= British nuclear tests at Maralinga =

British Nuclear tests at Maralinga occurred between 1956 and 1963 at the Maralinga site , part of the Woomera Prohibited Area in South Australia and about 800 kilometres north @-@ west of Adelaide . A total of seven nuclear tests were performed , with approximate yields ranging from 1 to 27 kilotonnes of TNT (4 @.@ 2 to 113 @.@ 0 TJ) . Two major test series were conducted at the Maralinga site : Operation Buffalo and Operation Antler . The site was also used for hundreds of minor trials , many of which were intended to investigate the effects of fire or non @-@ nuclear explosions on atomic weapons .

The site was contaminated with radioactive materials and an initial cleanup was attempted in 1967 . The McClelland Royal Commission , an examination of the effects of the tests , delivered its report in 1985 , and found that significant radiation hazards still existed at many of the Maralinga test areas . It recommended another cleanup , which was completed in 2000 at a cost of $ 108 million . Debate continued over the safety of the site and the long @-@ term health effects on the traditional Aboriginal owners of the land and former personnel . In 1994 , the Australian Government paid compensation amounting to $ 13 @.@ 5 million to the local Maralinga Tjarutja people .

The Maralinga tests were subject to extreme secrecy , but by the late 1970s there was a marked change in how the Australian media covered the British nuclear tests . Some journalists investigated the subject and political scrutiny became more intense . Journalist Brian Toohey ran a series of stories in the Australian Financial Review in October 1978 , based in part on a leaked Cabinet submission . In June 1993 , New Scientist journalist Ian Anderson wrote an article titled " Britain 's dirty deeds at Maralinga " and several related articles . In 2007 , Maralinga : Australia 's Nuclear Waste Cover @-@ up by Alan Parkinson documented the unsuccessful clean @-@ up at Maralinga . Popular songs about the Maralinga story have been written by Paul Kelly , Midnight Oil , Anderson , Bruford , Wakeman , Howe and Alistair Hulett .

= = Historical context = =

On 3 October 1952 , the United Kingdom tested its first nuclear weapon , named " Hurricane " , at the Monte Bello Islands off the coast of Western Australia . A year later the first nuclear test on the Australian mainland was Totem 1 (9 @.@ 1 kilotonnes of TNT (38 TJ)) at Emu Field in the Great Victoria Desert , South Australia , on 15 October 1953 . Totem 2 (7 @.@ 1 kilotonnes of TNT (30 TJ)) followed two weeks later on 27 October .

The British government formally requested a permanent test facility on 30 October 1953 . Due to concerns about nuclear fallout from the previous tests at Emu Field and the site 's inadequate infrastructure and water supply , the recently surveyed Maralinga site was selected for this purpose . The new site was announced in May 1955 . It was developed as a joint , co @-@ funded facility between the British and Australian governments .

Prior to selection , the Maralinga site was inhabited by the Pitjantjatjara and Yankunytjatjara Aboriginal people , for whom it had a great spiritual significance . Many were relocated to a new settlement at Yalata , and attempts were made to curtail access to the Maralinga site . These were often unsuccessful .

= = Major tests = =

Two major test series were conducted at the Maralinga site : Operation Buffalo and Operation Antler .

= = = Operation Buffalo = = =

Operation Buffalo commenced on 27 September 1956 . The operation consisted of the testing of four nuclear devices , codenamed One Tree , Marcoo , Kite and Breakaway respectively . One Tree (12 @.@ 9 kilotonnes of TNT (54 TJ)) and Breakaway (10 @.@ 8 kilotonnes of TNT (45 TJ))

were exploded from towers , Marcoo (1 @.@ 4 kilotonnes of TNT (5 @.@ 9 TJ)) was exploded at ground level , and Kite (2 @.@ 9 kilotonnes of TNT (12 TJ)) was released by a Royal Air Force Vickers Valiant bomber from a height of 35 @,@ 000 feet (11 @,@ 000 m) . This was the first British launching of a nuclear weapon from an aircraft .

