not an annual dose, and is equivalent to about four years' exposure to external radiation from natural sources…It is higher in the northern hemisphere then [sic. than] in the southern hemisphere.

This total dose, over and above natural background and spread over a very long time, represents a very small increase in radiation exposure to very large numbers of people. For each individual person, the risk is small, compared with the normal (non-exposed) incidence of those illnesses that may be attributable to radiation exposure. Recognition that contamination from atmospheric testing would increase the doses further was one of the factors that led to the adoption of underground containment for nuclear weapon testing.

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45 This dosage, in layman's terms, is equivalent to about four CAT scans over the course of one year.

APPENDIX 4: MEDIA ARTICLE HIGHLIGHTING THE CONFLICT BETWEEN THE FAITHS IN RELIGION AND SCIENCE

Source: Krauss, L. 'On the Side of the Angels'. New Scientist. 8 July 2006: 20.

ON THE SIDE OF THE ANGELS

Attempting to use science to discredit religion will not only fail, it also does a disservice to science itself, says **Lawrence Krauss.**

THE popular debate about intelligent design has, I am happy to say, discredited fundamentalists who want to censor science for religious reasons. It has also exposed pseudo-scientific organisations such as the Discovery Institute for what they are. Nevertheless, in pitching misguided evangelicals against the scientific community, it has had one negative affect: it has encouraged scientists to counter-attack by criticising religious faith in general.

Such attacks are nothing new. One of the more outspoken scientific opponents of religion, physicist Steven Weinberg of the University of Texas at Austin, has said: "There are good people, and bad people. Good people do good things, and bad people do bad things. When good people do bad things, its religion." It was a brilliant sound bite, but one of Weinberg's less vituperative statements is more instructive: "Science does not make it impossible to believe in God. It just makes it less possible to believe in God." His point is that the advent of modern science, all natural phenomena were viewed as miraculous, for want of any better explanation.

I agree with Weinberg that science has made it possible to dismiss God, and this, I believe lies at the heart of efforts by religious fundamentalists to censor science in schools. However, the first sentence of his quote is equally significant. The questions and assertions about design and purpose lie outside the realm of science so long as these things cannot be empirically tested. Thus, science may never make it impossible to believe in God, even if we ultimately develop a scientific understanding of all phenomena fight back to the beginning of time.

This point was well made by the Belgian priest and physicist Georges Lemaître, who was the first to demonstrate that Einstein's theory of general relativity predicted a big bang. When Pope Pius XII interpreted his result as a vindication of *Genesis*, Lemaître countered that this was inappropriate. The big bang, he said was a scientific theory that could be tested. Anyone choosing to use it to validate their belief in God, or as evidence that God is irrelevant, is doing so from their own religious convictions, and not from science.

There is a lesson for all scientists here. I know from experience that the great successes of our scientific exploration of the universe can tempt us to dismiss anything other than scientific understanding as of secondary importance. But spirituality, and with it religious faith, is deeply ingrained in human culture, and many people rely on their religious convictions to make sense of life. Whatever one's personal views about religion, it is undeniable that scientific understanding alone does not encompass the range of the human intellectual experience.

Scientists who fail to appreciate this, and who thus attack religious beliefs for being unscientific, do their discipline a disservice, not least because such attacks are themselves unscientific. This is why, while I am sympathetic with many of the points he raises, I disagree with Richard Dawkins's unfettered attack on God. Not only is it inappropriate to try to convince people of the validity scientific theories by first arguing that their deeply held beliefs are silly, it is also clear that the existence of God is a metaphysical question which is, for the most part, outside the domain of science. The phrase often used to defend aspects of evolution has particular significance here: the absence for evidence is not evidence for absence.

This is not to say all theological interpretations are beyond scientific criticism. A fundamentalist interpretation of the Bible is in clear violation of physical evidence. The Earth is not 10,000 years old; the universe was not created in seven days; the sun did not stand still in the ancient sky. Scientists can help explain why these literal interpretations of the Bible are not consistent pillars on which to build a faith – at least for anyone who rides in cars, flies in planes or uses any other technologies that rely on the same laws of nature that tell us why these things are incompatible with the universe in which we live.

Yet scientists go too far when they attack more generally any belief in divine purpose. From a strategic point of view it's a waste of energy. It plays into the hands of those who claim that scientific method is akin to atheism, and it weakens any efforts to speak out against those groups who regularly distort scientific education in the name of religion, preferring to promote ignorance rather than risk any threat of their flock. To counter these threats we need to argue compellingly that people of faith are ill served by ignorance, rather than argue that faith and ignorance are synonymous.