The fallout from these tests was measured using sticky paper , air sampling devices , and water sampled from rainfall and reservoirs . The radioactive cloud from Buffalo 1 (One Tree) reached a height of 37 @,@ 500 ft (11 @,@ 400 m) , exceeding the predicted 27 @,@ 900 ft (8 @,@ 500 m) , and radioactivity was detected in South Australia , Northern Territory , New South Wales , and Queensland . All four Buffalo tests were criticised by the 1985 McClelland Royal Commission , which concluded that they were fired under inappropriate conditions .

In 2001 , Dr Sue Rabbit Roff , a researcher from the University of Dundee , uncovered documentary evidence that troops had been ordered to run , walk and crawl across areas contaminated by the Buffalo tests in the days immediately following the detonations ; a fact that the British government later admitted . Dr Roff stated that " it puts the lie to the British government 's claim that they never used humans for guinea pig @-@ type experiments in nuclear weapons trials in Australia . "

= = = Operation Antler = = =

Operation Antler followed in 1957 . Antler was designed to test components for thermonuclear weapons , with particular emphasis on triggering mechanisms . Three tests began in September , codenamed Tadje , Biak and Taranaki . The first two tests were conducted from towers , the last was suspended from balloons . Yields from the weapons were 0 @.@ 93 kilotonnes of TNT (3 @.@ 9 TJ) , 5 @.@ 67 kilotonnes of TNT (23 @.@ 7 TJ) and 26 @.@ 6 kilotonnes of TNT (111 TJ) respectively . The Tadje test used cobalt pellets as a ' tracer ' for determining yield ; later rumours developed that Britain had been developing a cobalt bomb . The Royal Commission found that personnel handling these pellets were later exposed to the active cobalt 60 . Although the Antler series were better planned and organised than earlier series , intermediate fallout from the Taranaki test exceeded predictions .

= = Minor tests = =

In addition to the major tests , a large number of minor trials were also carried out , from June 1955 and extended through to April 1963 . Although the major tests had been carried out with some publicity , the minor tests were carried out in absolute secrecy . These minor tests left a dangerous legacy of radioactive contamination at Maralinga .

The four series of minor trials were codenamed ' Kittens ' , ' Tims ' , ' Rats ' and ' Vixen ' . In all , these trials included up to 700 tests , with tests involving experiments with plutonium , uranium , and beryllium . Operation Kittens involved 99 trials , performed at both Maralinga and Emu Field in 1953 ? 1961 . The tests were used in the development of neutron initiators , involving use of polonium @-@ 210 and uranium , and generated " relatively large amounts of radioactive contamination . " Operation Tims took place in 1955 ? 1963 , and involved 321 trials of uranium and beryllium tampers , as well as studies of plutonium compression . Operation Rats investigated explosive dispersal of uranium . 125 trials took place between 1956 and 1960 .

The Vixen minor trials (Vixen A and Vixen B) were formulated to investigate what would happen to a nuclear device which burnt or was subject to a non @-@ nuclear explosion . 31 Vixen A trials between 1959 and 1961 investigated the effects of an accidental fire on a nuclear weapon , and involved a total of about 1 kg of plutonium . Twelve Vixen B trials , between 1960 and 1963 , attempted to discover the effects of high explosives detonating a nuclear weapon in a fire (typical of conditions which would occur in aviation accidents) and involved 22 kg of plutonium . They produced " jets of molten , burning plutonium extending hundreds of feet into the air . " It was the lack of subsequent disposal of the plutonium from these minor trials ? Vixen B especially ? which created the major radiation problems at the site .

The Vixen experimental tests used TNT to blow up simulated nuclear warheads containing

plutonium @-@ 239 . In total , Vixen B scattered 22 @.@ 2 kg of plutonium around the Maralinga test site known as Taranaki , in particles of widely divergent size . Plutonium is not particularly dangerous externally - it emits alpha particles which are stopped by 9 cm (3 @.@ 5 in) of air , or the dead layer of skin cells on the body , and is not a very intensive source of radiation , due to its long half @-@ life of 24 @,@ 000 years . It is most dangerous when it enters the body , in the worst case by breathing , and therefore tiny particles , often the result of such explosion testing , are the worst threat . The extreme biological persistence of plutonium 's radioactive contamination and the cancer threat posed by alpha radiation occurring internally together establish plutonium 's dangers .