APPNDIX 5: ANALYSIS OF MAJOR SOURCES

Arnold, L. "A Very Special Relationship: British Atomic Weapons Trials in Australia"

The participants, who were interviewed during my research, and some historians, hold the view that Arnold presents the 'official' British perspective upon these events, therefore making her book an essential addition to this investigation. While she proclaims objectivity within her introduction, it is evident that this is not entirely the case, as her statement, "the contemporary United Kingdom records [of the 1980s] have been my main source"[46] and the foreword from a research colleague "The Ministry of Defence have given her every possible help"[47] shows.

Despite this, Arnold's book provides a unique perspective upon the role of the AWTSC, and the "erroneous inferences [made by Hedley Marston] from his iodine 131 results"[48], that further highlights her sympathies with British authorities. Mrs. Arnold also only consults two Australian sources to make her conclusions on the Marston controversy: Marston's own scientific paper, and Dr. J.L. Symonds, hardly adequate for such a complex issue.

However, one must ask whether British authorities were using her to present their historiography of these events in order to denigrate Marston for his attack on the AWTSC, and, in turn, the British government. Furthermore, the sources used by other historians on the issue may not have been available to Arnold due to security clearances. It must be noted that Arnold has

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46 . Arnold, L. A Very Special Relationship: British Atomic Weapons Trials in Australia. London: Her Majesty's Stationery Office, 1987: pp. *xvii*

47 Ibid. pp. *ix*

48 Ibid. pp. 194

released a subsequent book, 'Britain, Australia, and the Bomb', which was unable to be obtained and that she may have revised her conclusions.

McClelland, J.R. et. al. "Report of the Royal Commission into British Nuclear Tests in Australia"

The Royal Commission report, regarded by many as holding the definitive view on the entire narrative of events, proved to be an interesting source for this case study. Although this source largely adheres to the structuralist paradigm, presenting the events and separating them from a small amount of overall conclusions, it has been useful in obtaining a chronology of events as it incorporates a vast scope of sources.

The central findings of this source are: that "[n]one of Marston's results on the levels of iodine – 131 in thyroids was suppressed"[49] as they were "all published…in the Australian Journal of Biological Sciences"[50]; that "[t]here was a considerable disagreement between Marston and the Safety Committee on the interpretation…of the iodine – 131 results"[51]; and that "[t]he Safety Committee was high-handed in its treatment of Marston's paper."[52] Despite this, Marston is portrayed as being a menace to the AWTSC as his concerns have since been allayed as "[i]t is now known that radioiodine and radiostrontium act differently in, [sic.] the biosphere and that and that the radioiodine in the fallout from the tests…was of greater concern…"[53], and the numerous failed attempts by members of the Safety Committee to suppress Marston's results are ignored.

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49 McClelland, J.R. et. al. Report of the Royal Commission into British Nuclear Tests In Australia (Conclusions). Canberra: Australian Government Publishing Service, 1985: pp. 438

50 Ibid., pp.435

51 Ibid.

52 Ibid., 438

53 Ibid., 435

One must ask whether the underlying agenda of the Commission, to influence the British government to contribute to the clean up of the Maralinga and Emu Field test sites following a discovery of large plumes of residual decontamination and plutonium fragments, influenced its argument as it would have been unwise to castigate a party whose financial support was required.

Cross, R. "Fallout: Hedley Marston and the British Bomb Tests in Australia"

This was the only secondary source found that focused entirely upon the 'Marston controversy'. One receives the initial impression that his sole agenda is to contribute to the Australian meta-narrative by glorifying Marston as a nationalistic figure or icon, increase an interest in the field of science within Australia, and to draw parallels with the story of Alan Parkinson, "a nuclear engineer who was sacked for raising concerns about the clean-up"[54] of Maralinga.

However, it can be stated that this type of source is necessary in an historical debate whereby one historiography is dominant and is so broadly accepted. This alternative, 'revisionist'[55] perspective on these events is a well-researched, justified, and logical response to 'British' rhetoric that encourages a possible revision of the 'history' of those events. His narrative takes a more intimate view with the main protagonists and has some elements of the Annales 'school' of thought. This source has been highly valued in this investigation as it is the most comprehensive of those recovered.

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[54] Cross, R. Fallout: Hedley Marston and the British Bomb Tests in Australia. Kent Town: Wakefield Press, 2001: pp. xi.

[55] The term 'revisionist' is often connoted as derogatory. In this case, however, it refers to the fact that Cross' source is consistent with the definition listed in the Glossary on page xiii.

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