In terms of regular nuclear testing , Kittens represents bomb component testing , while Tims and Rats were early subcritical hydronuclear tests . Vixen is " safety testing " of a bomb ; assuring that the core would not accidentally undergo criticality in the event of a fire or unintended crash . These are always messy (see the US equivalent at Plutonium Valley in Project 56) , for a successful test subjects the core fuel to high explosives in the hope that it simply scatters rather than undergoes criticality . The differences in the sort of dangers presented by major vs the minor tests is that there was no critical explosion in the minor tests . In the major tests , the bomb cores reached critical mass ; the plutonium or uranium fissile materials " burned " into highly radioactive fission products , and those , along with the unspent fuel and activated bomb case , tower and soil if the explosion was close to the ground , are lofted into the stratosphere to be dropped eventually as fallout globally . In Vixen , an equivalent amount of plutonium fuel was simply smashed by explosives and spread about much more locally . In Kittens , Tims and Rats , smaller amounts of various materials were similar exploded locally and spread about .

= = Legacy = =

In the 1950s , Hedley Marston 's research into nuclear fallout from the Maralinga nuclear tests brought Marston into bitter conflict with the Australian government appointed Atomic Weapons Tests Safety Committee . He was vindicated posthumously by the McClelland Royal Commission , which found that significant radiation hazards existed at many of the Maralinga test sites long after the tests . His project tracked fallout across the continent by examining the thyroids of sheep and cattle as well as devices that filtered radioactive elements from air . Later the results , which showed dramatic increases of certain radioactive elements after British Nuclear Tests , caused a further , controversial study where the bones of deceased people (especially children) were burnt to ash and then measured for strontium @-@ 90 . These tests showed that the tests had increased the concentration of strontium @-@ 90 dramatically . As well as finding this after British tests a notable 50 % increase was noticed one year when there were no tests and it was cited as evidence that the previous year 's hydrogen bomb tests had contaminated the majority of the world .

A Maralinga cleanup operation codenamed Operation Brumby was conducted in 1967 . Attempts were made to dilute the concentration of radioactive material by turning over and mixing the surface soil . Additionally , the remains of the firings , including plutonium @-@ contaminated fragments , were buried in 22 concrete @-@ capped pits .

In the 1970s , whistle @-@ blower Avon Hudson disclosed details of the Maralinga testing program to the Australian media at risk of incarceration . His disclosures related to the inadequacy of clean @-@ up measures , persistent contamination and associated health risks of ionizing radiation . Hudson gave testimony to the Royal Commission into British nuclear tests in Australia in 1984 and 1985 and has since continued to work as a spokesperson for nuclear veterans in South Australia .

The McClelland Royal Commission into the tests delivered its report in late 1985 , and found that significant radiation hazards still existed at many of the Maralinga test sites , particularly at Taranaki , where the Vixen B trials into the effects of burning plutonium had been carried out . A Technical Assessment Group was set up to advise on rehabilitation options , and a much more extensive cleanup program was initiated at the site .

The TAG Report plan was approved in 1991 and work commenced on site in 1996 and was completed in 2000 at a cost of $ 108 million . In the worst @-@ contaminated areas , 350 @,@ 000 cubic metres of soil and debris were removed from an area of more than 2 square kilometres , and

buried in trenches . Eleven debris pits were also treated with in @-@ situ vitrification . Most of the site (approximately 3 @,@ 200 square kilometres) is now safe for unrestricted access and approximately 120 square kilometres is considered safe for access but not permanent occupancy . Alan Parkinson has observed that " an Aboriginal living a semi @-@ traditional lifestyle would receive an effective dose of 5 mSv / a (five times that allowed for a member of the public) . Within the 120 km ² , the effective dose would be up to 13 times greater . "

A Department of Veterans ' Affairs study concluded that " Overall , the doses received by Australian participants were small . ... Only 2 % of participants received more than the current Australian annual dose limit for occupationally exposed persons (20 mSv) . " However , such findings are contested . Australian servicemen were ordered to : repeatedly fly through the mushroom clouds from atomic explosions , without protection ; and to march into ground zero immediately after bomb detonation . Airborne drifts of radioactive material resulted in " radioactive rain " being dropped on Brisbane and Queensland country areas . A 1999 study for the British Nuclear Test Veterans Association found that 30 per cent of involved veterans had died , mostly in their fifties , from cancers .

Successive Australian governments failed to compensate servicemen who contracted cancers following exposure to radiation at Maralinga . However , after a British decision in 1988 to compensate its own servicemen , the Australian Government negotiated compensation for several Australian servicemen suffering from two specific conditions , leukemia (except lymphatic leukemia) and the rare blood disorder multiple myeloma .

One author suggests that the resettlement and denial of aboriginal access to their homelands " contributed significantly to the social disintegration which characterises the community to this day . Petrol sniffing , juvenile crime , alcoholism and chronic friction between residents and the South Australian police have become facts of life . " In 1994 , the Australian Government reached a compensation settlement with Maralinga Tjarutja , which resulted in the payment of $ 13 @.@ 5 million in settlement of all claims in relation to the nuclear testing .

= = Media coverage = =

According to Liz Tynan from James Cook University , the Maralinga tests were a striking example of what can happen when the popular media are unable to report on activities that the government may be trying to hide . Maralinga was an example of extreme secrecy , but by the late 1970s there was a marked change in how the Australian media covered the British nuclear tests . Some resourceful investigative journalists emerged , whistle @-@ blowers such as Avon Hudson spoke out and political scrutiny became more intense . The investigative journalist Brian Toohey ran a series of stories in the Australian Financial Review in October 1978 , based in part on a leaked Cabinet submission .

In June 1993 , New Scientist journalist Ian Anderson wrote an article entitled " Britain 's dirty deeds at Maralinga " and several related articles . They are a detailed analysis of the legacy of Vixen B and the Australian government 's prolonged negotiations with the United Kingdom on cleaning up Maralinga and sharing the cost of " safe @-@ sealing " waste plutonium . Previously , much of this highly toxic nuclear waste had simply been lightly bulldozed into the soil rather than buried in deep , secure , purpose @-@ built , concrete bunkers . In 1993 , Anderson won two Michael Daley Awards for his Maralinga articles .

Maralinga : Australia ? s Nuclear Waste Cover @-@ up is a book by Alan Parkinson about the clean @-@ up following the British nuclear tests at Maralinga , published in 2007 . Parkinson , a nuclear engineer , explains that the clean @-@ up of Maralinga in the late 1990s was compromised by cost @-@ cutting and simply involved dumping hazardous radioactive debris in shallow holes in the ground . Parkinson states that " What was done at Maralinga was a cheap and nasty solution that wouldn 't be adopted on white @-@ fellas land . "

= = In popular culture = =

Ground Zero is a fictional political conspiracy thriller about what happened during the Maralinga tests .

The 1991 folk song " Plains of Maralinga " by Alistair Hulett describes the tests and their deadly side @-@ effects on the Pitjantjatjara people .

The Career Highlights of the Mamu is an Australian play by Trevor Jamieson and Scott Rankin , performed by the Adelaide Festival in February ? March 2002 . The play tells the story of the Tjuntjuntjara Aboriginal people , who lived in the desert country between South Australia and Western Australia , and their experience with British nuclear testing at Maralinga and Emu Field . Tribal elders describe being moved out of the area , and the death and illness of their people when they attempted to return to their contaminated homelands .

Maralinga : The Anangu Story , by the Yalata & Oak Communities with Christobel Mattingley (Allen & Unwin , 2009) , is an information book about the history and culture of the region , the controversy and its original owners . Aimed at young people , the book was awarded a silver Honour medal in 2010 by the Children 's Book Council of Australia .

The Stranglers referenced the nuclear tests in Australia in their song " Nuclear Device (The Wizard of Aus) " .

The tests were the subject of the song " Birthright " by progressive rock group Anderson Bruford Wakeman Howe . The Australian band Midnight Oil wrote a song about the tests called " Maralinga " .

The Australian writer Judy Nunn published a novel titled Maralinga in 2011 .

The novel The Last Albatross by Ian Irvine referenced this location as the source of weapons grade plutonium used in a terror plot against Australia .

Web comic author Aaron Diaz wrote a one @-@ page comic re @-@ imagining the Maralinga tests .

The fictional story of a man with leukemia who was present during the tests featured in the 1982 A Country Practice episode " Field of Thunder . "